



**E-TENDER
FOR**

Designing, Providing, Constructing and commissioning modernized and fully automated package/modular Sewage Treatment Plants based on MBR technology along Poisar river on Design Build Operate (DBO), along with 15 years of Operation and Maintenance and Providing and laying of sewer network, provision of Interceptors for diversion of DWF, construction of service road and road side drains on either banks of Poisar River for interception & diversion of sewage.

Name of Project : Rejuvenation and Beautification of Poisar River

Project Consultant : Tandon Urban Solutions Pvt. Ltd.

**Volume – 3
(Employers Requirements & Technical
Specifications for Electrical, Mechanical &
Instrumentation Works)**

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1 ELECTRICAL EQUIPMENT

1.1 INTRODUCTION

This scope of this specification consists of general requirements of Design, manufacture, inspection and testing at manufacturer's works, supply, packing, forwarding and delivery to site, unloading, handling and storing the equipment at site, assembly, installation, testing and commissioning at site of the equipment/ system listed below as per Specifications, data sheets & Single Line Diagram. Particular requirements of all electrical equipment's are covered under, Part 12: Particular Requirements - Electrical of this Specification.

- a) Oil cooled Transformers
- b) HT Switchgear Panels
- c) HT Capacitor Banks & Panel
- d) FCMA Neutral Soft Start Panel
- e) 415V Metal enclosed switchboards (MCCs/PCCs)
- f) 415 V Power capacitor and control panel
- g) Bus Duct
- h) Diesel Generator Set with Acoustic Enclosure
- i) UPS
- j) Battery, Battery charger and DC Distribution board
- k) Cabling System: HV, LV, Control and Telecommunications
- l) Cable carrier system,
- m) Lighting
- n) Lighting System Equipment
- o) Earthing & Lightning protection system.
- p) Fire MCC Panel (Emergency DB)
- q) Fire Alarm and Protection System

The equipment of those manufacturers, who have sufficient proven experience of manufacturing the respective equipment of similar capacity, shall be considered. The respective equipment should have been manufactured, supplied, installed, tested, Commissioned successfully and should be working satisfactorily since at least last 5 years

continuously. Certificates from the end users, regarding their satisfactory Performances, shall have to be submitted in this regard.

Various equipment /items shall conform to latest applicable standards specified. In case of Conflict between standards and this specification, this specification shall govern.

1.2 TRANSFORMERS

Transformer system shall have provision such that inter-operability with instrumentation controls system.

- The entire substation shall be indoor type including transformers.
- Transformer shall be selected on the peak flow of TTP & Recycle plant process load.
- DG shall have 100% Backup provision.
- 100 % power backup for all TTP shall be provided.
- Bus bar material of 415 V Switchgears to be used as " Copper "
- The power distribution system was considered on 22 or 11 KV, (or As per STP existing power supply HT voltage, bidder may consider the same. For transformer HV side, LV side is 433 V; The MCGM electrical department need to be consulted.
- The bidders are requested to quote Vertical Turbine pumps (treated water pumping) based on design flow capacities, pump configurations shall be as per CPHEEO GUIDELINES.
- The perpetual licenses of software are now converted to subscription based licenses valid up to defect liability period (DLP). It can be scaled down to required software subscription licenses in O and M phase.

The successful bidder shall have to submit detail specifications of SCADA Implementation and nominate agency which shall implement SCADA. The competence of the agency and experience shall be evaluated by MCGM's representative and IIT then it shall be approved. Else MCGM shall nominate the agency for SCADA implementation which the bidder has to appoint exclusively for the project.

A. Applicable Standards

The transformers shall conform to the latest applicable standards specified below

Power Transformer	IS: 2026/BS: 171/IEC: 60076/ IS11171
Fittings and Accessories	IS: 3639

Outdoor type Oil immersed distribution transformers IS: 1180-2014

Upto 2500kVA, 22/11kV Transformer

Loading of oil immersed transformer	IS:6600/BS:CP.1010/IEC:60354
Transformer Oil	IS: 335/BS 148/IEC: 60296
Bushings for > 1000V, AC	IS: 2099/BS: 223/IEC: 60137
Bushings for > 1000V, AC	IS: 7421
Degree of Protection	IS: 13947 (Part 1)/ IEC: 60947-1
Double float type Buchholz Relay	IS: 3637
Electrical insulation classified by thermal stability	IS1271/BS:2757/IEC:60085
Climate Proofing	BS:CP1014
Code of Practice for selection, installation and Maintenance of transformers	IS - 10028
Manual on Transformers	CBIP Publication No.295

B. Features of Construction

- a) The transformer tank shall be made from high-grade sheet steel, suitably reinforced by stiffeners made of structural steel sections.
- b) All seams, flanges, lifting lugs, braces, and other parts attached to the tank shall be welded.
- c) The interior of the tank shall be cleaned by sand blasting and painted with two coats of heat resistant, oil insoluble paint.
- d) Adequately sized manholes shall be provided for ease of inspection and maintenance. Steel bolts and nuts exposed to atmosphere, shall be galvanized.
- e) The tank cover shall be removable and shall be suitably sloped so that it does not retain rainwater.
- f) Lifting lugs and eyebolts shall be so located that a safe clearance is obtained without the use of a spreader, between the sling and transformer bushings
- g) Transformers shall be provided with fixed type radiators. Fins of the radiators shall not have sharp edges and shall be rounded in shape.
- h) The transformer core shall be constructed from high grade, non-ageing, cold-rolled, grain Oriented, Silicon Steel Laminations. The steel laminations shall be of "core" type. Each lamination shall be coated with insulation which is unaffected by the temperature attained by the transformer during service. 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 connection to the tank.

- i) Windings shall be of insulated copper wire or copper strip. Windings and insulation shall be so arranged that free circulation of oil is possible between coils, between windings, and between winding and core. The windings shall be fully shrunk under vacuum before assembly. High voltage end-windings shall be suitably braced to withstand short circuit stresses and stresses caused up by surges.
- j) The sequence and orientation of HV/LV side phase and neutral bushings shall be as specified in the latest edition of relevant IS.
- k) Transformer shall operate without injurious heating at the rated KVA and at any voltage up to + 10 % of the rated voltage of any tap. Transformer shall be designed for 110 % continuous over-fluxing withstanding capability.
- l) Transformer shall be provided with Zero sequence / earth fault current protection on LV side transformer feeder protection. (Neutral CT to be provided in case of solid grounding)

C. Winding connections

Windings shall be of HV: Delta & LV: Star, vector group Dyn 11.

D. Rating

The rating of transformers shall be as per standard ratings shown in IS 1180:2014 or relevant standard.

E. Type of cooling

The transformers shall be oil immersed with natural oil circulation, type ONAN. With the provision for radiator cooling with fans for forced cooling, if required will be added in future. The rating of the transformer with ONAF shall be specified.

F. Impedance and losses

The percentage impedance, no load & load losses shall be as per IS 1180: 2014 or relevant standard.

G. Performance requirements

- a) The transformers shall be suitable for operation without danger on to any particular tapping at the rated kVA provided that the voltage does not vary by more than $\pm 10\%$ of the voltage corresponding to the tapping.
- b) The transformers shall be suitable for continuous operation with a frequency variation of $\pm 5\%$ of rated frequency, combined voltage and frequency variation should not exceed 10%.
- c) All transformers shall be capable of withstanding external short circuit without damage as per IS 2026.
- d) The transformers shall be capable of continuous operation in accordance with relevant IS for loading of oil immersed transformers.
- e) The neutral terminal of star windings shall be designed for the highest over current that can flow through this terminal.
- f) The temperature rise of oil & windings over the specified ambient temperature shall not exceed the limits given below with air as cooling medium when tested in accordance with IS 2026 (Part-2).

Top oil (measured by thermometer) : 40° C

Winding (measured by resistance) : 45° C

- g) Noise level of transformers shall be less than 80 dB at a distance of 1 meter.

H. Tap Changer

- a) The standard tapping range shall be +5% to -10% of HV in terms of 2.5 % with taps on HV Side. (consider as per IS 1180-2014, Part - 1)
- b) For transformer of rating less than or equal to 500 kVA, tap changing shall be carried out by means of an off circuit externally operated self-positioning switch when the transformer is in de-energized condition. Off circuit tapping arrangement shall be either by means of an externally operated switch with mechanically locking device and a position indicator. Arrangement for pad-locking shall be provided.
- c) On Load Tap Changing Gear for Transformer (above 500kVA) The OLTC gear shall be designed to complete successfully tap changes for the maximum current to which transformer can be loaded i.e. 150% of the rated current. Devices shall be incorporated to prevent tap change when the through current is in excess of the safe current that the tap changer can handle. The OLTC gear shall withstand through fault currents without injury.

- d) When a tap change has been commenced it shall be completed independently of the operation of the control relays and switches. Necessary safeguard shall be provided to allow for failure of auxiliary power supply or any other contingency which may result in the tap changer movement not being completed once it is commenced.
- e) Oil in compartments which contain the making and breaking contacts of the OLTC shall not mix with oil in other compartments of the OLTC or with transformer oil. Gases released from these compartments shall be conveyed by a pipe to a separate oil conservator or to a segregated compartment within the main transformer conservator. A Buchholz relay shall be installed in the above pipe. The conservator shall be provided with a prismatic oil level gauge.
- f) Oil in compartments of OLTC which do not contain the make and break contacts, shall be maintained under conservator head by valve pipe connections. Any gas leaving these compartments shall pass through the Buchholz relay before entering the conservator.
- g) OLTC driving mechanism and its associated control equipment (Local) shall be mounted in an outdoor, weather-proof cabinet with IP 55 protection which shall include:
 - (i) Driving motor (415V, 3-phase, 50 Hz. AC squirrel cage).
 - (ii) Motor starting contactor with thermal overload relays, isolating switch and HRC fuses.
 - (iii) Duplicate sources of power supply with automatic changeover from the running source to the standby source and vice versa.
 - (iv) Control switch: Raise/off/lower (spring return to normal type).
 - (v) Remote/local selector switch (maintained contact type).
 - (vi) Mechanical tap position indicator showing rated tap voltage against each position and resettable maximum and minimum indicators.
 - (vii) Limit switches to prevent motor over-travel in either direction or final mechanical stops.
 - (viii) Brake or clutch to permit only one taps change at a time on manual operation.
 - (ix) Emergency manual operating device (hand crank or hand wheel).
 - (x) A five digit operation counter.
 - (xi) Electrically interlocked reversing contactors (preferably also mechanically interlocked).

- (xii) 240V, 50 Hz. AC space heater with switch and HRC fuses. (xiii) Interior lighting fixture with lamp door switch and HRC fuses.
- (xiii) Gasketed and hinged door with locking arrangement.
- (xiv) Terminal blocks, internal wiring, earthing terminals and cable glands for power and control cables.
- (xv) Necessary relays, contactors, current transformers etc.

h) Control Requirements for OLTC

The following electrical control features shall be provided:

- (i) Positive completion of load current transfer, once a tap change has been initiated, without stopping on any intermediate position, even in case of failure of external power supply.
- (ii) Only one tap change from each tap change impulse even if the control switches or push button is maintained in the operated position.
- (iii) Cut-off of electrical control when manual control is resorted to. Cut-off of a counter impulse for a reverse tap change until the mechanism comes to rest and resets the circuits for a fresh operation.
- (iv) Cut-off of electrical control when it tends to operate the tap beyond its extreme position.

i) Automatic Control of OLTC

Automatic OLTC control shall include the following items:

- (i) Voltage setting device
- (ii) Voltage sensing and voltage regulating devices.
- (iii) Line drop compensator with adjustable R and X elements.
- (iv) Timer 5-25 seconds for delaying the operation of the tap changer in the first step for every tap change operation
- (v) Adjustable dead band for voltage variation
- j) The OLTC remote control equipment shall be housed in an indoor sheet steel cubicle to be located in a remote control room. It shall conform to degree of enclosure protection IP45 or better and shall comprise the following.

- k) The OLTC control panel shall comprise of rigid welded structural frames made of structural steel section or of pressed and formed cold rolled steel and frame enclosures, doors and partitions shall be of cold rolled steel of thickness 2 mm. Stiffeners shall be provided wherever necessary.
- l) All doors, removable covers and plate shall be gasketed all around with neoprene gaskets. Panel shall be dust, weather and vermin proof providing degree of protection of IP54, colour of finish shade for interior and exterior shall be glassy white and light grey semi glossy shade 631 of IS-5 respectively.
- m) Earthing bus shall be of 25 x 6 mm copper.
- n) The OLTC remote control equipment shall comprise of the following
- (i) Control switch: Raise/Off/Lower (spring return to normal type)
 - (ii) Auto/manual selector switch (maintained contact type)
 - (iii) Tap position indicator
 - (iv) Facia type alarm Annunciators with “accept” and “lamp test” facilities.
 - A.C. supply failure
 - Drive motor auto tripped
 - Tap change delayed
 - (v) Necessary auxiliary relays
 - (vi) Lamp indications for :
 - Tap change in progress
 - Lower limit reached
 - Upper limit reached
 - (vii) Cable glands for power and control cables.
 - (viii) 240 V rated panel space heater with ON-OFF switch.
 - (ix) Fluorescent type interior lighting fixture with lamp and door switch.
 - (x) HRC fuses.
 - (xi) Terminal blocks.
 - (xii) Internal wiring.
 - (xiii) Earthing terminal.
- o) Fittings and Accessories

The following fittings and accessories shall be provided for transformer:

- a) Inspection manhole(s) with cover(s) on the top cover of the transformer.
- b) Lifting lugs or eyes for lifting of fully assembled transformer by crane.
- c) Jacking pads, at least four in number, at suitable height, for lifting the complete transformer filled with oil.
- d) Lifting arrangements for
 - (i) Complete transformer filled with oil
 - (ii) For the assembly of core and coils and
 - (iii) For lifting the tank of large transformers whenever specified.
- e) Hauling eyes on each face of the transformer (for transformer rated 10000 KVA and above).
- f) Skids at the base of the transformer.
- g) A ladder assembly shall be provided to reach the top of the transformer for maintenance work. It shall be possible to padlock the ladder to the transformer tank so that ladder cannot be removed. Usage of transformer structure / marshalling boxes etc as means to climb transformer are not acceptable.
- h) Earthing pads: Two earthing pads of copper or other non-corrodible material shall be welded at the bottom corners of the transformer tank and supplied with clamp type terminals suitable for the Employer's earthing conductors. Suitable earthing terminals on cable boxes and separately mounted radiator banks shall also be provided.
- i) Neutral earthing bar of copper of specified section installed from the neutral bushing to ground level suitably supported along its run on porcelain insulators, together with clamping arrangements at neutral bushing and for two Employer's earth conductors. The supporting insulators shall be tank mounted.
- j) Terminal marking and rating plates shall be as per the specified standard and shall also give the following additional information:
 - (i) Connection diagram showing the internal connections.
 - (ii) Guaranteed Temperature rise of winding and oil.
 - (iii) Insulation levels of the windings, including neutral end of windings with uniform insulation.
 - (iv) Transportation weight.
 - (v) Un-tanking weight.
 - (vi) Core and winding weight.

- (vii) Table giving the tapping voltage, tapping current and tapping power factor for each tap. Values of short circuit impedance on the extreme tappings and on the principal tapping and indication of the winding to which the impedance is relates.
- k) The transformer shall also be provided with the following non -corrodible plates, indelibly marked showing:
 - (i) Location and function of all valves and plugs and indication of the maintenance instrument reference for applying vacuum of drying and oil filling.
 - (ii) Valves connection diagram
- l) The conservator shall be provided with the following accessories:
 - (i) Filling plug, sump and drain valve of 15 mm size for conservator of size 650 mm and 25 mm size for conservator above 650 mm diameter.
 - (ii) 150 mm diameter magnetic type oil level gauge with low oil level alarm contacts and a prismatic oil sight gauge, both as specified in Data Sheet and provided with markings for minimum oil level and oil level at rated temperature rise.
 - (iii) A bolted cover at one end for cleaning.
 - (iv) Valve for shutting off oil to the transformers.
 - (v) Weather proof dehydrating breather with silica gel and oil seal to eliminate constant contact with the atmosphere, mounted at a level of about 1400 mm above ground level.
- m) Gas and Oil Actuated Relay (Buchholz Relay)
- n) Temperature Indicators
- o) Dial Type Thermometer
- p) Winding Temperature Indicator

I. Cable Terminations / Cabling Requirement

22/11kV air insulated cable box with air insulated disconnecting chamber shall be provided with supporting brackets and structure to facilitate their support from ground level. The disconnecting chamber and terminal box shall be air insulated and Complete with seal-off bushings, removable flexible connectors/links and removable covers. LT terminal box shall be suitable for connecting LT air insulated bus duct.

All transformers shall be provided with lockable emergency Push Button station near the transformer to trip the transformer as per IER. All transformers shall be provided with alarm annunciation on breaker control panel.

J. Tolerance on Losses

The permissible tolerances on the guaranteed values of transformer losses shall be as per IS 2026. Cost loading shall be done for capitalization of losses at time of bid evaluation for all transformers as per CBIP Manual on transformers.

K. Rejection

- a) The Employer or Employer's Representative reserves the right to reject the transformer if the same does not meet the specification requirement, subject to tolerances as per IS 2026.
- b) The impedance values difference and temperature rise values shall not exceed from the guaranteed specified values.
- c) The rejected transformers shall be replaced by transformers complying with the requirements of this specification at the Contractor's cost. If the commissioning of the project is likely to be delayed by the rejection of a transformer, the Employer's Representative reserves the right to accept the rejected transformer until the replacement transformer is made available
- d) Transporting the rejected and replacement transformers as well as installation and commissioning of both the transformers shall be at the Contractor's cost.

L. Drawings and Data

All Drawings, data, technical particulars, temperature rise calculations, detailed literature, catalogues, type test certificates of typical transformer etc. shall be submitted along with the bid Documents.

1.3 HT METAL ENCLOSED SWITCHBOARDS & SWITCHGEARS

HT/MV metal enclosed Switchboards and Switchgear system shall have provision such that inter-operability with instrumentation controls system.

The HT/MV switchboard is proposed with "FORM 4 – B" enclosure as per the Indian Standard. All indoor boards/ panel are proposed with a degree of protection of IP55 while all

outdoor equipment above ground are proposed with a degree of protection of IP66 and above as per site condition.

A. Applicable Standards

The switchgear and its components shall conform to the latest applicable standards specified below:

Circuit Breakers	IS : 13118 / BS : 5311 / IEC: 60056,60694,IEC 62271-100
Metal Enclosed switchgear	IS:3427/ BSEN:60298 / IEC:60298,IEC 62271-200
Current Transformers	IS : 2705 / BS : 7626
Voltage Transformers	IS : 3156 / BS : 7625 / IEC : 60186 IS : 5578, 11353
Arrangement for Switchgear Busbars, Main Connections and Auxiliary wiring	IS : 2544 / BS : 3297 / IEC :60 273
Busbar Support insulators	IS : 13947 (Part 1) / IEC : 60947-1/ BSEN :60529
Degree of Protection	
Electrical Relays for Power system protection	IS : 3231, 3842 / BS : 142 / IEC : 60255
Electrical Indicating Instruments	IS : 1248 / BS : 89 / IEC :60051
High Voltage Fuses	IS : 9385 / BS : 2692 / IEC : 60282
AC Electricity Meters	IS : 722, 8530 / BS : 5685 / IEC :60145,60211
Specification for copper rods and bars for electrical purposes	IS : 613
Code of practice for phosphate iron and steel	IS : 6005 / BS : 3189
Alternating current Switches for voltages above 1000 V	IS : 9920 / IEC : 60129,60265 & 60298
Low voltage fuses	IS : 13703 / BS 1362 / IEC 60269
Toggle switches	IS : 3452 / BS : 3676
Code of practice for selection, installation and maintenance of switchgear and control gear	IS : 10118
Control switches	IS:6875 / BSEN 60947/IEC: 60947

Classification of Hazardous areas having Flammable gases and vapours for Electrical Installation	IS 5572, IS 5571
Electrical apparatus for explosive gas atmospheres-General Requirements	IEC 60079
Fault level calculation	IS: 2026

B. Constructional Features

- a) Switchgear design shall be of metal enclosed, single front, free standing, floor mounted and fully compartmental execution having separate sections for each circuit. Each Circuit shall have a separate vertical panel with distinct compartments for main bus bars, circuit breaker, cable termination and auxiliary devices.
- b) The adjacent panels shall be completely separated by steel sheets except in bus bar sheet compartments where insulated barriers shall be provided to segregate adjacent panels. Compartments with doors for access to operating mechanism shall be so arranged as not to expose high voltage circuits.
- c) Switchgear cubicle shall be provided with hinged door on the front with facility for locking door handle.
- d) Switchboard shall be dust and vermin-proof and shall have a degree of protection of enclosure of IP5X and the relay and meter compartments shall have a degree of Protection not less than IP 52.
- e) All removable covers shall be gasketed all around with neoprene or superior gaskets.
- f) 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.
- g) All transformers shall be provided with alarm annunciation on breaker control panel
- h) Each switchgear 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.
- i) Each relay, instrument, switch, fuse and other devices shall be provided with separate label.

- j) The fully draw-out modules shall have all the circuit components mounted on withdraw able type steel chassis.
- k) 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
- m) External cable connections shall be through separate cable compartments for power and control cables. Safety shutters shall be provided to cover up the fixed high voltage contacts on bus bars when the circuit breaker carriage is moved to test and isolated positions.
- n) One metal sheet shall be provided between two adjacent vertical sections running to the full height of the switchboard except for the horizontal bus bar compartment. However, each shipping section shall have metal sheets at both ends. 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.
- o) All sheet steel work shall be phosphate in accordance with the following procedure and in accordance with IS: 6005 “Code of Practice for Phosphate Iron and Steel”. Oil, grease, dirt and swarf shall be thoroughly removed by emulsion cleaning. Rust and scale shall be removed by pickling with dilute acid followed by washing with running water, rinsing with slightly alkaline hot water and drying.
- p) After phosphate, thorough rinsing shall be clean water followed by final rinsing with dilute dichromate solution and even drying. The phosphate coating shall be followed by the application of two coats of ready mixed stoving type zinc chromate primer. The first coat may be “flash dried” while the second coat shall be stove. After application of the two coats of primer finishing synthetic enamel paint shall be applied, each coat followed by stoving. The second finishing coat shall be applied after completion of tests. The final finished thickness of paint film on steel shall not be less than 100 microns and shall not be more than 150 microns. Finished painted surface of panels shall present an aesthetically pleasing appearance free from dents and uneven surface. A small quantity of finishing paint shall be supplied for minor touching up required at site after the installation of the panels.

C. Circuit Breaker

- a) Circuit breakers shall be vacuum type with three separate single pole interrupting units, operated through a common shaft by a sturdy operating mechanism. Surge Arrestors shall be provided for each motor / transformer feeder.
- b) Circuit Breakers shall be re strike free, stored energy operated and trip free 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.
- c) Anti-pumping relay and trip coil suspension relay shall be provided.
- d) 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.
- e) Separate limit switches, each having a minimum of 2NO+ 2NC contacts, shall be provided for both „Service“ and „Test“ positions of the circuit breakers. All these service, test, fully withdrawn, spring charge and also breaker ON / OFF shall be visible mechanically from outside the breaker panel when the front door is closed.
- f) Electrical closing & tripping shall be performed by shunt trip & close coils both in Local & Remote mode. 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”, “Test” and breaker readiness positions shall be indicated by separate indicating lamps on the cubicle door.
- g) 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.
- h) 10% spare feeders with at least one for each type of highest rating shall be provided in each switch gear.
- i) Surge arrestors shall be provided for all motors / transformer feeders and shall be metal oxide gapped or gapless type generally in accordance with IEC 60099 -1 and suitable for indoor only.

- j) Core balance CTs (CBCT) shall be provided on outgoing motor and transformer feeders having CT Ratio 50 / 1A or more. These CBCTs shall be mounted inside the switch gear panel.

D. 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 80-110 % of the control voltage. Trip coils shall operate satisfactorily between 50 -110 % the rated control voltage.

E. Safety Interlocks and Features

- a) Withdrawal or engagement of a circuit breaker shall not be possible unless it is in the open position.
- b) All circuit breaker shall have lockable local / remote selector switch, for closing the breaker from local shall be possible only in TEST position. Whereas as closing from remote shall be possible in either SERVICE and TEST position. For opening breaker from local shall be possible only when local remote selector switch shall be in local position. Opening breaker from remote shall be either breaker in service position or selector switch being in remote position.
- c) All Motors and Service Transformers feeder breaker shall have lockable emergency push button (openable only with key) near motor and service transformer, hard wired to circuit breaker panel emergency push button.
- d) Operation of a circuit breaker 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.
- e) Circuit breaker cubicles shall be provided with safety shutters operated automatically by the movement of the circuit breaker carriage to cover the stationary isolated contacts when the breaker 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.
- f) The circuit breaker carriage shall be earthed before the breaker reaches the test position from fully withdrawn position. In case of breakers 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.
- g) 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.

F. Earthing

- 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 without exceeding maximum allowable temperature rise.
- c) The earth bus shall be properly supported to withstand stresses induced by the momentary short circuit current.
- d) Suitable clamp type terminals at each end of the earth bus shall be provided to suit the size of the earthing conductors. Bolted joints, slices, tap, etc. to the earth bus shall be made with at least two bolts. 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.
- e) Hinged doors shall be earthed through flexible earthing braid of adequate cross section.
- f) All non-current carrying metal work of the switchboard shall be effectively bonded to the earth bus.
- g) Positive connection of the frames of all the equipment mounted in the switchboard to the earth bus bar shall be maintained through insulated conductors of size equal to the earth bus bar or the load current carrying conductor, whichever is smaller.
- h) All instrument and relay cases shall be connected to earth busbar by means of 1100V grade, green coloured, PVC insulated, stranded, tinned copper, 2.5 sq. mm conductor looped through each of the earth terminals.

G. 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 to prevent accidental earthing of live circuit or bus bars. 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.
- c) The earthing facilities proposed to be provided by the Bidder shall be clearly detailed in the Bid and shall be subject to Employer's approval. 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.

H. Annunciators

- a) Annunciators shall be of fascia type with translucent plastic window for each alarm point.
- b) Annunciated fascia plates shall be engraved in block lettering with respective alarm inscriptions. The inscriptions shall be clearly readable and visible when the respective fascia LED light is lighted.
- c) Each annunciation window shall be provided with two LED Lights to provide redundancy against LED light failure. Lamps shall be replaceable from the front. Lamps shall be of clustered LED type.
- d) All fascia annunciated points shall be suitable to accept external contacts of either „NO“ or „NC“ self or hand reset type for initiating the annunciation sequence shall be suitable for accepting fleeting faults of duration as less as 15 milliseconds.
- e) For static Annunciator schemes, special precaution shall be taken by the Contractor 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 neighbouring circuits within the panels / desks.
- f) A “Lamp Test” push button shall be provided for each individual panels group of Annunciators to limit the sudden drain on the battery. Provision of testing facilities for flasher and audible electronics alarm circuits of annunciators is desirable. The Contractor shall give the details of the offered scheme.
- g) Annunciator 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
 - Alarm annunciates having provision to integrate all alarm / trip signals to PLC.
 - Alarm annunciation shall be provided for transformers, Chlorination system and surge vessel system where ever discrete local automation is envisaged.

- All Annunciations shall have interfacing facilities for communication for SCADA.

I. Indicating Instruments & Meters

- a) The instruments shall 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.

Metering Instruments

- Multi Function Meter (MFM) with the facility to measure A, V, KW, KWh, KVA_r, PF, Hz with communication port
 - Multi-Function Meters shall be of the accuracy class 1.0, suitable for measurement of unbalanced loads in three phase three wire circuits.
- b) MFM 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.
 - c) The instruments can be electronic / digital type with LCD display & RS 485 connectivity for remote reading of parameters in SCADA. These instruments should have high performance ratio and can be equipped with digital output (for alarms).

J. Control and Selector Switches

- a) Control and instrument switches shall be heavy duty 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.
- b) The control switches shall be 3 positions, spring return to neutral type. They shall be provided with contacts to close in „normal after close“ and „normal after trip“ position.
- c) 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. Local / Remote selector switch shall be stay put 2 / 3 position with lockable provision.
- d) 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.

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.

K. Indicating Lights / Pilot Lights

- a) Indicating light shall be rated for operation at either 230 V AC or at the specified DC system voltage as applicable. Lights shall be provided with translucent light covers.
- b) Clustered LED type lamps shall be provided. Lenses shall be glass or plastic in standard colours, red, green, blue, white and amber, in accordance with IEC 60073. 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.
- c) The basis of colours shall be as follows:
 - Red: Flow of energy.
 - Green: No flow of energy.
 - White: Supervision of power available, relay coil healthy, etc.
 - Amber : For all alarm conditions such as pressure low, overload, Disagreement with original condition, „abnormal“ condition or „sequence-on“ condition also for service and test position.
 - Blue: For all healthy conditions such as control supply, spring charged and lockout relay coil healthy.
 - Yellow : For R, Y, B indication light, yellow as one of the light.

L. Push Buttons

- a) Push buttons shall be of momentary contact type with rear terminal connections. The colour of the push button actuator shall be red for „OPEN / STOP“ and green for „CLOSE / START“. 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.
- b) Normal stop push button shall be mushroom type latching in red colour, after pressing and it is latched, the latch can be removed by clockwise rotation. (Motor stops automatically after pre determined conditions such as delivery valve close in case of pumps.) This may replace stop push button.

- c) Emergency stop push button red in colour shall be lockable by pressing the push button and can be opening only with key and with shrouding. (Motor stopped immediately irrespective of predetermined conditions required)Emergency Push button with shrouding shall be provided near transformer and motors for remote tripping.
- d) Reset push button shall be either for resetting the flag and OLR or LEDs with push button for resetting
- e) 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 5A at 110V DC.
- f) All push button shall have additional NO/NC potential free for hard wiring to instrumentation control panel.

M. Space Heaters

Adequately rated anti-condensation space heaters shall be provided for each switchboard / cubicle, bus ducts and Motors above 7.5 kW. Space heater shall be of the industrial strip continuous duty type, rated for operation on a 240 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 RTD thermostat to cut off the heaters at 35 degree C.

Note: space heaters shall be provided for all motors above 30 KW

N. Cubicle Lighting / Receptacle

Each cubicle shall be provided with interior lighting by means of 18 W energy efficient (lumen per watt shall be indicated) LED lighting fixture. An MCB shall be provided for the lighting circuit. The lighting fixture shall be suitable for operation from a 240 V, 1 ph, 50 Hz, AC supply. A 240 V, 1 phase, AC receptacle (socket) plug point shall be provided in the interior of each panel with an MCB.

O. Power and Control Cable Termination

- a) Terminals for power connections shall be complete with adequate phase segregating insulating barriers, shrouds and suitable aluminium solder less crimping type of lugs for terminating the cables and control cables lugs and ferrules shall be tinned copper conforming to IS 8309. The cable lugs for control cables shall be

provided with insulating sleeve and shall suit the type of termination provide on the equipment.

- b) Double compression type glands with armour and bonding clamps for the termination of all solid dielectric multicore cables shall be provided and shall confirm to BS: 6121. 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.
- c) 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.
- d) 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.
- e) 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.

P. Wiring For Control and Protective Circuits

- a) 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.
- b) All wiring shall be run on the sides of panels and shall be neatly bunched and cleatted 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. Wire ways shall not be more than 50% full. Adequate slack wire shall be provided to allow for one re-stripping 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.
- c) Wiring shall only be jointed or tied at terminals. Terminals of the clamp type shall not have more than two wires connected.

Q. Termination and Ferrules

- a) 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.
- b) 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.
- c) All wires forming part of a tripping circuit shall be distinctively marked. Spare auxiliary contacts of electrical equipment shall be wired to terminal blocks.

R. Control Wiring Terminal Blocks

- a) Terminal blocks (TBs) shall be of 1000 V grade, 10A 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.
- b) 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.
- c) Terminals for circuits with voltage exceeding 110 V shall be shrouded. Terminal blocks at different voltages shall be segregated into groups and distinctively labelled. Terminals used for connecting current transformer secondary leads shall be „disconnecting and shorting “type with a facility for earthing the secondary.
- d) 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.
- e) At least 20 % cores shall be kept spare in multicore control cables. At least 10% spare terminals shall be provided and space for adding another 10% spares terminals shall also be available in each set of TBs.

S. Bus Bars

- a) The Bus bars shall be of electrical grade, high conductivity, copper and shall be provided with minimum clearances as per relevant IS. Bus bar cross section shall be uniform throughout the length of the switchgear.

- b) All bus bars and bus taps shall be insulated with close fitting sleeve of hard, smooth, dust and dirt free, heat shrunk PVC insulation of high dielectric strength, to provide a permanent non-ageing and non-tracking protection, impervious to water, tropical conditions and fungi. The insulation shall be non-inflammable and self-extinguishing type and in fast colours to indicate phases.
- c) The dielectric strength and properties shall hold good for the temperature range of 0 to 95 degree centigrade. If the insulating sleeve is not coloured, bus bars shall be colour coded with coloured PVC tape at suitable intervals.
- d) Busbar joints shall be of the bolted type. Spring washers shall be provided to ensure good contact at the joints. Bus bars shall be thoroughly cleaned at the joints and suitable contact grease shall be applied just before making a joint.
- e) Direct access to, or accidental contact with bus bars and primary connections shall not be possible. All apertures and slots shall be protected by baffles to prevent accidental shorting of bus bars due to insertion of maintenance tools.
- f) Sequence of red, yellow and blue phases and neutral for four-pole equipment shall be left to right and top to bottom, for horizontal and vertical layouts respectively.
- g) End terminations at transformer end and MV panel end shall be flexible bus bar such that no load / force / weight of the bus bar act on the terminal studs.

T. Current & Voltage Transformers

- a) Current transformers shall be of cast resin, bar-primary type unless specified otherwise, suitable for continuous operation at the ambient temperature prevailing inside the switchgear enclosure and shall have polarity markings indelibly marked on each transformer and at the lead terminations at the associated terminal block. The class of insulation shall be Class E or better.
- b) Current transformers shall be able to withstand the thermal and mechanical stresses resulting from the maximum short circuit and momentary duties of the switchgear. For wound-primary type CTs, the short time current rating shall not be less than 0.5 sec. CT core laminations shall be of high grade silicon steel. Where multi-ratio current transformers are specified, a label shall be provided, clearly indicating the connections required for the alternative ratios.
- c) These connections shall also be shown on panel wiring diagrams. Identification labels shall be fitted giving type, ratio, rating, output and serial numbers and duplicate rating labels are to be fitted on the exterior of the mounting chambers suitably

located to enable reading without the removal of any cover or metal sheeting forming part of the structure of the switchboard.

- d) Magnetization characteristics, calculated performance and protective settings shall be provided by the Contractor. All Voltage Transformers shall be of Single Phase type. The bus VT's shall be housed in a separate panel in a truck so as to be fully withdrawable. All Voltage transformers shall have HRC fuses on Primary and Secondary Side. There shall be provision for changeover on secondary side of Voltage Transformers to have alternate arrangement in case one Voltage Transformer fails.

U. Relays

- (i) All Protective relays shall be numerical type. Numerical relays shall have appropriate setting ranges, accuracy, resetting ratio, transient overreach and other characteristics to provide required sensitivity.
- (ii) All numerical protective relays shall be flush mounted at the front with connections at the rear. Shall have communication port for remote, metering and monitoring facility, suitable for electrical measurement including voltage, current, power (active / reactive) and energy parameters.
- (iii) All numerical relays shall have keypad to allow relay settings from relay front. Resetting knobs shall be accessible from the front on removing the external cover and shall be external to the case.
- (iv) All numerical relays and timers shall be rated for control supply voltage specified and be capable of satisfactory continuous operation between 70 % and 110 % of the rated voltage. Making, Carrying and Breaking Current ratings of the relay Contacts shall be adequate for the circuits in which they are used.
- (v) The numerical relays shall have communication, Metering and Monitoring Facility. The communication facility shall have two Ports local front port (RJ45/USB) for laptop communication and the second port (Rear RS485) for SCADA.
- (vi) The numerical processor shall be capable of measuring and sharing values of a wide range of quantities, events, faults and disturbance recordings with time stamping using internal real time clock. Battery backup for real time clock in the event of power failure shall be provided
- (vii) Numerical Relays shall have diagnostic feature with self-check for power failure, Programmable routines, memory and main CPU Failures etc.

- (viii) The Protective relays shall have adequate number of potential free contacts (Programmable). The Contacts shall be suitable for directly wiring in the breaker closing and tripping circuits operating from 110 V DC Control Voltage.
- (ix) The current operated relays shall have provision for 4 Sets of CT Inputs and Voltage operated relays shall have provision for 3 PT inputs. Relays shall be suitable for CT secondary current suitable for CT Secondary current of 1 A / 5 A selectable at Site.
- (x) Numerical Relays shall be immune to any kind of electromagnetic interference and capacitance effect due to length of connected control cables.
- (xi) Timer function shall be programmable for ON/OFF delays.
- (xii) Numerical Relays shall be able to provide supervisory function such as trip circuit monitoring, circuit breaker monitoring, PT & CT supervisions and recording facilities with post fault analysis.
- (xiii) All relays shall withstand minimum test voltage of 2 KV AC RMS for one minute.
- (xiv) Numerical relays shall have two level password protections, one for read only and other for authorization for modifying the setting etc.

V. Energy monitoring and power supply management

- a) Necessary Provisions & features shall be incorporated to enable energy monitoring /energy management for the installation. Energy Metering shall meet the requirement of guaranteed specific energy consumption specified by the contractor through instrumentation control system.
- b) In case, Numerical relays having built in features of energy measurement of requisite accuracy and provided in switch gear, separate energy meter is not required.
- c) Necessary provision & features shall be incorporated to under voltage monitoring/ relay for incomer feeder, bus bar chamber and control supply.

W. I / O signal for Instrumentation, Control & Automation System from Electrical panels.

- a) I/O signals from instruments shall be separately wired to a marshalling box such that instrumentation engineers will not enter in to power panel that are not familiar with them.
- b) Necessary provisions shall be incorporated to meet the requirements indicated in

- (i) I/O Schedules - ACB/VCB, Command Open & Close, Feedback trip, Breaker healthy (Ready to close), Local /Remote, Breaker Opened / Closed. (ii) Data Transfer Schedule
- (ii) Alarm Schedule of Particular requirement of Instrumentation, Control & Automation System, Part-13, and Volume 2 of the Bid document.

X. Drawings and Data

All Drawings, data, technical particulars, temperature rise calculations, detailed literature, catalogues, type test certificates etc. shall be submitted along with the bid.

1.4 FCMA NEUTRAL SOFT START PANEL

A. Applicable Standards

The design, manufacture and performance of equipment shall conform to the latest standards specified below.

Metal enclosed switchgear	: IS: 3427
Current transformers	: IS: 2705/BS: 7626
Arrangement for switchgear busbars, Main connections and auxiliary wiring	: IS: 5578/IS: 11353
Busbar support insulators	: IS: 2544/BS: 3297/IEC: 273
Degree of protection	: IS: 13947 (Part I) /BSEN: 60529/ IEC:947-1
Electrical relays for power system Protection	: IS: 3231/BS: 142/IEC: 255
Electrical indicating instruments	: IS: 1248/BS: 89/IEC: 51
A.C. electricity meters	: IS: 722/BS: 2692
Specification for copper rods and bars	: IS: 613 for electrical purposes
Code of practice for phosphating iron And steel	: IS: 6005/BS: 3189

Constructional and Performance Features

- a) Flux Compensated Magnetic Amplifier (FCMA) neutral soft start panel shall be indoor, metal clad with separate metal enclosed compartments for (i) control, metering and current transformers for differential protection (ii) shorting switch (iii) busbars (iv) power cable terminations (v) push buttons with indicating lamps.

- b) FCMA shall achieve smooth starting by torque control for gradual acceleration of the drive system thus preventing jerks and extending the life of equipment.
- c) Starting current shall be limited to 3.0 times the full load current of the motor.
- d) Separate removable gland plates shall be provided for power and control cables. The gland plate for the power cables shall be of non-magnetic material.
- e) All sheet steel work shall be thoroughly cleaned of rust, scale, oil, grease, dirt and swarf by pickling, emulsion cleaning etc. The sheet steel shall be phosphated and then painted with two coats of zinc rich primer plant. After application of the primer, two coats of finishing synthetic enamel paint oven baked/ stoved, shall be applied.
- f) The cable compartment shall house all power cable connections along with associated cable terminations.
- g) 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
- h) Caution name plate with inscription “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, e.g. incoming terminals of main disconnecting switch.
- i) Starting of motor shall be from either FCMA panel located near to motor or shall be from 11 kV motor modules or from PLC. Necessary wiring diagram shall be provided considering starting interlock, trip circuit, starting and running mode signal.

B. Main Busbars

- a) Busbars shall be fully insulated by encapsulation in epoxy resin, with moulded caps protecting all joints.
- b) Busbars shall be supported on insulators capable of withstanding dynamic stresses due to short circuit.
- c) Busbars shall be of copper conductor of hand drawn (HD) and high conductivity. Busbars shall be fully insulated by encapsulation in epoxy resin with moulded caps protecting all joints.

C. Earthing

- a) An earthing bus shall be provided at the bottom and extended throughout the length of the panel. It shall be bolted/ welded to the frame work.

- b) 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.

D. Panel Accessories and Wiring

- a) Panel shall be supplied completely wired internally up to 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 650 volts grade, single core, stranded copper conductor with PVC insulation. The sizes of wire shall be not less than 1.5 mm²
- c) Terminal blocks shall be of stud type, 650 volts grade 10 amps 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 2.0 or better. Instruments shall be 110 mm square, 240V scale for flush mounting with only flanges projecting.
- f) Relays shall be suitable for flush mounting with only flanges projecting.
- g) All protective relays shall be in draw-out cases with built-in test facilities. Necessary test plugs shall be supplied loose and shall be included. All auxiliary relays and timers shall be supplied in non-draw-out cases. Externally operated hand reset flow indicators shall be provided on all relays and timers. Timers shall be of electromagnetic or electronic type only.
- h) Push buttons shall be provided with inscription plates engraved with their functions.
- i) LED Indicating lamps shall be panel mounting type with series resistors. The wattage of lamps shall be 5 to 10 watts.
- j) Space heaters of adequate capacity shall be provided inside each panel. They shall be suitable for 240 V, 1 ph, 50 Hz supply. They shall be complete with HRC fuses, isolating switches and thermostat.
- k) Each panel shall be provided with 240 Volts, 1 phase, 50 Hz, 5 amps, 3 pin receptacle with switch located in a convenient position. An interior illuminating lamp together with the operating door switch and protective fuses shall be provided.

- l) Provision shall be made for receiving, distribution, isolating and fusing of auxiliary D.C. and A.C. supplies for controls, space heating etc. The fuse ratings shall be so chosen as to ensure selective clearance of subcircuit faults.
- m) Fuses shall be HRC cartridge type mounted on plug in type fuse base.
- n) The D.C. and A.C. auxiliary supply shall be distributed inside the panel with necessary isolating arrangements at the point of entry and with sub-circuit fuses as required.

E. Cable Termination

- a) Necessary number of cable glands shall be supplied for terminating auxiliary power and control cables. Glands shall be of heavy duty brass castings, machine finished and complete with check nut, washers, neoprene compression ring etc.
- b) Cable lugs for all power and control cable connections shall be supplied. The lugs shall be tinned copper/aluminium depending on cable conductor and of solderless crimping type.
- c) All necessary materials required for terminating the power cables such as tapes, fillers, binding wires, armour clamps, brass glands etc. shall be supplied.

F. Drawings and Data

All Drawings, data, technical particulars, calculations, detailed literature, catalogues, test certificates etc. shall be submitted along with the bid.

1.5 415 V METAL ENCLOSED SWITCHGEARS / MCC

A. Applicable Standards

The switchgear and its components shall conform to the latest applicable standards specified below.

Switchgear General Requirements	IS:13947/BS:5486/IEC:60947
Factory Built Assemblies of SWGR and Control gear for Voltages upto and including 1000V AC & 1200V DC	IS:8623/BS:5486/IEC:60439
Air Break Switches	IS:13947-P3 /BSEN60947

	/IEC:60947-3
Moulded Case Circuit Breaker	IS 2516 / IEC 60947-2/ BS EN 60947-2
Miniature Circuit Breakers	IS:8828/BSEN:60898
Low voltage Fuses	IS:13703/BS:1362/IEC:60269-1
Contactors	IS:13947/BS EN60947-4 /IEC:60947-1
Starters	IS:13947/BS EN60947-4/IEC:60292-1- 4
Control Switches / Push buttons	IS:6875 / BSEN 60947
Current Transformers	IS:2705/BS:7626
Voltage Transformers	IS:3156/BS:7625/IEC:60044, 60186
Indicating instruments	IS:1248/BS:89/IEC:60051
Marking and Identification of Conductors and Apparatus Terminals	IS:11353/BS:159
A.C. Electricity Meters	IS:722, 8530/BS:5685 / IEC 60145,60211
Degree of Protection	IS:13947/IEC:60947-P1
Selection installation and maintenance of switchgear and control gear	IS:10118
Code of practice for phosphating iron and steel	IS:6005/BS:3189
Specification for copper rods and bars for electrical purposes	IS:613
Control transformers for switchgear and control gear voltage not exceeding 1000V AC	IS:1202

B. Features of Construction

(The panels shall be constructed as per form 4B as per IEC 60439-1)

The construction of LV panel shall be such that the Switchgear panel and starter feeder for each pumps shall be separated physically and the connected through suitable rating of cable so as the operational problem during breakdown shall be avoided. The switchgear used in the

panel shall be fuse less type only. The selection of the motor for pumping application shall limited to 300 HP. Use of motor for LT application above 300 HP shall not permitted.

The LV switchboard is proposed with “**FORM 4 –B**” enclosure as per the Indian Standard. All indoor boards/ panel are proposed with a degree of protection of IP54 while all outdoor equipment above ground are proposed with a degree of protection of IP65 and above as per site condition.

- a) The switchgear shall be metal enclosed, dust proof, modular type, suitable for indoor floor mounting and shall have following features.
 - (i) Total height of switchgear shall not exceed 2300 mm. Height of Switches; Pushbuttons shall not exceed 1800 mm and shall not be less than 700 mm.
 - (ii) Shall be double front execution and fixed type
 - (iii) Shall have designation labels both on front and rear sides
 - (iv) Shall be provided with proper gasketing for removable covers, doors, between panels and base frame and all around the perimeter of adjacent panels.
 - (v) Degree of Protection shall be IP54.
 - (vi) Thickness of CRCA Sheet is 2mm.
- b) Switchgear shall be divided into distinct vertical sections each comprising :
 - (i) A completely enclosed busbar compartment running horizontally
 - (ii) Enclosed vertical busbars serving all modules in vertical section
 - (iii) A separate horizontal enclosure for all auxiliary power and control buses if required
 - (iv) Vertical cable alley of 250mm wide covering entire height
- c) Operating devices shall be incorporated only in the front of switchgear
- d) Each shipping section shall have metal sheets at both ends.
- e) Cable alley shall be provided with suitable hinged doors.
- f) GS/GI Earth bus of size 50mm x 10 mm shall be provided at the bottom.
- g) Rear of Single Front Switchgear shall be provided with removable panels with screws.
- h) All doors shall be with concealed type hinges and captive screws
- i) Each vertical section shall be equipped with 240 V, 1 Phase, 50 Hz space heater controlled by thermostat.
- j) A 240 V, 1 phase, AC plug point shall be provided in the interior of each cubicle with on- off switch for correction of head lamps.
- k) Interchangeability

All identical equipment and corresponding parts be fully interchangeable without any modifications.

l) Main and Auxiliary Buses

- (i) Switchgear busbars shall be of uniform cross section throughout the length and made of high conductivity, electrical grade hard drawn copper conductor.
- (ii) Busbar shall be fully insulated by encapsulation in epoxy resin with moulded caps protecting all joints and shall be adequately supported to withstand stresses developed due to short circuits. Supports shall be of glass reinforced phenolic material or cast resin.
- (iii) Busbar joints shall be provided with contact grease at the joints and shall be complete with tensile steel bolts and Belleville washers and nuts.

C. Air Circuit Breaker (ACB)

- a) Air circuit breaker shall be selected for feeders for load current equal to and more than 630A.
- b) Circuit breakers shall be operated by a motor spring charging type of mechanism. The motor operated spring charged mechanism shall be complete with motor, opening spring, closing spring and all accessories to make the mechanism a complete operating unit.
- 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. 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 has been operated and the first device in the control scheme has responded,

even though the PB 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 be provided on the operating mechanism.
- g) All operating mechanisms shall be provided with "ON" - "OFF" mechanical indication.
- h) 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.
- i) The Breaker shall be provided with Microprocessor based releases for Inverse - time delayed overload releases for the phases, Short-time delayed short-circuit releases and earth-fault releases.
- j) The breaker service Short Circuit breaking capacity (ICS) shall be equal to ultimate Short Circuit capacity (ICU) and shall be equal to short time withstand current of Breaker (ICW)

D. Moulded Case Circuit Breaker (MCCB)

- (i) 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 short circuit current Specified. MCCBs shall have a service short circuit breaking capacity (ICS) equal to the ultimate short-circuit capacity (ICU).
- (ii) Each pole of MCCB shall be fitted with a bi-metallic thermal element for inverse time delay protection and a magnetic element for short circuit protection. Alternatively, they shall be fitted with a solid state protection system. Such a protection system shall be fully self-contained, needing no separate power supply to operate the circuit breaker tripping mechanism. Thermal element shall be adjustable. Adjustments shall be made simultaneously on all poles from a common facility. Thermal elements shall be ambient temperature compensated.
- (iii) The MCCBs shall be provided with the following features. (i) Common trip bar for simultaneous tripping of all poles (ii) Shrouded terminals
- (iv) Time for clearing short circuit current of 20 msec. (iv) 2 NO + 2 NC auxiliary contacts

E. Miniature Circuit Breaker (MCB)

- a) MCB shall be hand operated, air break, quick make, quick break type.
- b) Operating mechanisms shall be mechanically trip-free from the operating knob to prevent the contacts being held closed under overload or short-circuit conditions.
- c) Each pole shall be fitted with a bi-metallic element for overload protection and a magnetic element for short-circuit protection. Multiple pole MCBs shall be mechanically linked such that tripping of one pole simultaneously trips all the other poles. The magnetic element tripping current classification shall be of the type suitable for the connected load. Where this is not specified, it shall be Type C. The short circuit rating shall be not less than that of the system to which they are connected.

F. Contactors

- a) The power contactors used in the switchboard shall be of, air break, single throw, triple pole, electromagnetic type. Contactors shall be suitable for uninterrupted duty and rated for Class AC3 duty in accordance with the latest edition of IS 13947.
- b) Operating coils of all contactors shall be suitable for operation on 240 V, single phase, 50 Hz supply. Contactors shall be provided with at least two pairs of NO and NC auxiliary contacts. Contactors shall not drop out at voltages down to 70 % of coil rated voltage. 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 contactor shall all be provided with single phasing preventer (SPP).

- c) Motor starters shall be complete with auxiliary relays, timers and necessary indications.

G. Current Transformers

- a) Current Transformers shall be Cast Resin type.
- b) Current transformers shall have polarity markings indelibly marked on each transformer and at the lead terminations at the associated terminal block.

- c) Current transformers shall be able to withstand the thermal and mechanical stresses resulting from the maximum short circuit and momentary duties of the switchgear, as indicated in the Technical Specification
- d) CT core laminations shall be of high grade silicon steel.
- e) Identification labels shall be fitted giving type, ratio, rating, output and serial numbers.

H. Voltage Transformers

- a) Voltage Transformers shall be Cast Resin type.
- b) Secondary and tertiary windings of voltage transformers shall be rated for a three phase line to line voltage of 110 V.
- c) It shall be possible to replace voltage transformer fuses easily without having to de-energize the main bus-bars.

I. Indicating Instruments & Meters

- a) Electrical indicating instruments shall be 110 mm square with 240° scale. Taut band type of instruments is preferred. Taut band moving coil instruments for use on AC systems shall incorporate built-in transducers. Instrument dials shall be white with black numbers and lettering.
- b) 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. Watt hour meters shall be of the induction type and shall be provided with reverse running stops. Instruments shall have an accuracy of Class 1.0.

J. Indicating Lamps

Indicating lamps shall be of the cluster LED type, with low watt consumption. Indicating lamp shall be of the double contact, bayonet cap type rated for operation at either 240 V AC or at the specified DC system voltage as applicable. Lamps shall be provided with translucent lamp covers. Bulbs and lenses shall be interchangeable and easily replaceable from the front.

K. Push Buttons

"Start" and "Stop" push buttons shall be coloured green and red respectively. Stop Push Button shall be lockable stay-put type with Mushroom head.

L. Space Heaters

Adequately rated anti-condensation space heaters shall be provided, one for each control panel, for each switchboard and for each marshalling kiosk. Space heater shall be of the industrial strip continuous duty type, rated for operation on a 240 V, 1 phase, 50 Hz, AC system. Each space heater shall be provided with a single pole MCB with overload and short circuit release, a neutral link and a control thermostat to cut off the heaters at 350 °C.

M. Safety Arrangements

All terminals, connections and other components, which may be “live” when front access door is open, shall be adequately screened. It shall not be possible to obtain access to an adjacent cubicle or module when any door is opened. Components within the cubicles shall be labelled to facilitate testing.

N. Earthing of Switchboards / Panels

- a) Each switchboard, control panel, etc. shall be provided with an earth busbar running along its entire length. The earth bus bar shall be located at the bottom of the board/panel.
- b) Earth bus bars shall be of copper and shall be rated to carry the rated symmetrical short circuit current of the associated board/panel for one second, unless otherwise specified. Earth bus bars shall be properly supported to withstand stresses induced by the momentary short circuit current of value equal to the momentary short circuit rating of the associated switchboard/panel.
- c) Positive connection of the frames of all the equipment mounted in the switchboard to the earth bus bar shall be maintained through insulated conductors of size equal to the earth bus bar or the load current carrying conductor, whichever is smaller.
- d) All instrument and relay cases shall be connected to earth bus bar by means of 1100 V grade, green coloured, PVC insulated, stranded, tinned copper, 2.5 sq. mm conductor looped through the case earth terminals.

O. Internal Wiring

The internal wiring shall be carried out with 650/1100V grade, PVC insulated, stranded conductor wires. The minimum size of conductor for power circuits shall be 4 Sq.mm copper conductor. Control circuits shall be wired with copper conductor of atleast 1.5 Sq.mm.

P. I / O & Other Data for Instrumentation, Control & Automation System

Necessary provisions shall be incorporated to meet the requirements indicated in

- (a) I / O Schedules
- (b) Data Transfer Schedule
- (c) Alarm Schedule

Q. Drawing and Data

All Drawings, data, technical particulars, calculations, detailed literature, catalogues, test certificates etc. shall be submitted along with the bid/ after award of contract as specified,“

1.6 415 V POWER CAPACITOR AND CONTROL PANEL

A. Applicable Standards

The capacitor and control panel conform to the latest applicable standards specified below. In case of conflict between standards and this specification, this specification shall govern

Shunt capacitors for power systems	IS : 13340
Internal fuses and internal overpressure disconnectors for shunt capacitors	IS : 12672
Metal enclosed switchgear	IS : 3427 / BSEN 60298/ IEC : 60298
Code of practice for phosphating iron and steel	IS : 6005/BS : 3189
Specification for copper rods and bars for electrical purpose	IS : 613

B. Design Features

- a) The capacitor banks shall be complete with all parts that are necessary or essential for efficient operation. Such parts shall be deemed to be within the scope of supply whether specifically mentioned or not.
- b) The capacitor bank shall be complete with the required capacitors along with the supporting post insulators, steel rack assembly, copper bus bars, copper connecting

strips, foundation channels, fuses, fuse clips, etc. The steel rack assembly shall be hot dip galvanised.

- c) The capacitor bank may comprise of suitable number of single phase units in series parallel combination. However, the number of parallel units in each of the series racks shall be such that failure of one unit shall not create an overvoltage on the units in parallel with it, which will result in the failure of the parallel units.
- d) The complete capacitor banks with its accessories shall be metal enclosed (in sheet steel cubicle), indoor floor mounting and free standing type.
- e) All sheet steel work shall be thoroughly cleaned of rust, scale, oil, grease, dirt and swarf by pickling, emulsion cleaning etc. The sheet steel shall be phosphated and then painted with two coats of zinc rich primer paint. After application of primer, two coats of finishing synthetic enamel paint oven baked/stoved shall be applied.
- f) The assembly of the banks shall be such that it provides sufficient ventilation for each unit. Necessary louvers may be provided in the cubicle to ensure proper ventilation.
- g) Each capacitor unit/bank shall be fitted with directly connected continuously rated, low loss discharge device to discharge the capacitors to reduce the voltage to 50 volts within one minute in accordance with the provisions of the latest edition of IS : 2834.
- h) Capacitors shall be of Mixed Dielectric of polypropylene and paper with internal element fuses. The impregnate shall be non PCB (poly chlorinated biphenyl) oil.
- i) Each unit shall satisfactorily operate at 135% of rated KVAR including factors of overvoltage, harmonic currents and manufacturing tolerance. The units shall be capable of continuously withstanding satisfactorily any overvoltage upto a maximum of 10% above the rated voltage, excluding transients.
- j) Unit Protection

Each capacitor unit shall be individually protected by an HRC fuse suitably rated for load current and interrupting capacity, so that a faulty capacitor unit shall be disconnected by the fuse without causing the bank to be disconnected. Thus, the fuse shall disconnect only the faulty unit and shall leave the rest of the units undisturbed. An operated fuse shall give visual indication so that it may be detected during periodic inspection. The fuse braking time shall co-ordinate with the pressure built up within the unit to avoid explosion. Mounting of the individual fuse may be internal or external to the capacitor case.

C. Power Capacitor and Control Panel

The selection of APFC panel and capacitor bank shall be online with MSEDCL Penalty clause, if any violation, lead to penalty imposed by MSEDCL shall be borne by Bidder/Contractor, corporation will not compensate these charges.

- a) Power capacitor and control panel shall be housed in metal enclosed cubicle. Power capacitor shall be housed in the lower compartment and capacitor control panel at top compartment.
- b) The control equipment including capacitors shall be mounted in a panel of cold rolled sheet steel. The panel shall be of indoor type and shall consist of :
- c) Busbars shall be of copper conductor of hard drawn (HD) and high conductivity
- d) Isolating switch
- e) Contactor with overload element
- f) Relays responsive to current/voltage/KVAR/PF as specified for automatic switching
- g) Sequencing devices, timers and auxiliary relays for automatic sequential switching of the capacitors in and out of the circuit.
- h) Auto-manual selector switches
- i) Push button for opening and closing the power circuit.
- j) Red and green lamps for capacitors ON/OFF indication.
- k) Protective relays to protect the healthy capacitor units when one unit fails in a series connection.
- l) Space heater and cubicle lighting as per the requirements.

D. Drawings and Data

All Drawings, data, technical particulars, calculations, detailed literature, catalogues, test certificates etc. shall be submitted along with the bid/ after award of contract as specified,“

1.7 415V BUS-DUCT

- a) All bus-ducts will be of non-segregated metal enclosed phase with cross over chamber (if required), all bends and accessories like flexible expansion joints, terminal connectors and flanges, wall frame assembly etc.
- b) The Bus-bar shall be
 - (i) Electrolytic grade copper
 - (ii) 99% purity

(iii) 97% Conductivity

- c) The metal enclosed bus duct shall be designed to operate continuously.
- d) The material of the enclosure shall be CRCA with minimum thickness of 2 mm.
- e) Bus-duct enclosure will be of MS epoxy painted with outer shade of Siemens grey RAL 7032 & black matt paint on the inside. Paint thickness shall be 140 microns or above.
- f) Wall frame assembly shall be provided if required.
- g) The enclosure shall be totally enclosed, dust & vermin proof with ventilation louvers.
- h) All nuts, bolts, hardware used for Bus-duct shall be of M12 size, grade 8.8 & of cadmium.
- i) All joints in the enclosure shall have neoprene gaskets.
- j) The Bus-duct shall comply with the technical parameters of the latest version of the IS/IEC
- k) The bus duct shall be inclusive of the following:
 - i. Straight run of the duct
 - ii. 90 deg bends
 - iii. Copper flexible at Transformer end
 - iv. Copper flexible at LT DG end
 - v. Copper flexible at LT panels end.
 - vi. Wall frame assembly and seal off bushing
 - vii. Phase crossover chamber
- l) The bidder shall submit type test certificates along with the bid for Bus duct for The following:
 - i) S.C. withstand capacity for 1 second.
 - ii) Degree of protection.
 - iii) Temperature rise.

1.8 DIESEL STANDBY GENERATOR

(Bidder shall consider bulk storage capacity for 1 day (24hrs) operation. DG set with acoustic enclosure, shall be the part of indoor substation)

A. Applicable Standards

The Diesel Standby Generator and its components shall conform to the latest applicable

Diesel Engines for General Purposes	: BS 5514 / ISO 3046
The Electrical Performance of Rotating Electrical Machinery	: BS 5000
Rotating Electrical Machines	: IS 4722
Circuit breakers BSEN-60942 (P-2)	: IS-13118, BS-5311, IEC-56 & 694,
Air break switches air break disconnectors, air break switch disconnectors and fuse combination units for voltage not exceeding 1000 V AC or 1200 V DC	: IS-13947 (P-3), BS-EN60947, IEC- 60947-3
Current transformer	: IS-2705/BS-7626, IEC-60185
Voltage transformer	: IS-3156/BS-7625/IEC 60186
Electrical Relays	: IS-3231,3842/BS-142/IEC-60255
Contactors for voltage not exceeding 1000 V ac or 1200 VDC	: IS-13947 Part-IV/ BSEN-60947-4- 1/ IEC-60947-4-1
Control Switches IEC-60947-4-1	: IS-6875/BSEN-60947 /
High Voltage Fuse	IS-9385/BS-2692/ IEC-60282
Low Voltage Fuse	: IS-13703/BS-1362 IEC-269-1
Electrical direct acting indicating Instruments	: IS-1248/BS-89/IEC-60051
A.C. electricity metres of induction type voltage greater than 1000 volts	: IS722, 8530/BS-5685 / IEC-60145, 60211
Resistance wire, tapes and stripes for heating elements	: IS-3725
Wrought aluminium and aluminium alloy bars, rods, tubes and sections for electrical purposes	: IS-5082

Specification for copper rods and bars for electrical purposes	: IS-613
Toggle switches	: IS-3452/BS-3676
Control switches/push buttons	: IS-6875/BSEN 60947
Noise and Emission Limit of Environment and Forests	: As per latest notification of ministry

B. General Requirements

(100% working load of the plant should be considered for DG set sizing)

- a) The diesel engine shall draw cooling air directly from outside the room through a weatherproof, acoustically treated duct. The exhaust system shall be insulated to minimize the amount of heat entering the room and to prevent injury to personnel. The exhaust system pipe shall be 2 Meters above the nearest building as per CPCB/ MoEF norms. The exhaust pipe line diameter shall be suitably designed to avoid back pressure when discharged at higher elevation. The silencer shall be of the „residential“ type and be located externally.
- b) The generation voltage shall be 415V for D.G capacity less than 2 MVA and generation voltage shall be 22/11kV for D.G capacity more than 2 MVA. Even if one D.G set is required for achieving the required capacity they shall be operated in parallel with necessary synchronizing arrangement with LCD.
- c) At no point D.G sets will be operating parallel with grid. The diesel engine fuel shall be stored in an above ground bulk storage steel tank to be located adjacent to the generator room at a site accessible for filling to local road tankers.
- d) The storage tank shall be sized to store fuel for 1 day running of the engine at full load. The tank shall be provided with fittings to permit the visual observation of fuel level and filling by local tanker operators. A level sensor shall also be mounted in the tank so that remaining fuel volume can be monitored at the generator / substation PLC and the operator stations in the SCADA room.
- e) The storage capacity shall be considered for 1 full day operation, all the Regulatory permission/ approval are mandatory for bidder before commissioning of plant.

- f) The fuel storage tank shall be located in a bund capable of holding not less than 125% of the maximum storage tank contents. Fuel transfer pumps shall be provided to automatically transfer fuel from the bulk storage tank to a high level 990 litres day tank located in the generator room or generator skid mounted day fuel tank. The fire proof gland packing shall be used for fuel transfer pumps. A semi- rotary hand pump shall be provided to permit transfer of fuel in the event of a failure of the transfer pump.
- g) Any leakage from the pumps shall be routed to the bund. A system shall be provided within the generator room to detect fire, to raise a local audible alarm (manually silenced locally) and if a high level day tank is used, to automatically dump the day fuel back to the bulk storage tank.
- h) The Fuel system shall be constructed such that leakage of water, fuel or oil within the generator room shall be routed to a local sump where a detector shall be provided to raise an alarm. Adequate sensors shall be provided to detect the fault and shall be wired to control panel.
- i) The system shall be constructed such that the leakage of fuel or the accumulation of water within the fuel storage bund shall be detected and shall raise an alarm.
- j) All alarms shall be conveyed to the central HMI through the PLC.

C. Diesel Generating Set Automatic Control

- a) AMF Diesel Generator Set capable of automatic starting and picking the load within 30 seconds shall be provided to cater for emergency loads and lighting during mains power failure.
- b) Diesel generating set for use in auto mains failure mode shall have a three position automatic /off /manual selection and shall operate as follows:

(i) Automatic mode:

On occurrence of mains failure the following sequence shall be followed.

- a) Mains to Generator changeover
 - mains failure detected
 - delay of 10 seconds
 - generator is started and run up to speed
 - time delay of 50 seconds
 - mains supply is switched off

- generator supply is switched on

b) Generator to Mains changeover

- mains healthy detected
- manual changeover signal received,
- generator supply is switched off
- mains supply is switched on
- generator runs for 2 minutes and stops

All timer settings shall be adjustable.

- c) If mains power is restored during the initial one minute delay then the power shall be monitored for a further one minute and if it is still healthy, mains power shall be restored. The generator shall be stopped after a further 2 minutes of running on no load. If the generator fails to start after an initial period of cranking, two further attempts shall be made with an appropriate interval between each attempt. If the engine fails to start after their attempts the system shall shut down and a local and remote alarm shall be annunciated.

(ii) Manual mode:

- d) The generator shall run to the dictates of manual controls on the generator. No automatic changeover of mains to generator supply or vice versa shall take place. The generator shall be loaded by manual switching if required.

D. Diesel Engine for Generating Set

- a) Engine shall be four-stroke, direct injection, and turbocharged industrial machines. They shall be fitted with renewable wet cylinder liners if water cooled and shall be direct coupled to the alternator and mounted on a common rigid steel bedplate.
- b) Engines shall be rated for continuous duty at site ambient conditions with an inherent O/ L Capacity of 10% for 1 hour in any 12 hours.
- c) The engine shall be capable of running at full load for not less than 180 hours without maintenance adjustments and 10,000 hours between major overhauls. The maximum operating speed shall be 1 500 rpm. The range of manual adjustment shall not be less than $\pm 5\%$ of rated speed. The performance of engine governors under load conditions shall be to Class A2 in accordance with BS 5514: Part 4.

- d) Engine governors shall be suitable for remote control load sharing between identical engine units. In addition to any electrical over speed trips, there shall be a mechanical over speed device which shall operate at 120% of the rated speed. Re-setting of the over speed trip shall be possible by hand only.
- e) The steady state output speed drop between no load and full load shall not exceed 5%. The transient output speed deviation shall not exceed 10% for a step of 60%. Engines shall be designed to run on fuel oil complying with IS 1460 or BS 2869, Class A2.
- f) Engines shall be cooled by means of a water jacket, heavy duty air blast radiator with integral radiator header tank, circulating pump and engine driven pusher type fan. The fan shall draw air in from the vicinity of the engine block and discharge it through the radiator core. The radiator shall be mounted on the same bedplate as the engine and alternator on suitable vibration isolators and be arranged so that it is located directly behind automatic louvers set into the external wall of the engine room. A thermostatically operated by-pass valve shall be fitted in the cooling system to maintain an optimum operating temperature during starting and running conditions. Drain cocks shall be provided so that all the water can be drained from the system. A separate oil cooler shall be used for cooling the engine oil. A thermostatic by-pass valve shall be incorporated.
- g) Engine lubrication shall be by a closed circuit wet sump, forced feed system supplied by an engine driven pump fitted with pressure regulating and relief valves, sump suction filter and changeover renewable micro-felt full flow line filters. A hand operated semi- rotary oil pump shall be installed to carry out initial priming or to fill or empty the sump as required. The sump shall be fitted with an easily accessible drain point. The oil shall be of the grade recommended by the engine manufacturer.
- h) The starting system shall comprise 12 or 24 V heavy duty lead acid batteries (positioned on a floor mounted stand adjacent to the engine) connected by heavy duty flexible butyl rubber cables. Batteries shall be sized to give six consecutive starts of the engine. An engine driven alternator and charging system shall be provided. An automatic mains energized battery charger shall be provided, with sufficient capacity to maintain the battery in a condition to full fill the starting requirements.
- i) Barring (hand turning) equipment shall be provided so that the engine can be manually rotated for maintenance purposes. It shall be arranged so that normal starting of the engine is inhibited whilst the hand turning equipment is connected.

- j) Twin heavy duty air intake filters in accordance with IS 3169 or BS 7226 suitable for operating in dust laden atmospheres shall be fitted. The filters shall be of the paper element with pre-cleaner type. Turbo charger filters shall be fitted. Breathers shall be fitted with washable filters which are easily accessible for maintenance.
- k) Instrumentation shall be provided to monitor speed, oil pressure, oil temperature (sets larger than 250 kVA), and water temperature and battery charge current. The bedplate shall be of heavy gauge steel construction, stress relieved and free from distortion. Engine shall be provided with sensors for engine protection and shall be wired to control panel.
- l) Machined surfaces shall be incorporated for mountings and for levelling. Anti-vibration mountings shall be fitted between the bedplate and the floor to prevent vibrations being transmitted to the building. The mountings shall be adjustable for levelling purpose and shall be designed to resist horizontal movement of the diesel set.
- m) The fuel System shall comprise an engine driven feed pump with duplex filters, 990 litres day tank with supporting structure or generator skid mounted day fuel tank, with all inter connecting pipe work , flexible engine connection pipe etc.

E. Diesel Generator Control Panel:

- a) The control panel shall have provision such that inter-opera ability with instrumentation control system. The control panel with communication facility shall be separately mounted on anti-vibration mountings and shall comprise the following:

- (i) Breaker incorporating short circuit and overload trip
- (ii) Earth fault protection for the Alternator
- (iii) Alternator Over & Under Voltage Protection
- (iv) Voltage Controlled Over Current Relay
- (v) Voltmeter with built in selector switch /(digital)
 - ammeter with built in selector switch / (digital)
 - frequency meter
 - Power Factor Meter
 - KWH Meter (Multifunction meter)
 - engine temperature and oil pressure gauge
 - service hours run indicator
 - key switch start and stop control

- operational status indicator
 - anti-condensation heater and thermostat
 - alternator anti-condensation heater controls
 - mains fed battery charger
 - Auto start on mains power supply failure facility
 - Fails to Start (Alarm)
 - Over / Under Voltage (Alarm)
 - Battery Charger Fault (Alarm)
 - Low fuel Oil Level (Alarm)
 - Over Load (Alarm)
 - Low Lube Oil Pressure (Trip)
 - High Water Temperature(Trip)
 - High Lube Oil Temperature (Trip)
 - Electrical Protection Relays (Trip).
- b) A reset button shall be provided to cancel the alarm /shut-down condition prior to re-starting.
- c) Simple operating instructions shall be detailed on the fascia of the control panel. All alarm and trip status signals from diesel supply system, engine control panel and alternator protection shall be hard wired to a marshalling box for instrumentation control system.

F. Synchronising Panel

Whenever two or more sets are required to operate together, necessary synchronizing panel complete with circuit breaker, synchroscope, numeric relays, digital meters etc shall be provided. The Panel shall be floor standing, CRCA Sheet steel enclosed.

G. Acoustic Enclosure

- (i) The DG Set shall be provided with acoustic enclosure, fully integrated, weather proof with superior finish for long and durable life.
- (ii) The acoustic enclosure shall be CRCA sheet steel enclosed with necessary panels and doors, inside lining of fire retardant foam/glass wool as acoustic material.
- (iii) The sound level shall be restricted to 75dB at a distance of 1 meter, under full load, free field conditions as per relevant standards.
- (iv) The acoustic enclosure shall be certified to meet the emission norms.

H. Bulk Fuel Storage Tanks

- (i) Bulk fuel storage shall be in accordance with the explosives norms and necessary approval shall be obtained by the contractor.
- (ii) Tanks and fittings, etc shall conform to IS 803 or BS 799: Part 5The tank shall be constructed in mild steel and the fittings in materials other than:
 - (iii) Yellow brass, including low grade alloys of copper and zinc.
 - (iv) Lead and zinc.
 - (v) Galvanized metals.
 - (vi) Natural rubber.
- (vii) The maximum fuel surface level below the point of entry of the vent shall not be less than 100 mm. The internal surface shall be cleaned and treated with temporary preservative, soluble in fuel oil, before shipment.
- (viii) The following fittings shall be included:
 - (a) 600 mm diameter manhole complete with portable cover situated in the top of the tank complete with ladder to the interior.
 - (b) Dipstick, calibrated in litres with guide tube and striker plate.
 - (c) Local indication of fuel level to be given at a position where it can be easily read during fuel delivery.
 - (d) Filling pipe work and fittings complete with isolation valve and captive end cap. The filling point to be at the top of tank to prevent siphoning.
 - (e) Outlet pipe situated at the raised end of the tank not less than 150 mm above tank bottom, complete with check valve, isolating valve and end cap.
 - (f) Drain pipe situated at lowest point in tank complete with isolating valve and captive end cap.
 - (g) Inlet fittings for overflow pipe from daily service tank or tanks (where specified).
 - (h) Vent pipe situated at high level in the tank. The pipe shall rise continuously from the tank and terminate with an inverted 'U' bend and vermin screen.
 - (i) External ladder for horizontal tanks more than 2 m diameter.
 - (j) Level sensors shall be included which are connected to Low fuel oil level.

I. Drawings

All Drawings, data, technical particulars, temperature rise calculations, detailed literature, catalogues, type test certificates etc. shall be submitted along with the bid/ after award of contract.

1.9 UPS SYSTEM

- a) UPS shall be supplied as per Instrumentation specification. UPS shall be three phase incoming supply with breaker.
- b) All UPS shall have IGBT technology for rectifier and inverter.
- c) The system shall be complete with all mounting stands, insulators, interconnecting accessories etc all as per enclosed specifications and data sheets.

1.10 BATTERY, BATTERY CHARGER & DCDB

- a) Battery, Battery Charger shall be three phase incoming supply with breaker. DC equipment shall comply with IEC 60896 including those standards referred to therein.
- b) General Requirements

Following items shall be covered in the Contract:

- (i) 110 V Valve Regulated Lead Acid Battery (VRLA)
 - (ii) Float-cum-boost charger for 110 V batteries
 - (iii) DC distribution board.
 - (iv) Min. 30 minutes backup for batteries
- c) All connections between battery, battery chargers and DC distribution board shall be designed for effective segregation between positive and negative leads
 - d) The system shall be complete with all mounting stands, insulators, interconnecting accessories etc all as per enclosed specifications and data sheets.

A. VRLA SMF Battery

Scope of the Tender

The scope covers disconnection and remove existing battery (200Ah) from the UPS room at RRCAT Indus-2 building and supply, install & commissioning of VRLA SMF Battery (200Ah) as per specifications given here below:

Tender submission requirement

The following shall be furnished as per IS 15549:2005

- a. Capacity of the battery at C10 rate.
- b. Manufacturer's name.
- c. Method of connections between cells, whether bolted or burnt.
- d. Type and material of the container.
- e. Material of the separator.
- f. Overall dimensions and weight of each complete cell.
- g. Space and floor loading in standard configuration.
- h. Specific order, if any in which the cells are to be arranged.
- i. Procedure for monitoring the health of battery during maintenance and preventive measures required.
- j. Measures required to be taken at the site of installation. Showing the state of discharge and procedure for Recoument thereof.
- l. The VRLA SMF battery should be warranted for minimum 24 Months from the date of installation. A warranty certificate from manufacturer should be submitted along with offer

Type test of battery

The contractor shall submit the type test certificates as specified in IEC 896-2 attested by external certification agency for an identical series of equal or higher rating battery sets with their tenders, without which the offers are likely to be ignored. Accelerated life test reports attested by external certification agency for 20 years life shall be submitted along with the tender for similar type of design, without which the offers are likely to be ignored.

Capacity requirements and operating data

The bidder shall submit full technical data of the battery offered under the tender and shall provide calculation to show the number of cells required and their capabilities which shall match the load requirement and the charging characteristics of the existing UPS as given in the technical specification as given below:

Battery should be compatible with existing UPS to which these batteries shall be connected:

- Type of charging: constant potential current limited to 20% of the rated capacity (0.2Amp)
- Float Voltage: 2.25 ± 0.01 VPC at 27 °C
- Boost Voltage: 2.30 ± 0.01 VPC at 27 °C

- AC ripple: Ripple content shall not exceed 3% RMS
- However, the tenderer shall specify the recommended voltage per cell for float charging and recharging.
- Operating temperature range shall be between 0 °C to 55 °C
- The battery shall be capable of giving 1200 cycles at 80% DOD and 4000 cycles at 20% DOD at an average temperature of 27 °C. Depth of discharge is defined as the ratio of the quantity of electricity in ampere-hour removed from a cell or battery on discharge to its rated capacity. The battery sets shall have a minimum design life of 20 years at float operation at 27 °C.

Stacking arrangement

All batteries shall be mounted in a suitable metallic trays / frame. Cells shall be housed in a ventilated & protected modular steel tray to promote airflow between the cells for effective thermal management. The partitions shall have grooves to facilitate airflow. The steel tray shall have partitions for each of the cell to maintain consistent compression & single cell replacement. The steel trays shall be powder coated for acid resistance. The Cell orientation in the steel trays shall be horizontal (i.e. the positive & negative plates should be parallel to ground) for consistent battery performance of the cell.

Standards and approvals

Manufacturer's catalogue and certificates should confirm to the following

Standards

- a. The battery sets to be supplied shall meet the requirement of IEC 60896-2:1995 and shall be suitable for continuous operation. The batteries shall be suitable for float / quick charging.
- b. Should meet IEEE 1188 Standards.

Approvals

- a. The battery must be ISO 9001:1994 approved and IEC 60896-2 (or equivalent) approved.

Packing & Transport

Equipments shall be packed and protected so as not to suffer deterioration, damage or breakage during shipment, trans shipment and storage in a tropical climate. All lifting points shall be clearly marked. Each package shall be properly labeled to

indicate the type and quantity of material it contains along with the Purchase Order number, dimensions and weights and any other necessary data to identify the equipment and relate it to the contract. The supplier shall not ship the equipment without prior approval of the Purchaser's representative and subsequent written instructions to do so.

Guarantee

The guarantee shall be for a period of 24 months after the acceptance test at site.

Specification of battery

Constructional Requirement

The design of battery shall be as per field proven practices. Partial plating of cells is not Permitted. Protective transparent front covers with each module shall be provided to prevent accidentally contact with live module / electrical connections.

Container

The container shall have chemical and electro-chemical compatibility and shall be acid resistant. The material shall meet all the requirements of VRLA SMF batteries and be consistent with the life of the battery. The container shall be made with fire retardant material. The porosity of the container shall be such as not to allow any gases to escape except from the regulation valve. The tensile strength of the material of the container shall be such as to handle the internal cell pressure of the cells in the worst working conditions. The container shall be capable of withstanding the rigours of transport, storage and handling. The containers shall be enclosed in a steel tray.

Cell covers

The cell covers shall be made of suitable material compatible with the container material and permanently fixed with the container. It shall be fire retardant. Fixing of Pressure Regulated Valve terminal posts in the cover shall be such that the seepage of electrolyte gas escapes and entry of electro static spark are prevented.

Plates

Positive grid shall be of pure lead calcium tin alloys for low corrosion, low self-discharge rates & maintenance free characteristics. Positive plate shall not contain cadmium. The positive & negative plates should be flat pasted. The material used shall be easy to recycle and should not pose environmental hazard. Both positive & negative plates shall be tanked formed to ensure that plates are fully formed.

Grid Growth Provision

This Provision should be made in the cell design to prevent failure due to internal shorting / rupture of cell because of grid growth.

Separators

The separators used in manufacturing of battery cells shall be absorbent glass mat or synthetic material having high acid absorption capability, resistant to Sulphuric acid and good insulating properties. The design of separators shall ensure that there is no misalignment during normal operation and handling.

Pressure Regulating Valve

Each cell shall be provided with a pressure-regulating valve. The valves shall be self-re-sealable and flame retardant. The valve unit shall be such that it cannot be opened without a proper tool. The valve shall be capable to withstand the internal cell pressure specified by the manufacturer.

Terminal posts

Both the positive and the negative terminals of the cells shall be capable of proper termination and shall ensure its consistency with the life of the battery. The surface of the terminal post extending above the cell cover including bolthole shall be coated with an acid resistant and corrosion retarding material. Terminal posts of any other metal part, which is in contact with the electrolyte, shall be made of same alloy as that of the plates or of a proven material that does not have any harmful effects on cell performance. Both positive and negative posts shall be clearly and unambiguously identifiable.

Connectors, Nuts, Bolts, Heat Shrinkable Sleeves

Where it is not possible to bolt the cell terminals directly to assemble a battery, separate non-corroding lead or copper connectors of suitable size shall be provided to enable connection of the cells. Copper connections shall be suitable lead coated to withstand corrosion due to Sulphuric acid at a very high rate of charge or discharge. Nuts and bolts for connecting the cells shall be made of copper, brass or stainless steel. Copper or brass nuts and bolts shall be effectively lead coated to withstand lead coating. All inter cell connectors shall be protected with heat shrinkable silicon sleeves for reducing environmental impact including a corrosive environment.

Flame Arrestors

Each cell shall be equipped with a Flame Arrestor to defuse the Hydrogen gas escaped during charge and discharge. Material of the flame arrestor shall not affect the performance of the cell.

Battery Bank Stand and cell orientation

All batteries shall be mounted in a suitable metallic trays / frame. Cells shall be housed in a ventilated & protected modular steel tray to promote airflow between the cells for effective thermal management. The partitions shall have grooves to facilitate airflow. The steel tray shall have partitions for each of the cell to maintain consistent compression & single cell replacement. The steel trays shall be powder coated for acid resistance. The Cell orientation in the steel trays shall be horizontal (i.e. the positive & negative plates should be parallel to ground) for consistent battery performance of the cell.

Rating & designation

Rating

The rating assigned to the cell or battery shall be the capacity expressed in ampere hours (Ah) (After correction to 27°C) stated by the manufacturer to be obtainable when the cell or battery is discharged at the 10-hour rate to an end voltage of 1.75 V. This rating is known as 10-hour rating of the cell or battery and shall be designated as C 10.

Designation of Cells

Cells shall be suitably designated in order to identify the type, capacity and rating, etc.

Marking on cell

The following information shall be durably marked on the outside of the cell or battery or battery module.

1. Manufacturers' name
2. Cell designation
3. Cell Ah capacity
4. Month and year of manufacture
5. Date on which charge given before dispatch

6. Next due date for freshening charge

Table-1: Technical Specifications

S.N.	Particulars	Specifications	Vendors Confirmation
1	Type	Valve Regulated Lead-Acid (VRLA SMF)- Standard 2 V cells, suitable for 120 Minutes backup at full load with 40 KVA UPS.	
2	Nominal Capacity (Ah) @ C10 rating	200Ah	
3	Cell Containers	The containers shall be made of Polypropylene co-polymer of high Impact strength.	
4	Pressure Regulating Valve	Each cell shall be provided with a Self-resealing, pressure-regulating and explosion proof valve.	
5	Inter cell Connectors	All inter cell connectors shall be protected with heat shrinkable silicon sleeves for reducing environmental impact including a corrosive environment. The current rating of connectors should be suitable for 40KVA UPS System	
6	Battery Bank Stand and cell orientation	All batteries shall be mounted in a suitable metallic trays / frame. The steel trays shall be Ventilated for proper thermal management of battery and powder coated for acid resistance.	
7	Positive Plate	Flat pasted type with Lead Calcium High Tin alloy grid	
8	Negative Plate	Flat pasted type with Lead Calcium alloy grid	

9	Separator	Low Resistance, High porosity and high absorbent type Glass Mat Separator.	
10	Electrolyte	High Quality Sulphuric acid to maximize shelf life	
11	Terminals	Lead Plated copper for high conductivity	
12	Expected Battery Life	The battery shall be capable of giving 1200 cycles at 80% DOD (depth of discharge) and 4000 cycles at 20% DOD at an average temperature of 27 deg. C. The battery sets shall have a minimum design life of 20 years at float operation at 27 deg. C.	
13	Typed test of battery	The Bidder shall submit the typed test certificates as specified in IEC 60896-2 attested by external certification agency for an identical series of equal or higher rating battery sets with their tenders, without which the offers are likely to be rejected.	
14	Accelerated Life test	Accelerated life test reports attested by external certification agency for 20 years Design life shall be submitted along with the tender for similar type of design, without which the offers are likely to be rejected.	
15	Operating Temperature Range	0 to 50 degree Centigrade	

Pre-dispatch Inspection and Testing

Type tests

Type test shall be done as per IS 15549:2005 and the following shall constitute type test:

1. Visual examination

2. Checking dimension as per manufacturer's drawing
3. Test for C 10 capacity and voltage during discharge
4. Test for C I capacity and voltage during discharge
5. Ampere hour and watt hour efficiency test
6. Test for retention of charge
7. Acid retention capability test on separators
8. Wicking test on separators
9. Test on vent seal operation
10. Test for oxygen recombination efficiency
11. Endurance life cycle test.

Electrical test

Charging test

- The battery charging should be possible with float charge from the UPS. All the cells in a battery shall be designed for continuous float operation at the specified float voltage throughout the life. Float voltage of each cell in the string shall be within the average float voltage / cell +/- 0.05 V band.
- The battery shall be capable of reaching 90% state of charge (SOC) from fully exhausted condition i.e. 1.75 V / cell within 10 hours.

10 hour discharge test

The battery should be capable to deliver at least the rated capacity at shipment, so that full performance can be obtained from first load cycle itself. When the battery is discharged at 10 hours rate, it shall deliver 80% of rated capacity corrected at 27 °C before any of the cells in the battery reaches 1.85 V / Cell. The capacity corrected at 27 °C shall also not be less than Capacity and not more than 120% of Capacity before any cell in the battery reaches 1.75 V/ cell. The battery voltage shall not be less than the following values, when a fully charged battery is put to discharge at C/10 rate as per IS 15549:2005

- After six minutes of discharge 1.98 V/ cell.
- After six hours of discharge 1.92 V / cell.

- After 8 hours of discharge 1.85 V/ cell.
- After 10 hours of discharge 1.75 V/ cell.
- **Extended type test on a cell during guaranty period:**
 Loss in capacity during storage at an average ambient temperature of 35 deg. C for a period of 6 months shall not be more than 60% and the cell / battery shall achieve 85% of its rated capacity within 3 charge / discharge cycles and full rated capacity within 6 cycles after storage period of 6 months. Voltage of each cell in the battery set shall be within 0.05 V of the better than 90% and watt hour efficiency shall be better than 80%.

Installation

The supplier shall install the batteries in racks and interconnect them suitably.

B. Battery Charger and D.C. Distribution Board

Applicable Standards

The battery charger and D.C. Distribution board shall conform to the latest applicable standards specified below. In case of conflict between the standards and this Specification, this Specification shall govern.

Basic climatic and mechanical durability tests for components for electronic and electrical equipment	:	IS: 9000
Environmental tests for electronic and electrical equipments	:	IS: 9000
Metal clad base material for printed circuits for use in electronic and telecommunication equipment	:	IS: 5921
Transformers and inductors (power audio, pulse and switching) for electronic equipment	:	IS: 6297
Printed wiring boards	:	IS: 7405
Environmental requirements for semi-conductor devices and integrated circuits	:	IS: 6553
Terminals for electronic equipment	:	IS: 4007

Factory built assemblies of switchgear and control gear for voltages upto and including 1000 V AC and 1200 V DC	:	IS:8623/BS:5486 / IEC:60439
Air break switches	:	IS: 13947(Part-3) BSEN 60947-3
Miniature circuit breakers	:	IS 8828/BSEN: 60898
HRC cartridge fuses	:	IS: 9224/BS: 88
Contactors	:	IS: 13947 (Part - 3) /BS: 775/ IEC: 60158-1
Control switches/push buttons	:	IS: 6875
Indicating instruments	:	IS: 1248/BC: 89/ EC:51
Degree of Protection	:	IS: 13947-(Part 1) /IEC: 60947-1
Climate-proofing of electrical equipment	:	BSCP: 1014
Code of practice for phosphating iron and steel	:	IS: 6005/BS: 3189
Semi-conductor converters	:	IEC: 60146
Semi-conductor rectifier equipment safety code	:	IS: 6619
Specification for copper rods and bars for Electrical purposes	:	IS: 613

Battery Charger

- a) Battery charger shall be combined float-cum-boost type.
- b) The charger shall be static type composed of silicon controlled rectifiers (SCRs) and diodes connected in three phase full wave half controlled bridge circuit.
- c) The rectifier transformers for float and boost chargers shall be indoor dry type, double wound with delta-star connections. The BIDDER shall ascertain if taps are required and provide adequate number of primary and secondary taps, if necessary.
- d) The float charger shall be designed for supplying :
 - (i) The D.C. loads specified under Sr. No. 8.19.2 of Vol II, Part-8 i.e. continuous load and short-time overload.
 - (ii) The trickle charging current of the battery.
- e) The boost charger shall be designed for supplying the boost charging current of the battery.

- f) If the battery and charger are to be supplied by separate contractors, the charger Contractor shall coordinate with the battery contractor regarding float /trickle boost charging current & voltages required for the battery.
- g) Battery Charger shall be provided with facility for both automatic and manual control of output voltage and current and necessary selector switch shall be provided. Contractor regarding the float/trickle and boost charging current and voltages required by the battery,
- h) Performance
- i) Float Charger

The D.C. output voltage during float charging shall be stabilised within

- (i) 1% of the set DC bus voltage. Manual control shall be used if auto mode fails.
- (ii) Boost Charger

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. After a specified number of hours (adjustable) when the rated cell voltage is reached, the charger shall be returned to float charge status.

- In case of combined float-cum-boost charger, the switching and control of high rate charge and return to float charge shall be by automatic controller/regulator.
- Manual control shall be used if auto-mode fails.
- During boost charging following emergency measures shall be provided:
- If the AC mains supply fails, an arrangement shall be made to automatically connect the battery directly across the load.
- If the separate or spare float charger supplying D.C. load fails, the load shall be fed from the point of connection at the tapping of the battery via adequately rated blocking diodes.
- j) Suitable filter Circuits shall be provided in the chargers to limit the ripple content (peak to peak) in the output voltage to 1% irrespective of D.C Loads.
- k) The D.C System shall be unearthed.

Charger Panel and D.C. Distribution Board

- a) Battery charger panel and D.C. distribution board shall be sheet metal enclosure freestanding type with cable entry from bottom
- b) Indications, controls and output voltage setting adjustments shall be on front panel. The Contractor shall submit a scheme for alarm and trip indication lamps on the cabinet and for fault annunciation contacts paralleled for remote annunciation.
- c) The components shall be liberally rated and housed in a well ventilated sheet metal cubicle complete with input and output terminals. Louvers shall be provided for ventilation backed up by fine wire mesh so that the degree of protection shall be equal to or better than IP-42.
- d) Busbars shall be of copper conductor of hard drawn (HD) and high conductivity. Busbars shall be fully insulated by encapsulation in epoxy resin with moulded caps protecting all joints.
- e) All printed circuit cards shall be plug-in type, interlocked to prevent insertion in a wrong slot. Each card shall have LED indication on its front plate to indicate normal condition and readily and marked test pins.
- f) All components shall be accessible to the maintenance technician for easy disassembly and replacement. Access to parts of equipment shall be with minimum danger from all hazards.
- g) All components and modules shall be clearly and unambiguously marked and all wiring colour-coded and tagged.
- h) All power and control wiring within the cubicle shall be done with stranded copper wires. The power wiring shall be adequately sized for the required rating. The minimum sizes for control wiring will be 1.5 mm² and for power wiring shall be 2.5 mm².
- i) Ground terminals with isolating links shall be provided.
- j) Cable glands shall be provided to suit the incoming and outgoing cables.

Components/Accessories

- a) The main items are listed below. However, additional items required for completeness or to meet the specified performance or operational requirements of the charger, shall be deemed to be included in the Contractor's scope. Instead of incoming ON/OFF switches, sticker fuses and contactors, the Contractor may provide suitably rated 3 pole MCBs with overload and short circuit protection and auxiliary contacts.

- (i) One (1) set - Three phase full wave full controlled bridge rectifier circuit comprising silicon controlled rectifiers and silicon diodes complete with resistor/ capacitor network for surge protection. The diodes/SCRs shall be individually protected by fuses with fuse fail indication.
- (ii) One (1) Double wound, dry type, three phase suitably rated mains transformer.
- (iii) One (1) set of suitably rated control transformers for electronic controller.
- (iv) One (1) Electronic controller comprising of power supply card, soft start cum current limit card, auto trickle mode card with facility for setting trickle charge current and monitoring battery current, error amplifier cards and pulse generating cards for achieving the DC output voltage stabilisation of <1% and also for achieving current limiting feature. The electronic controller shall have protection features with indications for under-voltage, over-voltage, set output voltage and phase failure or voltage unbalance.
- (v) The electronic controller shall be provided with following features.
 - Boost current stabilisation of +2% with AC input variation of voltage and frequency variation of +10% and +5% respectively.
 - Boost charge current limiter with potentiometer to adjust the setting.
- (vi) Adequately sized necessary built-in accessories shall be provided such that on failure of the controller in auto mode the voltage can be effectively controlled manually
- (vii) One (1) Filter circuit comprising of smoothing choke and condensers complete with HRC fuse with trip indication for filter condenser circuit.
- (viii) One (1) Auto/Manual selector switch for selecting the mode of operation of the controller.
- (ix) One (1) front panel mounted potentiometer for set point adjustment of output voltage in auto mode.
- (x) One (1) front panel mounted potentiometer for manual adjustment of voltage in manual mode.
- (xi) One (1) TP AC ON/OFF switch for float charger incoming.
- (xii) One (1) set of HRC fuses complete with fuse fittings for AC input with suitable ratings and with trip indication.

- (xiii) One (1) set of the pilot lamps with series resistors to indicate float charger AC Mains,, ON“ condition.
- (xiv) One (1) AC contactor with suitably rated coil and three main and 2 NO + 2 NC auxiliary contacts, suitably rated thermal overload relay and ON/OFF control switch. (xiv) One (1) set of HRC fuses complete with fuse fittings for the DC output, and with trip indication.
- (xv) One (1) moving coil DC ammeter, with shunt, of size 96 x 96 mm and suitable range to read the float charger output current
- (xvi) One (1) Double pole DC ON/OFF rotary switch for float charger output.
- (xvii) One (1) pilot lamp with series resistor to indicate float charger DC „ON“ condition.
- (xviii) Annunciation System for the following
 - (a) AC Supply Failure.
 - (b) Rectifier Fuse Failure.
 - (c) Surge Circuit Fuse Failure.
 - (d) Filter Fuse Failure.
 - (e) Load Limiter Operated.
 - (f) Charger Trip.
 - (g) Battery on Float.
 - (h) Battery on Boost.

Power Electronic Components

- a) Diode and thyristors shall be of monocrystalline type silicon, capable of continuous output at specified voltages. It shall have high power efficiency.
- b) If many diode or thyristor assemblies are connected in parallel, care shall be taken to ensure that each rectifier or thyristor operates within its rating and shares the load uniformly. This may be achieved with the help of chokes. Also, care should be taken to select matched pairs of rectifier heat sink units.
- c) Each diode or thyristor built in a multi-built assembly shall be provided with a short circuit protection to avoid complete shut-down of the equipment because of a fault on single unit. Suitable fuses shall be provided for such protection.

- d) Necessary spare capacity shall be built in the equipment to continuously supply full load even with one unit out of circuit.
- e) The diodes or thyristor banks shall be natural air cooled.
- f) The diodes or thyristors shall be protected against overvoltage due to chopping surges with the aid of snubbers (i.e. resistor-capacitor combination and Metal oxide varister). It shall be ensured that normal load currents and especially fault currents are shared equally between parallel links, within the specified limits. To achieve this, great care shall be taken to design the layout of the rectifier links to ensure equal lengths of busbars and as near as possible identical contact resistance in each current path.

Drawings and Data

All Drawings, data, technical particulars, calculations, detailed literature, catalogues, test certificates etc shall be submitted along with the bid.

1.11 CABLING SYSTEM: HV, LV, CONTROL AND TELECOMMUNICATIONS

A. Applicable Standards

The cables shall conform to the latest applicable standards specified below.

PVC insulated cables (For voltage upto 1100 V)	:	IS: 694
HRPVC & PVC insulated cables heavy duty	:	IS: 1554
Cross linked polyethylene (XLPE) insulated PVC sheathed cables	:	IS: 7098
Low frequency cables and wires with PVC insulation and sheath	:	IEC: 60189-1 & IEC-60189-2
PVC insulation and sheath of electric cables	:	IS: 5831
Polyethylene insulation and sheath for electric cables	:	IS: 6474
Conductors for insulated electric cables	:	IS: 8130
Methods of test for cables	:	IS: 10810

Specification for drums of electric cables	: IS: 10418
Specification for PVC insulated cables for electricity supply	: BS: 6346
Specification for PVC insulation and sheath of electric cables	: BS: 6746

B. Features of Construction

a) XLPE Insulated HV Power Cables :

The Cables shall be 11 KV/ 11 KV (Un earthed) grade, heavy duty, stranded aluminium Conductor, XLPE Insulated, Conductor Screening by extruded Semiconducting Compound, insulation screening through Combination of semi conducting compound and non magnetic tape(Copper tape), inner sheath over laid up cores, galvanised steel wire /strip armoured (Aluminium wire armouring for single core cables), outer sheath of extruded black PVC Compound type ST-2. Core Identification shall be by printed numerals.

b) LT Power Cables

(i) PVC Insulated Cables:

The Cables shall be 1.1 KV Grade, heavy duty, Stranded Aluminium/ Copper Conductor, PVC Compound type A insulated, inner sheathed, galvanised steel wire /strip armoured, black PVC compound type ST1 outer sheathed.

(ii) XLPE Insulated Cables:

The Cable shall be 1.1 KV Grade, heavy duty, stranded aluminium/ Copper Conductor, XLPE insulated, inner sheathed, galvanised steel wire/ strip armoured ,extruded black PVC Compound type ST2 outer sheathed.

c) Control Cables:

The Cables shall be 1.1 KV grade, heavy duty, stranded copper conductor, PVC Compound type A Insulated, galvanised steel wire/ strip armoured extruded PVC type ST1 outer sheathed.

d) Telecommunication Cables:

The cables shall meet the following requirements:

- (i) Conductor : Solid, tinned, annealed copper
- (ii) Insulation : PVC insulation Type-A as per IS:5831
- (iii) Twisting : The insulated conductors shall be twisted together to form twisted pairs or quads, these shall be stranded in concentric layers to form the cable core. The cable thus formed shall be tightly lapped with outer wrapping tapes. The interstices of insulated cable core shall be completely filled with viscose compound
- (iv) Overall screening : With 0.075 mm Aluminium tape or 0.013 mm melinex tape, overlap not less than 30%
- (v) Other details : A suitable non-magnetic rip cord shall be laid longitudinally under the sheath. The armouring shall be of galvanised steel wires or galvanised single steel strip. The inner PVC sheath shall be of Type-A. The outer PVC sheath shall be of Type ST-1.

C. Cable Rating

- a) The Contractor shall ensure that cable and wires associated with the distribution and control systems, plant wiring and all other installations throughout the Works are adequately rated for their use.
- b) In assessing the rating of any cable or wire, the following factors shall be taken into account:
 - Supply voltage and frequency
 - Maximum voltage drop permissible
 - Type and magnitude of load
 - Fault level and duration related to circuit protection relays and fuses
 - Circuit over current protection
 - Route length and disposition of cables
 - Ambient temperature
 - Method of installation
- c) All power cables shall be sized for continuous current carrying capacity at the ambient temperature of 45 °C. The design current of any circuit shall exceed the full load current of the supplied device by at least 10%. Power cables shall be sized to limit the

maximum voltage drop to no more than 3 %.

- d) Under motor starting conditions the corresponding voltage drop shall not affect the operation of the motor controls or the ability of the motor to start and run effectively and in any event shall not exceed 10%. The Contractor when sizing cables for the remote operation of shunt trip coils shall take due account of the voltage drop caused by the momentary current surge taken at the instant of energisation. HV and LV cables shall be sized for a fault clearance time of 0.5 seconds for the incoming feeders and 0.16 seconds for switchboard feeders controlled by circuit breaker.

D. Cable Colours

All cable cores shall be colour coded throughout their length and shall be so connected between switchboard, distribution board, plant and accessories, that the correct sequence or phase colours are preserved throughout the system.

The colour coding should be as follows:

3 Phase	Red, Yellow And Blue
Single phase or DC	Red And Black
Earth	Green/Yellow
Control	Blue (DC), Red (AC)

E. Cable Conductors

Copper conductors shall be used for cables of sizes upto 6 Sq.mm. Aluminium conductors shall be used for cables of size 10 Sq. mm and above. Cores of cross-sectional area greater than 1.5 mm² shall be stranded. Lighting final distribution circuits shall be of a minimum cross-section of 1.5 mm². Power cables shall be of a minimum cross-section of 2.5 mm². Internal wiring of control panels shall be of a minimum cross-section of 1.0 mm² flexible and stranded. Control cables shall be of a minimum cross-section 1.5 mm² for external use and 1.0 mm² for internal use.

F. Cable Numbering

All cables shall be allocated a unique number which shall be fixed to each end of the cable using a corrosion resistant label. Cables of different categories shall be tagged with the following subscripts and three digit numbers.

HV power HV-P_ _ _

LV power	P_ _ _
Control	C_ _ _
Instrumentation	I_ _ _
Protection	PR_ _ _
Telecommunication	T_ _ _

G. Cable Drums

Cables shall be supplied in non-returnable wooden drums. The wood used for construction of the drum shall be properly seasoned and free from defects and wood preservative shall be applied to the entire drum. All ferrous parts shall be treated with a suitable rust preventive coating to avoid rusting during transit or storage.

The Bidder shall indicate in the offer, the maximum length for each size of cable, which can be supplied on one drum. The actual length supplied on each drum shall be within tolerance limit of < 5% without any tolerance on total ordered quantity of each size of cable. However before winding the cables on drums. Contractor shall obtain Employers approval for the drum lengths. Each drum or coil of cable shall be accompanied by a certificate stating the manufacturer's name, cable size, and number of cores, length, result and date of tests as required in the Employer's Requirements. Cables manufactured more than 12 months before delivery will not be accepted. All cables shall be delivered with cable ends effectively sealed by hygroscopic scaling caps. When a cable is cut from a drum both ends shall be immediately sealed to prevent ingress of moisture. Cables shall not be transported to site in loose coils but a number of short lengths of cable may be transported on the same drum. The Contractor shall be wholly responsible for the purchase and/or hire costs of all cable drums and for the removal of these drums from site after use.

H. Drawings and Data

All Drawings, data, technical particulars, calculations, detailed literature, catalogues, Test certificates etc. shall be submitted along with the bid.

1.12 CABLE CARRIER SYSTEM

A. General

The cable carrier system covers the supply of cable racks, cable trays and its supporting accessories.

B. Applicable Standards

Steel for general structural purposes	: IS: 2062
Dimensions for hot rolled steel beam	: IS: 808
Column channel and angle sections	
Code of practice for use of metal arc	: IS: 816
Welding for general construction in Mild steel	
Hot deep galvanising of iron & steel	: IS: 2629
Methods of testing uniformity of coating Of zinc coated articles	: IS: 2633
Hot dip zinc coatings on structural Steel and other allied products	: IS: 4759

C. Cable Racks and Trays

- (a) All cable trays, vertical raceways, cable racks and cable tray supporting structures shall be hot dip galvanised.
- (b) Cable trays shall either be run in concrete trenches or run overhead supported from building steel, floor slab, cable racks, cable cum pipe racks, etc.
- (c) Vertical trays/raceways and outdoor cable trays shall be covered by removable 16 gauge GS sheet covers.
- (d) The size of ladder/perforated cable trays to be supplied and installed shall be 150, 300, 450, 600 and 800 mm wide.
- (e) The mounting structures/cable racks shall be fabricated from standard structural steel members (channels, plates, angles and flats).
- (f) The cable racks and supports shall be painted after installation with one coat of red lead primer, one coat of oil primer followed by two finishing coats of aluminium paint

D. Galvanising

Wherever galvanising has been specified, the hot dip process shall be used. The galvanised coating shall be of uniform thickness. Weight of Zinc coatings for various applications shall not be less than those indicated below;

(a) Fabricated Steel

Thickness less than 2 mm, but not less than 1.2 mm 340 gms/sq.m

Thickness less than 5 mm, but not less than 2 mm 460 gms/sq.m

Thickness 5 mm and over 610 gms/sq.m

(b) Fasteners

Upto nominal size M10 270 gms/sq.m

Over M10 300 gms/sq.m

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

E. Cable Ducts and Trenches

Providing and laying RCC (M-150) cable duct of size given below for laying electric cable including form work for centering M.S. bar reinforcement, necessary excavation bolder filling, PCC (M100), compacting, curing , plastering, including providing and fixing 35 X 35 X 5 mm M.S. angles, RCC pre cast cover of Adequate length with 100 mm over lap on either walls etc. complete and providing RCC pre-cast covers.

Cable duct 2x3 tier-1000W X 1000D

1.13 LIGHTING SYSTEM

(Only LED fixtures shall be considered for indoor and outdoor application)

A. General Requirements

- a) LED lighting shall be considered for indoor and outdoor lighting
- b) The Lighting system includes the following items.
 - (i)Lighting fixtures complete with Lamps and accessories.
 - (ii)Lighting system equipment

- Light control switches, receptacle units with control switch units, lighting wires, conduits and other similar items necessary to complete lighting system.
 - Lighting fixture supports, street lighting poles and flood light towers.
 - Main Lighting distribution board, lighting panels.
 - Multi core cables for street, boundary and flood lighting.
- c) All Lighting Fixtures, luminaires shall be considered for Emergency Lighting and fed from Main Lighting Board supplied by both mains supply normally and DG Set during power failure.
- d) DC Emergency Lighting shall be provided for Control rooms of Switchyards SCADA room, Switchgear and Control room of Pump houses.

B. Applicable Standards

The design, manufacture and performance of equipment shall conform to the latest standards specified below.

Lighting Fixtures & Accessories Electrical lighting fittings general and Safety requirements	:	IS: 1913/ BS: 4533
Code of practice for industrial lighting	:	IS: 6665
Calculation of co-efficient of utilisation	:	IS: 3646 (Part - III)
Industrial lighting fittings with metal Reflectors	:	IS: 1777
Decorative lighting outfits	:	IS: 5077
Dust proof electric lighting fittings	:	IS: 4012
Dust tight electric lighting fittings	:	IS: 4013
Flood lights	:	IS: 10322/BS: 4533
Luminaires for street lighting	:	IS: 10322 Part 5
Water tight electric lighting fittings	:	IS: 3553/ BS: 4533, 5225(I)
Bayonet lamp holders	:	IS:1258/BSEN 61184IEC:60061
Edision screw lamp holders	:	IS: 10276/BSEN 60238
Bi-Pin lamp holders for tubular fluorescent lamps	:	IS: 3323
Starters for fluorescent lamp	:	IS: 2215/BSEN 60155

<p> Holders for starters for tubular fluorescent Lamps : : Ballast for use in fluorescent lighting fitting Transistorised ballast for fluorescent lamps : Ballast for HP mercury vapour lamp : : Capacitors for use in fluorescent, HPMV & LP sodium vapour discharge Circuits Vitreous enamel reflector for tungsten Filament : lamp : Tubular fluorescent lamps : High pressure mercury vapour lamps Tungsten filament general electric lamps : Cast acrylic sheets for use in Luminaires : Screwless terminal and electrical connections for : lighting fittings High pressure sodium vapour lamps : Emergency lighting units : Ignition proof enclosures, dust-tight for Elect. : Equipment Luminaires : </p>	<p> IS: 3324/ BSEN 60400 IS: 1534 (Part 1)/BSEN 60920& 60921 IS: 7027 IS: 6616 IS:1569/ BSEN 61048 & 61049 /IEC: 60586 IS: 8017 IS: 2418 (Part -1) /BSEN 60081 IEC: 60081 IS: 9900/BS: 3677/ IEC: 60188 IS: 418/IEC: 60432 IS: 7569 IS: 10322 IS: 9974 IS: 9583 IS: 11005 IS: 10322 (Part I to V) </p>
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Lighting System Equipment

<p> Arrangement for busbars, main connections and : auxiliary wiring and marking Enclosed distribution fuse boards and cutouts for : voltages not exceeding 1000V General requirements for switchgear and control : gear for voltages not exceeding 1000 V Code of practice - installation and maintenance of : switchgear </p>	<p> IS: 5578/ 11353/BS: 159 IS: 2675/ BSEN 60439 IS: 13947 IS: 10118/BS: 6423 BS 6626, BS 6867 </p>
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Factory built assemblies of switchgear and control gear for voltages upto and Including 1000 V AC and 1200 V DC	:	IS: 8623/BS-5486/ IEC: 60439
Miniature air break circuit breakers for AC circuits	:	IS: 8828/ BSEN 60898
HRC cartridge fuse links upto 650 V „D“ Type fuses	:	IS: 9224/BS: 88/ IEC: 60269
Current transformers	:	IS: 8187
Voltage transformers	:	IS: 2705/BS: 7626/ IEC: 60185
Direct acting electrical indicating Instruments	:	IS: 3156/BS: 7625/ IEC:60186
A.C. electricity meters	:	IS: 1248/BS: 89/ IEC: 60051
Electrical relays for power system protection	:	IS: 722/BS 5685
Switches for domestic and similar purposes	:	IS: 3231/BS: 142/ IEC: 60255
Three pin plugs and socket outlets	:	IS: 3854/BS: 3676
Boxes for enclosure of electrical accessories	:	IS: 1293/BS: 546
Rigid steel conduits for electrical wiring	:	IS: 5133(1)
Accessories for rigid steel conduits for electrical wiring	:	IS: 9537/BS: 31
Flexible steel conduits for electrical wiring	:	IS: 3837/BS-31
Rigid non-metallic conduits for electrical Installations	:	IS: 3480
Fittings for rigid non-metallic conduits	:	IS: 9537/BS: 4607(2)
PVC insulated cables for working voltages upto and including 1100 V Tubular steel poles	:	IS: 3419/BS: 4607(2)
Specification for copper rods and bars for electrical purposes	:	IS: 694
Code of practice for phosphating iron and steel	:	IS: 2713
Fittings for rigid steel conduits for Electrical wiring	:	IS: 613
	:	IS: 6005/ BS: 3189
	:	IS: 2667

C. Lighting Fixtures (Luminaries)

- a) Luminaries shall be designed for continuous trouble-free operation without reduction in lamp life or without deterioration of materials and internal wiring. Outdoor fittings shall be weather-proof and rain-proof type.
- b) Flame proof luminaries to be provided in DG Room , Diesel storage room & Battery charger room.
- c) The Luminaires shall be designed so as to facilitate easy maintenance, including cleaning, replacement of lamps/starters etc.
- d) Connections between different components shall be made in such a way that they will not work loose by small vibration.
- e) For each type of Luminaires the Contractor shall furnish the utilisation factor tables to indicate the proportion of the light emitted by the bare lamps which falls on the working plane.
- f) All Luminaires shall be supplied complete with lamps suitable for operation on a supply voltage with the variation in supply voltage, frequency and combined voltage and frequency of +10%, +5% and +10% respectively.
- g) The Luminaires and accessories shall be designed to have low temperature rise. The temperature rise above the ambient temperature shall be as indicated in the relevant Standards.
- h) Fluorescent type, metal halide type luminaires shall be complete with accessories like lamps, ballasts, power factor improvement capacitors, starters, re-wirable fuse and fuse base. These shall be mounted as far as possible in the luminaire housing only. If these cannot be accommodated integral with the Luminaires then a separate metal enclosed control gear box shall be included to accommodate the control accessories together with a terminal block suitable for loop-in, loop-out connections. Outdoor type fixtures shall be provided with outdoor type weather-proof box.
- i) Fluorescent type Luminaires with more than one lamp shall be provided with capacitors connected in lead-lag circuit for correction of stroboscopic effect.
- j) Each luminaire shall have a terminal block suitable for loop-in, loop-out and T-off connection by 250/400 V, 1 core, PVC insulated copper/aluminium conductor wires upto 4 sq.mm in size. In outdoor areas the termination at the luminaire shall be suitable for 1100 V, PVC insulated, copper/aluminium conductor, armoured cables of sizes upto 6 sq.mm conductor. Terminals shall be of stud or clamp type. The internal wiring should be completed by means of standard copper wire of minimum 1 sq.mm size and

terminated on the terminal block. Terminal blocks shall be mounted with minimum two fixing screws.

k) Mounting facility and conduit knock-outs for the luminaries shall be provided.

l) Earthing

(i) Each luminaire shall be provided with an earthing terminal suitable for connection to the earthing conductor of 12 SWG GI wire.

(ii) Where separate control gear box is provided for housing the accessories the same shall be provided with an earthing terminal suitable for connecting earthing conductor of 12 SWG GI wire.

(iii) All metal or metal enclosed parts of the luminaire/control gear box shall be bonded and connected to the earthing terminal so as to ensure satisfactory earthing continuity.

m) Painting/Finish

(i) All surfaces of the Luminaire/Control gear box housing accessories shall be thoroughly cleaned and degreased. It shall be free from scale, rust, sharp edges and burrs.

(ii) When enamel finish is specified, it shall have a minimum thickness of 2 mils for outside surface and 1.5 mils for inside surface. The finish shall be non-porous and free from blemishes, blisters and fading.

(iii) The luminaire housing shall be stove-enameled/epoxy stove-enamelled-vitreous enamelled or anodised as indicated under various types of fittings.

(iv) The surface shall be scratch resistant and shall show no sign of cracking or flaking when bent through 90 deg. over 1/2" dia. mandrel.

(v) The finish of the luminaire shall be such that no bright spots are produced either by direct light source or by reflection.

(vi) External control gear box provided for housing accessories shall be painted or galvanised.

D. LED Lighting

(i) High Power White LEDs used in the luminaries shall have wattage greater than ONE watt.

(ii) LED shall be operated at a forward current of less than 90% of the rated current.

(iii) Colour Rendering Index (CRI) of the LEDs used in the luminaire shall be greater than

70.

- (iv) The illumination of the luminaire shall be uniform without dark bands or abrupt variations and soothing to the eye.
- (v) Light Uniformity Ratio (E_{min} / E_{avg}) would be > 0.4 .
- (vi) Luminary Body Temperature would be less than 30 °C above the ambient, even after continuous burning of Luminary for 24 Hrs.
- (vii) The Luminaire works on single phase three wire system (Phase, Neutral & Earth).
- (viii) The luminaire housing is made up of Corrosion free High Pressure Aluminum die cast thus confirming the luminaire to IP-68 protection and safety as per IEC 60598-1.
- (ix) The Luminaire is equipped with distortion free, clear, Heat Resistant toughened, UV stabilized glass cover in the front fixed to the die cast Aluminum frame which would be fixed to the housing by means of stainless steel screws.
- (x) The minimum technical specifications for LED lighting will be as follows:
 - a. Powered by the latest bright LEDs with high efficiency and meeting LM-80 standard.
 - b. Average rated life span of 50000 hrs.
 - c. LED efficacy shall be greater than 125 Lumens/watt.
 - d. Luminaire efficacy of at least 80 Lumens/watt.
 - e. Input voltage range 90-300 V.
 - f. Power factor > 0.9 .
 - g. THD $< 15\%$.
 - h. Ingress protection as per IP 68 for outdoor luminaries
 - i. Operating temperature -5°C to 50°C
 - j. Storage temperature -5° to 70°C
 - k. Humidity 10% - 100%
 - l. LEDs shall be operated at a forward current less than 90% of its rated current.
 - m. The LEDs used in the luminaire shall have minimum angle of 120 degree.
 - n. Colour rendering index (CRI) of the LEDs shall be greater than 70.
 - o. Conform to Photo Biological Safety for the LEDs as per IEC 62471.
 - p. Free replacement warranties of 5 years for technical defects.

E. Decorative Luminaries

- a) These luminaires shall be generally indoor type provided with cold rolled cold annealed (CRCA) sheet steel channel/rail cum reflector housing complete with all electrical control accessories mounted on it. The finish shall be stove enamelled.

- b) Decorative fluorescent type luminaires shall be either open type, provided with translucent white opal acrylic diffusers, polystyrene lens prismatic or square polystyrene louvers.
- c) Luminaires shall be suitable for the number of lamps of specified wattage, direct mounting on ceiling/wall/column pendant mounting or for recess mounting in false ceiling.
- d) Decorative luminaires with mirror optic reflectors shall be of the wide angle dispersion type. Where these luminaires are mounted in control rooms and computer rooms, clip-on type adjustable reflectors which can be attached onto the tube shall be provided to direct the light output in the desired direction. This is mainly to reduce reflection of the light source from TV/monitor screens.
- e) Luminaires mounted recessed in false ceiling shall be with reflector housing and spring loaded fixing arrangement for the diffuser/louver frame. It shall be possible to have access to the lamp and other accessories from below.

F. Industrial Luminaries

- a) The luminaire shall be provided with CRCA sheet steel mounting rail with reflector of minimum 20 SWG thicknesses and complete with all control accessories mounted on it. The finish shall be vitreous enamelled.
- b) Luminaires shall be suitable for the number of lamps of specified wattage, direct mounting on ceiling/wall/column/pendent mounting.
- c) The distribution of light shall be such that at least 80% of the total luminous flux from the luminaire shall be in the lower hemisphere.
- d) The luminous output of the luminaire with reflector shall not be less than 75% irrespective of type of reflector used.

G. Bulk Head / High Bay luminaires

Bulk Head Luminaire

- a) The luminaire shall be of robust construction, with cast aluminium/vitreous enamelled housing, heat and shock resistant prismatic or clear glass cover fixed with neoprene gaskets for sealing. For mechanical protection to the glass cover, round steel wire-guard with vitreous enamelled finish shall be provided.

- b) The luminaire shall be suitable LED lamp upto 150 watts, for direct mounting to ceiling/wall/column and used for general purpose indoor lighting.

High and Medium Bay Luminaries

- a) High and medium bay luminaires shall be with cast aluminium housing, anodised aluminium mirror polished reflector canopy with eye bolt for suspension, cooling fins and glass cover.
- (i) The luminaire shall be suitable for LED lamps upto 1000 watts. The control gear accessories shall be mounted integral with the luminaire.
- (ii) High bay luminaires shall be used when the mounting height is above 8 metres while medium bay luminaires shall be used when the mounting height is around 6 to 8metres.

H. Flood Light Luminaire

General purpose flood light luminaire

- a) Flood light luminaires shall be of weather proof construction with cast aluminium housing, anodised aluminium mirror polished reflector, heat resistant, toughened glass cover and necessary neoprene gaskets to prevent ingress of dust.
- b) The housing shall be supported on a cast iron base and capable of being swivelled in both horizontal and vertical directions and locked in any desired position.
- c) For focussing purposes, knobs, shall be provided along with sector plate indicating the angle in degrees between 0 and 90 deg. in vertical direction.
- d) The Luminaires shall be suitable for LED lamps upto 1000 watts.
- e) The luminaire shall be provided with cable gland on the canopy in down ward direction for cable connection.
- f) It shall be possible to adjust the lamp position to achieve wide beam, medium beam or narrow beam.
- g) It shall be possible to replace the lamp from the canopy without opening the front glass.

I. Outdoor Lantern Luminaries

Post top Lantern

- a) Post top lantern Luminaires shall be generally outdoor weather proof type for illumination of walkways, gate posts, gardens etc.
- b) The luminaire shall have cast aluminium spigot of 50/60 diameter finished with corrosion proof paint for mounting, opal acrylic or high density polyethylene (HDP) diffuser bowl, complete with integral mounted control gear, neoprene gaskets, earthing terminal etc.
- c) The luminaire shall be suitable LED Lamps.

J. Sub-station Lantern

- a) Sub-station lantern shall be generally outdoor weather proof type for illumination of switchyard equipment.
- b) The luminaire shall have cast aluminium housing finished with corrosion proof paint, spigot for mounting on pole, prismatic glass refractor dome to give distribution of light in horizontal plane, anodised aluminium reflector to give light distribution at an angle 20 to 40 degrees, above the horizontal plane, complete with integral mounted control gear, neoprene gaskets, earthing terminal etc.
- c) The Luminaires shall be suitable LED lamps of suitable wattages.

K. Portable Emergency LED Light Luminaire

- a) Emergency light of Installite luminaire shall be indoor type for providing emergency light during failure of normal AC supply.
- b) The luminaire shall be with CRCA sheet steel enclosure, complete with metallised mirror reflector, leak proof re-chargeable battery rated for two hour discharge, battery charger, charger-on lamp, push button switches, automatic changeover switch/relay, two metre length cord with plug, mounting pads and other accessories required for satisfactory operation of the luminaire.
- c) The luminaire shall be suitable for connection to 240 V, 50 Hz single phase supply. On failure of normal A.C. supply the luminaire shall pick-up automatically and on restoration of A.C. supply the luminaire shall switch off automatically.
- d) The luminaire shall be suitable for LED lamps of suitable wattages.

L. Accessories for Luminaries

Reflectors

- a) The reflectors shall be made of CRCA sheet steel/aluminium/silvered glass/chromium plated sheet copper as indicated for above mentioned luminaries.
- b) The thickness of steel/aluminium shall comply with relevant standards. Reflectors made of steel shall have vitreous enamelled finish. Aluminium used for reflectors shall be anodized/epoxy stove enamelled/mirror polished. The finish for the reflector shall be as indicated for above mentioned fittings.
- c) Reflectors shall be free from scratches or blisters and shall have a smooth and glossy surface having an optimum light reflecting coefficient so as to ensure the overall light output specified by the Contractor.
- d) Reflectors shall be readily removable from the housing for cleaning and maintenance without disturbing the lamps and without the use of tools. They shall be securely fixed to the housing by means of positive fastening device of captive type.

M. Lamp/Starter Holders

- a) Lamp holders shall have low contact resistance, shall be resistant to wear and shall be suitable for operation at the specified temperature without deterioration in insulation value. They shall hold the lamps in position under normal condition of shock and vibration met with under normal installation and use.
- b) Lamp holders for the fluorescent lamps shall be of the spring loaded bi-pin rotor type. Live parts of the lamps holder shall not be exposed during insertion or removal of lamp or after the lamp has been taken out. The lamp holder contacts shall provide adequate pressure on the lamp cap pins when the lamp is in working position.
- c) Lamp holders for incandescent, mercury vapour and sodium vapour lamps shall be of Edison Screw (E.S.) type.
- d) The starter holders shall be so designed that they are mechanically robust and free from any operational difficulties. They shall be capable of withstanding the shocks met within normal transit, installation and use.

N. Drawings and Data

All Drawings, data, technical particulars, calculations, detailed literature, catalogues, test certificates etc shall be submitted along with the bid.

1.14 LIGHTING SYSTEM EQUIPMENT

A. Main Lighting Distribution Board and Lighting Panels (AC & DC)

a) Constructional Features

- (i) Boards and panels shall be sheet steel enclosed and shall be fully dust and vermin proof, providing a degree of protection of IP 52. Outdoor panels shall in addition be completely weather-proof with a sloping canopy for protection against rain and providing a degree of protection of IP 55. The sheet steel used for frame, frame enclosures, doors, covers and partitions shall be cold rolled 2 mm thick.
- (ii) All boards and panels shall be provided with hinged doors for access to equipment. Doors shall be gasketed all round with neoprene gaskets. For the main floor mounted distribution boards with the switch fuse units arranged in tier formation, the hinged door of each unit shall be interlocked so as to prevent opening of the door when the switch is ON and to prevent closing of the switch with the door not fully closed.
- (iii) However, a device for by-passing the door interlock shall be provided to enable the operation of the switch with the door open, when necessary, for examination/maintenance. For wall mounting 1-phase ways lighting panels when provided with MCBs, a hinged, latched front door shall be provided with key-locking facility and a slotted backelite sheet shall be provided inside. Only the MCBs operating knobs or the fuse cap covers shall project out of the backelite sheet slots for safe operation and neat appearance. Incomer to lighting panels shall be provided with TPN MCB with ELCB.
- (iv) All accessible live connections/metals shall be shrouded and it shall be possible to change individual fuses, switches, MCBs from the front of the boards/panels without danger of contact with live metal.
- (v) For floor mounting type distribution boards, adequately sized mounting channels shall be supplied and for wall/column/structure mounting type panels suitable mounting straps shall be provided.
- (vi) Adequate interior cabling space and suitable removable cable entry plates shall be provided for top/bottom entry of cables through glands and or conduits as required. Necessary number of glands to suit the specified cable sizes shall be provided. Cable glands shall be screwed on type and made of brass.
- (vii) Two earthing terminals shall be provided to suit the earthing conductor.
- (viii) All sheet steel parts shall undergo rust-proofing process which should include degreasing, de-scaling and a recognised phosphating process. The steel

works shall then be painted with two coats of Zinc - chromate primer and two coats of final stove-enamelled finish paint of specified colour.

b) Busbars

- (i) Busbars shall be of copper conductor of hard drawn (HD) and high conductivity. Busbars shall be fully insulated by encapsulation in epoxy resin with moulded caps protecting all joints.
- (ii) Busbars shall be provided with at least the minimum clearances in air as per applicable standards for 500 V, 3 phase system.
- (iii) Busbars shall be adequately sized for the continuous current rating such that the maximum temperature of the busbars, busbar risers/droppers and contacts does not exceed 85 deg C under site reference ambient temperature.
- (iv) The busbars, busbar connections and busbar supports shall have sufficient strength to withstand thermal and electro-mechanical stresses of the fuse/MCB's let through/cut-off current associated with the specified short-circuit level of the system.
- (v) Busbar supports shall be made from suitable insulating material such as Hylamsheets; glass reinforced moulded plastic materials, permali wood or cast resin. Separate supports shall be provided for each phase of the busbars. If a common support is provided for all three phases, anti-tracking barriers shall be incorporated.
- (vi) The neutral bus of the main 3 phase, 4 wire distribution board shall be rated not less than 50% of the phase busbars. The neutral bus of the 1 phase ways lighting panel shall be rated same as the phase busbars. The neutral bus should have sufficient terminals and detachable links for full number of single-phase outgoing lighting circuits.

B. Panels/Boards" Component Equipment

a) Switches/Miniature Circuit Breakers (MCB)

- (i) Switches/MCBs shall be hand operated, air break, quick make, quick break type conforming to applicable standards.
- (ii) The switch shall be protected by fuse and the MCB shall be provided with overload/short-circuit protective device for protection under overload and short-circuit conditions. The minimum breaking capacity of MCBs shall be 6 kA R.M.S.at 415 V/220 V D.C.

- (iii) Switch shall have provision for locking in both fully open and closed positions. MCBs shall be provided with locking facility.
 - (iv) The connections between switch and fuse shall be insulated and all live connections shall be shrouded.
- b) Indicating Instruments and Meters
- (i) Whenever required, instruments and meters shall be of the flush mounting type. They shall be suitably mounted so as to provide for easy access to CTs and small wiring.
 - (ii) Instruments shall be of minimum 96 mm square size, shall have provision for zero adjustment outside the cover and black numerals on white dial.
 - (iii) Watt-hour meters shall be of direct reading electro-dynamometer type complete with cyclometer type dials and reverse running stops.
 - (iv) Ammeter/Voltmeter selector switches having 3 positions and off, with stay -put contacts rated 10A shall be provided when specified.
 - (v) Potential fuses shall be provided at the tap-off point from the busbars for the voltmeters.
- c) Instrument Transformers
- (i) Current and voltage transformers shall be of the dry type, of metering accuracy class 1.0. Unless otherwise specified, it shall be the responsibility of the Contractor to ensure that the VA burden of the instrument transformer is adequate for the meters connected to it.
 - (ii) Test links shall be provided in both secondary leads of the CTs to easily carry out current and phase angle measurement tests. Facilities shall be provided for short circuiting and grounding the CTs at the terminal blocks.
 - (iii) Voltage transformers shall be provided with suitably rated primary and secondary fuses.
- d) Indicating Lamps
- Indicating lamps shall be of the LED type and low watt consumption. Lamps shall be provided with series resistors.
- e) Internal Wiring
- (i) Panels/boards shall be supplied completely wired, ready for the external connections at the terminal blocks. Wiring shall be carried out with 650/1100V

- (ii) grade, PVC insulated, stranded aluminium/copper conductors. Conductors of adequate sizes shall be used to suit the rated circuit current.
- (iii) Engraved identification ferrules, marked to correspond with the wiring diagram shall be fitted at both ends of each wire.
- (iv) All wiring shall be terminated on terminal blocks. Terminal blocks shall be one piece moulded rated 500 V, of reputed make, preferably stud type for higher current ratings such that wires are connected by cable-lugs and complete with nuts and washers. Terminals shall be adequately rated for the circuit current; the minimum rating shall be 20 A.
- (v) Terminals for circuits with voltage exceeding 125 V shall be shrouded.
- (vi) Terminals shall be numbered and provided with identification strip for identification of the circuit.
- (vii) Terminal blocks for C.T. secondary lead wires shall be provided with shorting and disconnecting/earthing facilities.

C. Labels & Diagram Plate

- a) All door mounted equipment as well as equipment mounted inside the switchboard/panels shall be provided with individual labels with equipment designation/rating. Also the boards/panels shall be provided on the front with a label engraved with the designation of the board/panel.
- b) Labels shall be made of non-rusting metal, 3-ply lamicaid or engraved PVC.
- c) Inside the door of the 1 phase ways lighting panels a circuit diagram/description shall be fixed for reference and identification.

D. Light Control Switches

- a) Light control switches of ratings and types, i.e. decorative/industrial shall be supplied as required. The switches shall be suitable for use on 240 V, 1 Ph, 50 Hz supply.
- b) Switches shall be of flush type for mounting behind an insulated plate or incorporated with a switch plate for mounting flush with the surface of wall or switch box/suitable enclosure. The switch box/enclosure may be recessed into or mounted on a wall as per the requirement of project layouts.
- c) The size of enclosure boxes shall be chosen to accommodate the number of switches to be installed at the particular location. The enclosures shall be 18 gauge sheet steel galvanised. The enclosure box shall be covered with perspex/insulating cover. An

enclosure intended for surface mounting shall not have holes or gaps in its sides other than those expressly provided for cable entry.

E. Receptacle Units

- a) Receptacle units shall consist of socket outlet with associated switch and plug. The socket outlet and switch or MCB shall be flush mounted within galvanised 18 gauge steel enclosure with insulation cover. The box may be recessed into or mounted on a wall as per requirements of project layouts.
- b) The receptacle units shall be suitable for 240 V, 1 ph - N, 50 Hz/415 V, 3 Ph - N, 50 Hz supply as required.
- c) Single phase receptacles shall be associated with a switch/MCB of same current rating and the receptacle shall become live only when the associated switch/MCB is in “ON” position.
- d) Three phase receptacles shall be associated with a TPN switch housed in the same enclosure. The receptacle shall become live only when the associated switch is in “ON” position.
- e) The plugs shall be provided with cord grips to prevent strain and damage to conductors/wires at connection and entry points.

F. Lighting Wires

- a) The wires for wiring in lighting system shall be 250/440 V, 1/C, PVC insulated, unarmoured with stranded copper conductors.
- b) The minimum area of conductors shall be 2.5 sq.mm. for light fittings and 5A Receptacles and 4 sq.mm for receptacles rated 15 A and above.
- c) The wires shall be coated white for phase/positive of D.C. and black for neutral/negative of D.C. Dedicated earthing wire shall be provided for each LED

G. Conduits

- a) Rigid steel/non-metallic conduits and their associated fittings as required shall conform to applicable standards. The minimum size of conduit shall be 20 mm for surface installation and 25 mm for concealed installation.
- b) Steel conduits shall be seamed by welding and hot dip galvanised. They shall be supplied in standard lengths of 5 m.

- c) Supply of conduits shall include all associated fittings like couplers, bends and tees as required for lighting system installation work.

H. Junction Boxes

- a) Junction boxes with terminals shall be supplied for branching and terminating lighting cables when required for outdoor areas, 3 phase receptacles etc.
- b) The junction boxes shall be dust and vermin proof and shall be fabricated from 14 gauge sheet steel and shall be complete with removable cover plate with gaskets, two earthing terminals each with nut, bolt and washer. Boxes shall be additionally weather proof.
- c) The boxes shall have provision for wall, column, pole or structure mounting and shall be provided with cable/conduit entry knock outs, terminal blocks, HRC fuses as required.
- d) The terminal blocks, with specified number of terminals, shall be mounted securely on brackets welded to the back sheet of the box. The terminals shall be 600 V, grade, one piece construction complete with terminals, insulation barriers, galvanised nuts, bolts and washers and provided with identification strips of PVC. The terminals shall be made of copper alloy and shall be of box clamp type.
- e) The boxes shall be painted with one shop coat of Red oxide zinc chromate primer followed by a finishing coat of paint.

I. Lighting Poles and Flood Light Pole Mounting

- a) Specification & Quantities for Street lighting poles

Fabricating, supplying and Supply and erection of Street lighting poles – street lighting poles – suitable heights ----- meter with contemporary arched design which suits to clean aesthetics of modern Architecture. The pole shall be tubular/Octagonal hot dip galvanized pole. Hot dip zinc coat of 85 microns to with single/ double arm decorative arched design brackets, suitable for mounting street lights luminaries. The pole shall be able to with stand wind speed considered in design as per 50m/sec. The pole shall be provided with built-in control box including service door with lock and safety chain. The control gear tray shall be prewired with 2.5 sq.mm Cu FRLS cable, SP MCB of 6/10 Amp rating with heavy duty 3 phase, 4 wire 32 Amps terminal block for loop-in loop-out arrangement suitable for terminating Al armoured cables with

armour grounding up to 3.5 core 35 sq mm size. Each pole base plate size 4000x 400 x16 mm (steel of grade Fe-410 to 2062:1999) having holes (48 x 24) for alignment of pole to suit M20 bolt at CC 215 welded at bottom of pole. The pole shall include 4 No. Of hot dip galvanized M20 X 500 mm foundation bolts. The pole shall be coated with zinc rich polyurethane base primer 30 micron and environmentally stable polyurethane based paint with 35 micron coat. The pole shall be with foundation bolt, fittings internal cabling, painting and printing with MCGM logo on poles by consultation with MCGM Official and standard pipe earthing. (the design / sketch of poles & brackets shall be pre-approved by MCGM authorities.) colour shade as approved by Engineering In Charge

- b) Poles for mounting flood lights shall be supplied whenever required and as per typical attached drawing. Unless otherwise specified, poles shall be painted with red lead oxide primer and two coats of aluminium paint. A steel ladder shall be provided. The length of each step of the ladder shall be at least 300 mm and spacing between two adjacent steps not more than 300 mm.
- c) The supply of poles shall be complete with fixing bracket/necessary pipe reducer for fixing the fitting and also include the necessary associated pole mounted junction boxes. The required sizes of poles and the junction box shall be as indicated in the attached drawings.

J. Drawings and Data

All Drawings, data, technical particulars, calculations, detailed literature, catalogues , test certificates etc shall be submitted along with the bid.

1.15 EARTHING AND LIGHTNING PROTECTION SYSTEM

A. General

- (i) The earthing and lightning protection system covers earthing conductors, earth electrodes and accessories.
- (ii) Metallic frame of all electrical equipment shall be earthed by two separate and distinct connections to earthing system. Crane rails, tracks, metal pipes and conduits also shall be earthed at two points.
- (iii) Steel RCC Columns, metallic stairs and rails of the building housing electrical equipment also shall be connected to nearby earthing grid conductor. Metallic

sheaths/ screens and armour of multicore cables shall be earthed at both ends. Metallic sheaths and armour of single core cables shall be earthed at the switchgear end only.

- (iv) Every alternate post of switchyard fence shall be connected to the earth grid by GS flat and gates by flexible lead to earthed post.
- (v) Each Continuous laid length of cable tray shall be earthed at minimum two places by GS/GI Flats to earthing system, the distance between the earthing points shall not exceed 30m.
- (vi) Lightning Protection System shall comprise vertical / horizontal air terminations, down conductors, test limits and earth electrodes. Air terminations, down conductors and test links shall be of galvanised steel conductors and earth connection below the ground level shall be of mild steel.
- (vii) Lightning Protection System down conductors shall not be connected to other earthing conductors above the ground level.

B. Applicable Standards

The earthing and lightning protection system shall conform to the Indian Electricity rules, and the latest applicable standards indicated below:

Code of Practice for Earthing	:	IS: 3043
Code of Practice for the Protection of	:	IS/IEC: 62305
Building and allied structure against lightning		
Hot dip galvanising	:	IS: 2629, 2633, 4759
Structural steel	:	IS: 2062 & 808
Welding	:	IS: 816

C. Earthing Conductor

- (i) The electrical installation shall where required be connected to the general mass of the earth by an earthing conductor. The material used for the earthing conductor shall be as follows:
 - (a) Conductors above ground shall be galvanised steel flat;
 - (b) Conductor buried in the ground or embedded in concrete shall be mild Steel, rod /flat.

- (ii) Allowance shall be made for reduction in the cross section of the steel over the design life of the earthing system;
- (iii) The earth electrode system shall comprise one or more earth electrodes, earthing network, mesh or a combination of these in order to obtain the required earth electrode resistance.
- (iv) Earth electrodes where used shall be of heavy duty galvanised mild steel of not less than 40 mm NB and 3000 mm long. Where multiple electrodes are used they shall be separated by a distance of not less than the driven length.
- (v) Each earth electrode pipe shall be welded at the top to a mild steel plate to which the earthing tapes shall be connected. These connections shall each be housed in individual concrete inspection chamber set flush to the finished ground level and shall allow disconnection for testing of individual electrodes. The chamber shall be permanently marked 'Electrical Earth'.
- (vi) All materials used for the earth electrode installation shall be purpose made for the application and site conditions and shall be approved by the Employer's Representative.
- (vii) Unless otherwise stated all excavation for the installation of the earth electrodes and the inspection pit shall be carried out by the Contractor.
- (viii) After the earth installation has been completed the Contractor shall demonstrate to the Employer's Representative that the resistance of the electrodes to earth and the continuity of the earth network are within the limits specified. Any additional earth electrodes and test instruments required for the tests shall be provided by the Contractor.
- (ix) Marker posts and plates shall be provided to mark the route of buried tape or conductor electrodes. The markers shall be similar to those provided for cable routes.
- (x) Lightning Protection System
 - a) The need of lightning protection has been established by calculating the overall risk factor as per IS/IEC 62305.
 - b) Air termination system comprising of rods/mesh or combination of both will be provided and the methods used to determine the positioning of Air termination system will be as per IS 62305.
 - c) Air termination system will be connected to the earthing system by down conductors fixed along the outer surface of building. Number & layout of the down conductors will be as per IS/IEC 62305.

- d) Each down comer will be terminated to a separate treated test earth electrode which in turn will be connected to station earthing system.
- e) Test link will be provided in the run of each down conductor at approximately 1000 mm above ground level.

D. Main Equipotential Bonding Conductor

- (i) Main equipotential bonding conductors shall be provided to connect the earth electrode system to conductive parts forming the Works.
- (ii) Equipotential bonding conductors shall have the following minimum sizes, the contractor shall specifically design the equipotential earthing for each site locations.

a) Main Equipotential Conductors

-Main Earth Conductor buried in earth	40 mm dia.	MS Rod
-11/0.433 kV transformers, main switchboard and standby generator installation.	50 x 10 mm	flat
-interconnection to lightning protection system	50 x 10 mm	flat
interconnection to MCC s	50 x 10 mm	flat

b) Equipotential Conductors

- interconnection to CP s	25 x 3 mm	flat
- power factor correction capacitor panel	25 x 3 mm	flat
- local push buttons	14 SWG	wire
- lighting distribution board	4 SWG	wire
- lighting and receptacle system	12 SWG	wire
- outdoor street lighting	8 SWG	wire
- ladder rack and cable tray at suitable points	25 x 3 mm	flat
- hand rails and metallic structures	25 x 3 mm	flat
- building reinforcement	25 x 3 mm	flat
- incoming and outgoing process services	25 x 3 mm	flat
- steel structures comprising storage tanks, mezzanine platform, crane rails, air handling ductwork systems etc.	25 x 3 mm	flat

- (iii) The armouring of the supply cable shall not form the sole means of earthing a switchboard or large electrical load.
- (iv) Where the cable armouring or sheath is used as the circuit protective conductor it shall be securely bonded at both ends to the metalwork of the apparatus and to an earth bar. Particular care shall be taken to ensure continuity across items of apparatus situated within a cable run and should the design of such items of apparatus not give adequate and lasting continuity through its structural body then additional earthing clips and conductors shall be provided to independently bond the cable sheaths together. Similarly additional earthing clips shall be provided to bond the cable sheaths/armour to any piece of apparatus fitted with a special earth terminal should the earth connection for the termination gland be inadequate. Any additional earthing clips shall be fitted within the apparatus wherever possible.
- (v) **Instrumentation Earth**
An instrumentation earth bus, if required shall be provided in each control panel. This shall comprise a copper flat of cross section not less than 25 x 6 mm and length to suit the number of connections. It shall be mounted on at least two insulated supports and be provided with a single earth connection to the instrument earth. If due to the physical size of a control panel more than one instrument earth bar is required the additional bar shall be connected again with a single earth connection to the same point as before. In this fashion all instrument earths shall be connected radially from the same earth point.
- (vi) The earth pit for instrumentation system shall be separate. Electric earth pits shall not be used for earthing of instrumentation equipment. All signal cable screens (analogue and digital) shall be terminated onto the instrument earth bar. Signal cable screens shall be earthed at the control panel end only. Screens at the field end shall be tied back and insulated.
- (vii) SPDs associated with the control and instrumentation system shall be earthed to the instrument earth in accordance with the SPD manufacturers recommendations.

F. Galvanising

Wherever galvanising has been specified, the hot dip process shall be used. The galvanised coating shall be of uniform thickness. Weight of Zinc coatings for various applications shall not be less than those indicated below:

- a) Fabricated Steel

Thickness less than 2 mm,	
But not less than 1.2 mm	340 gms/sq.m
Thickness less than 5 mm, but not less than 2 mm	460 gms/sq. M
Thickness 5 mm and over	610 gm / sq.m
b) Fasteners	
Upto nominal size M10	270 gms/sq.m
Over M10	300 gms/sq.m

Burrs shall be removed before galvanising. Any site modification of galvanised parts should be covered well by zinc rich primer and aluminium paint.

1.16 FIRE DETECTION AND ALARM SYSTEM

- a) Fire alarm system shall be provided for notification of fire alarm, supervisory and trouble condition and to control fire safety functions.
- b) The design requirements are defined in the specifications. as part of design engineering, fire alarm scheme based on requirements of NFPA 72, National Fire Alarm Code (2002 edition) shall be developed for the areas given in the tender drawings.
- c) The Fire Alarm and Detection system shall comply with NFPA 72 & IS 2189 for all applications.
- d) The Fire Detection and Alarm system include sprinkler system designed as per NFPA 70 or Above.
- e) The design is typically provided in compliance with the model building codes having jurisdiction in that area. NFPA 72, 2000 edition: The National fire Alarm code is usually used for the installation methods, testing and maintenance.
- f) Connection conditions from relevant regional authorities & institutions shall be maintained (Police & Fire, emergency services).
 - a) National Building code of India (BIS)
 - b) BIS: Bureau of Indian standard (IS: 2189)
 - c) NFPA: National Fire Protection Association
 - d) IEC: International Electro technical commission
 - e) NEC: National Electric Code
 - f) NEMA: National Electrical Manufacturer's Association

g) NBC: National Building Code

- g) Fire Alarm system shall be designed to provide continuous surveillance against fire in the areas covered by the system under all conditions.
- h) The Fire alarm control panel, detectors and other related devices used in the system shall conform to international Standards UL / LPCB / FM.
- i) Fire Alarm Control Panel (FACP):

(a) The FACP shall be of microprocessor based design having the required number of outgoing loops (Minimum 8 loops per panel) to connect addressable type detectors and devices.

(b) Microprocessor based Control unit(Panel) at each local Fire alarm system shall have following Features:

- The Panel shall conform to FM /UL listed.
- Each detector / device that is connected on the loop shall be identified by a unique address that shall be assigned to each device. This address shall indicate the individual device address as well as the address of the loop to which it is connected.
- Check the status of the system at definite pre set intervals and give warning in case of system faults like open circuit, short circuit, dirty detector, removal of detector or any other faults.
- In case of fire the panel shall give audio as well as alphanumeric display. From the display the zone and location of fire should be readily identified.
- Power to detection devices and notification appliances shall be supplied from FACP.

Characteristics of Main Display Unit of each FACP:

- i. General display current date, time, last event, number of alarms, priority wise alarm list, and any other applicable information shall be displayed on each FACP.
- ii. Automatically display system messages, alarms. Vital information to operators concerning a fire situation.
- iii. Fire progression & evacuation details.

(c) Power Supply Requirement for FACP

Power Supply requirement for FACP (Fire Alarm & Control Panel). Primary supply - 230VAC, 50Hz.

1. Back-up/secondary supply - sealed, lead-acid batteries.
 - (i) FDAS panel shall be backed up with its built in battery & battery charger. Battery shall have capacity to back up complete operation for 48 hrs. Battery shall have sufficient capacity to power the fire alarm system for not less than 48 hours plus 30 minutes of alarm to an end voltage of 1.14volts per cell, upon a normal AC power failure.
 - (ii) The power supply unit shall accept 230 V AC mains power. The power supply unit shall supply DC power to all the interface cards/modules within the FAP as well as to all the devices wired on all the FAP loops.
 - (iii) Simply monitoring the battery voltage level shall not be accepted as battery supervision.
 - (iv) Batteries shall be rechargeable, sealed maintenance-free type. Battery capacity shall be sized to provide backup power to the FAP for supervision and alarm.
2. Both mains failure as well as low battery level troubles shall be annunciated by the FAP.
3. Battery Charger:
 - i. The power supply shall supervise the standby batteries and provide a dual rate constant current battery charger featuring automatic temperature compensation. It shall be completely automatic, constant current charger maintaining the battery fully charged under all service conditions. Charger shall operate from a 230V, 50 Hz power source.
 - ii. It shall have protection to prevent discharge through the charger.
 - iii. It shall have protection for overloads and short circuits on both AC and DC sides. A trouble condition shall actuate the charger signal.
 - iv. Charger shall have automatic AC line voltage regulation, automatic Current limiting features, and adjustable voltage controls.
- j) Manual Call Points (MCPs) shall be mounted at exit points of all areas (at operating height of 1.2 M) with operating instruction (IN CASE OF FIRE BREAK GLASS”) printed on the facia housed in a suitable housing to avoid inadvertent operation.

- k) The FAP shall have the facility to monitor & process all the input signals received and also have the facility to control all the output signals connected to various devices in the field through any of the loop interface modules/cards.
- l) Fire fighting system shall contain but not to limited to, the items listed below -
- i) Portable fire extinguishers
 - ii) Nitrogen injection fire prevention method for transformer
 - iii) Sand & Water Bucket

1.17 PREFERRED MAKES/ MANUFACTURERS:

The list of preferred Makes/ Manufacturers is given below:

SL NO	DESCRIPTION	MANUFACTURER/MAKE
1	Power transformers	M/s ABB M/s BHEL M/s Siemens M/s Areva T&D M/s Crompton Greaves Limited
2	Auxiliary transformers	M/s ABB M/s BHEL M/s Siemens M/s Areva T&D M/s Crompton Greaves Limited M/S Volt Amp M/S Bharat Bijlee M/s Kirloskar Electric M/s Siemens M/s ABB
3	11 kV Metal enclosed switchgears /MCC	M/s Siemens M/s Areva M/s BHEL M/s Mitsubishi
4	HV Vacuum Circuit Breaker	M/s Siemens M/s ABB

SL NO	DESCRIPTION	MANUFACTURER/MAKE
		M/s Crompton Greaves Limited M/s Areva M/s BHEL
5	Protective Relays	M/s ABB M/s Schneider Electric M/s L&T M/s GE M/s Siemens M/s Areva T&D
6	H.T & L.T Current Transformers	M/s ABB M/s Areva T&D M/s CGL M/s BHEL
7	Neutral earthing resistors	M/s Bharatia Cutler Hammer (I). Ltd M/s Crompton Greaves Limited M/s Indcoil Mfg Company Limited
8	LV Switchgears /MCC	M/s Schneider Electric M/s ABB M/s. Siemens M/s GE M/s L&T M/s Mitsubishi
9	Lighting Fixtures and Accessories	M/s Philips M/s ABB M/s Crompton Greaves Limited M/s Wipro M/s Bajaj Electricals
10	L.T Power Capacitors	M/s BHEL M/s ABB, M/s CG Power Systems M/s Universal Cables

SL NO	DESCRIPTION	MANUFACTURER/MAKE
11	Alternators for DG Sets	M/s Kirloskar Electric M/s CGL M/s BHEL M/s Kirloskar M/s Stomford
12	Cables	M/s Universal Cables M/s Polycab M/s Havell's
13	Battery	M/s Exide Industries M/s AMCO M/s HBL-NIFE
14	Battery Chargers	M/s Universal Instruments M/s Amara Raja M/s Chabhi Electricals M/s HBL-NIFE M/s Caldine
15	Cable Termination Kits	M/s Mahindra Engg and Chemical Products M/s REPL M/s Raychem
16	FCMA Starters	M/s. Innovative technomics M/s. Sunshine controls M/s. Sakthi power innovative (or) Equivalent as per tender requirement

Note:

Other Makes, if offered, are subject to Specific Approval by the Employer/ Employer's Representative based on the Submission of the following documents by the bidder:

- (i) Copies of Type Test Certificate for the items offered.

- (ii) List of Clients to whom already the items have been supplied along with the year of Supply and Value of Orders
- (iii) Copies of Performance Certificate from the User's for the items.
- (iv) Copy of latest ISO Certification for the Manufacturer
- (v) Details of Manufacturing Facilities
- (vi) Turn Over of the Manufacturer
- (vii) Copies of Approval for the items from reputed Consultants.

2 GENERAL REQUIREMENTS -INSTRUMENTATION CONTROL AND AUTOMATION

2.1 Introduction

This part covers the general requirements for the design, supply, installation, inspection and testing of the instrumentation, Control and Automation (PLC based SCADA system inclusive of wired and wireless communication system) and associated plant and materials.

2.2 Reference Standards

Unless otherwise approved, instrumentation shall comply with relevant quality standards test procedures and codes of practice collectively referred to as Reference Standards including those listed below in accordance with the requirements detailed elsewhere in this specification.

BS 89-2:1990, EN 60051-2:1989, IEC 60051-2:1984	Direct acting indicating analogue electrical measuring Instruments and their accessories.
BS 1042 (Various)	Measurement of fluid flow in closed conduits.
BS 1646-1:1979, ISO 3511/I-1977	Symbolic representation for process measurement control Functions and instrumentation. Basic requirements
BS EN 837-1:1998	Pressure gauges. Bourdon tube pressure gauges. Dimensions, metrology, requirements and testing
BS EN 60751:1996, IEC 60751:1983	Industrial platinum resistance thermometer sensors
BS 3680 (Various)	Measurement of liquid flow in open channels.
BS 3693:1992	Recommendations for design of scales and indexes on analogue indicating instruments
BS EN 60770-1:1999, IEC 60770-1:1999	Transmitters for use in industrial-process control systems. Methods for performance evaluation
BS 4675-2:1978, ISO 2954-1975	Mechanical vibration in rotating machinery. Requirements for instruments for measuring vibration severity

BS EN 60584-1:1996, IEC 60584-1:1995	Thermocouples. Reference tables
BS 5308 (Various)	Instrumentation cables
BS EN 60529:1992	Specification for degrees of protection provided by enclosures (IP code)
BS ISO 11631:1998	Measurement of fluid flow. Methods of specifying flowmeter performance
BS 5863-1:1984, IEC 60381-1:1982	Analogue signals for process control systems. Specification for direct current signals
BS 5863-2:1980, IEC 60381-2:1978	Analogue signals for process control systems. Specification for direct voltage signals
BS EN 60654-1:1993, IEC 60654-1:1993	Industrial-process measurement and control equipment. Operating conditions. Climatic conditions
BS 6739:1986	Code of practice for instrumentation in process control systems: installation design and practice
BS EN 60073:2002	Basic and safety principles for man-machine interface, marking and identification. Coding principles for indicators and actuators
BS 1553 (Various)	Specification for graphical symbols for general engineering
ISA-5.1-1984 - (R1992)	Instrumentation Symbols and Identification
ISA-5.4-1991	Instrument Loop Diagrams
ANSI/ISA-7.0.01-1996	Quality Standard for Instrument Air
ANSI/ISA-18.1-1979 -(R1992)	Annunciator Sequences and Specifications
ISA-26-1968	Dynamic Response Testing of Process Control Instrumentation
ISA-37.1-1975 - (R1982)	Electrical Transducer Nomenclature and Terminology
ISA-37.3-1982 - (R1995)	Specifications and Tests for Strain Gage Pressure Transducers
ANSI/ISA-50.00.01-1975 (R2002)	Compatibility of Analog Signals for Electronic Industrial Process Instruments
ANSI/ISA-51.1-1979 - (R1993)	Process Instrumentation Terminology
ISO 9000 and 09004	Quality Systems
IEEE 60587	Power Supply Surge Protection
IEC 61131-3	Programming Languages for Programmable Controllers.
IEC 61158-2	Communication Protocols
ISO 9075 (BS 6964)	Structured Query Language (SQL)
BS 5515	Documentation of Computer Based Systems
BS 7165	Recommendation for Achievement of Quality in Software
BS EN 50081	Electromagnetic Compatibility

ISO 3511	Process measurement control functions- instrumentation symbolic representation.
ISO-OSI	7 Layer Communication Model
IEC-8705101	Modbus Protocol Conversion
IEEE 472-1974	Surge protection.
NEMA	National Electrical Manufacturers Association

2.3 Statement of Compliance

The Contractor shall provide a list of the reference standards used and shall provide a compliance/non-compliance statement during FDS submission once the contract has been awarded.

All standards which the Contractor intends to use but which are not part of the above Standards or other listed Reference Standards, shall be submitted to the Engineer for consent before any design against that standard proceeds.

2.4 Qualification Criteria for Instrumentation Manufacturer, Automation System Manufacturer, and Automation System Integrator

ISO 9001 or above accreditation shall be a minimum qualification for all Instrumentation and/or Automation System Manufacturers and all Automation System Integrators (System Integrators).

The complete Instrumentation, Control, and Automation works in this contract shall be executed by a single System Integrator with a minimum of 5 years of experience in automation projects. The System Integrator shall demonstrate capability and resources for integrating/interfacing control systems from different manufacturers as well as coordination with multiple agencies for contract execution.

The System Integrator shall submit evidence that they employ in excess of 25 personnel, including no less than 15 technical staff to include engineers, programmers, and field technicians. Qualifications and license details for a minimum of three professional engineers in the direct employ of the System Integrator, as well as resumes of all personnel assigned to this contract shall be submitted as part of the Contractor's technical bid.

The System Integrator shall be an authorized system integrator for the Automation System Manufacturer(s). Verification certificates shall be submitted directly from the manufacturer(s)

of the Automation System. In addition, references shall be provided with the Contractor's technical bid for a minimum of five (5) locations where the proposed manufacturer's Automation System has been successfully installed by the proposed System Integrator within five (5) years prior to the bid date and has been successfully operating for at least two (2) years immediately prior to the bid date. References shall include name, address, and telephone number for the appropriate contact person.

The Instrumentation Manufacturer(s) shall have minimum 15 years of experience in India in the field of instrument supply and service and shall have a local service centre in Mumbai.

All hardware and software proposed shall have been successfully used in a similar sewage treatment plant application for a period of at least five (5) years and be from established and reputable suppliers.

2.5 Documents to be submitted during Bid Submission

1. Include a complete Table of Conformance to each and every reference standards or part of the specifications. Use a chart format with specification part identified, indicate whether each part is in compliance, a deviation or an exception to the specific part. If an exception or deviation, include a narrative description as to how the deviation or exception can benefit the end-user of the system over that item specified.
2. Provide a block diagram of the proposed system showing all major components and their interconnections and interrelationships. Label each diagram and indicate all external power and communications interfaces.
3. Provide a written overview of the proposed SCADA system, instrumentation system describing the principal functions and capabilities of the system's PC, PLC's, system communications and general system capabilities (maximum number of network nodes, PLC's and I/O points, communication protocols available, etc.).
4. Provide an equipment list with descriptive literature for the proposed system. Included on the list shall be all major hardware items. List shall include as a minimum, the manufacturer, the quantity provided, and model numbers for each. Technical schedules for Instruments, PLC & SCADA shall be duly filled in with relevant details.
5. Provide an operating system and software applications list with descriptive

literature for the proposed system. Include all major software items, supplier name, quantity, and model numbers. Indicate whether any proposed software is proprietary and would not be turned over to the owner. (No proprietary software shall be accepted).

6. Information is required for:

- a) Name and version of the proposed PC's operating system.
- b) Name and version of the proposed computer operator graphical user interface software package (SCADA).
- c) \Name and version of the PLC on-line/off-line programming software for all controllers
- d) Name and version of any required communications software, firmware, etc.
- e) Name and version of the specified report application software.
- f) Name and version of the specified maintenance application software if any.
- g) Describe how system data points are linked from the system database into various applications such as reporting or maintenance. If via DDE (Dynamic Data Exchange) describe specifically the steps required to import data automatically and on-line into the proposed software applications.
- h) Briefly describe the required procedure for configuration and/or programming of the proposed system to add a simple remote PLC and additional I/O's to the system in the future. Describe in detail, specifically how communications are programmed for the future remote PLC and the necessary changes required at the main controller.
- i) Provide a description of any non-resident software required to program, troubleshoot or diagnose any devices in the system
- j) Provide a tentative construction schedule for completion of the project within the specified Contract period. Indicate the following activities with milestones: Mobilization, radio communications licensing, submittal preparation, submittal review, equipment procurement, equipment assembly, system configuration and programming, factory testing, system delivery, system installation, start up, field testing and training, and post acceptance routine service intervals.
- k) Describe the system supplier's provisions for service, technical assistance

and re-placement parts for the proposed system. Include the system supplier's 1-800-toll free number. Identify with resumes, all personnel who will be providing technical support services for the project after it is accepted.

The Contractor shall provide the above required details/documents during the bid submission. Failure to submit even one of the above will be treated as a non-responsive bid and lead to technical rejection of the bid. Contractor shall note the importance of this obligation.

2.5.1. General Submissions

The Contractor shall make submissions to the Engineer of all design drawings, schedules and complete documentation on spare parts relating to instrumentation, control and Automation equipment and systems provided under this Contract.

These submissions shall include, where relevant, the following:

2.5.2. Functional design specification

The Contractor shall submit a complete Functional Design Specification (FDS) for approval by the Engineer within 3 months of the award of contract. This document shall serve as the primary mechanism by which the Engineer may confirm that the Contractor possesses an accurate understanding of the system and its control requirements. The Contractor is encouraged to obtain clarifications and to suggest refinements to the control descriptions contained in this Specification.

The FDS shall comprise an overall description of the plant, its functioning and control, and a detailed description of each section of the control system covering modes of operation, manual overrides, set point and parameter selection and adjustment. The detailed description shall include a step-by-step control description which defines the function of each piece of equipment and each control action and interlock, including details of the program in each programmable item. Proposed SCADA screens shall form an integral part of FDS submissions.

The format of the program details may be chosen by the Contract, project. It is suggested that this format be chosen to satisfy the requirements of the software design documentation, if applicable, as described elsewhere.

The FDS shall describe the fail-safe features incorporated into the design for the event of failure of a

plant item or system, or loss of an input signal affecting a control loop or process sequence.

The FDS shall describe control actions taken and monitoring functions which remain available during a power failure, and any automatic controls or sequencing which take place during system start-up and shut-down.

The FDS shall be presented in a clear and precise manner and shall include figures or drawings where appropriate.

The Contractor shall submit and obtain approval of the FDS from the Engineer before beginning the detailed control system design. The contractor should take note of the importance of this obligation.

2.5.3. Drawings and schedules

- Process and instrumentation diagram which shall comply with BS 1646 and BS 1553/equivalent ISA standard.
- General arrangement drawings of field-mounted instruments showing installation details. 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.
- Layout drawings of panel fascia’s showing instruments, controls and details of all labels
Layout drawings of panel interior showing equipment, terminal blocks and cable ways.
- Annunciator arrangement and engraving details.
- Internal circuit and wiring diagrams for instrument and control panels
- Schematic control diagrams.
- Instrument loop diagrams.
- Instrument wiring and piping diagrams. Interconnection wiring diagrams.
- Cable block diagrams, drawings and schedules.
- Instrument system and panel power distribution diagrams.
- Programmable-device functional design specifications which shall include hardware details, logic flow charts, ladder diagrams and program listings.
- Schedules of inputs to and outputs from programmable controllers and telemetry outstations.
- Labelling schedules.
- Comprehensive testing schedules for all off-site, on-site, pre-commissioning

and commissioning tests and take-over tests.

All other drawings necessary for the provision of ducts, openings, trenches, fixing holes for panels

and the like and for the complete understanding of the operation, maintenance and extension of the system including any required for the Purchaser to dismantle, repair, maintain, modify or extend the Plant.

2.5.4. Data and calculations

- a) Manufacturers ' catalogues and data sheets.
- b) Calculations to support control system design.
- c) Specification for protective coatings and painting.

2.5.5. Certificates

- a) Manufacturers' works tests.
- b) Pre-installation checks.
- c) Pressure-testing schedules.
- d) Instrument loop test check sheets.
- e) Installed instrument performance tests.
- f) System tests
- g) Statutory certificates of compliance (such as hazardous area equipment).

2.5.6. Operation and maintenance instructions

- a) Composite manual describing the functional and operation of each piece of equipment.
- b) Composite manual for testing and servicing every system and individual item.

2.6 Design

2.6.1. Basic Features

Instrumentation, Control, Automation system shall be designed, manufactured and installed to achieve the following basic requirements:

- to maintain the highest standards of availability, reliability and accuracy and to give clear warnings of any deterioration in performance;
- to suit the abilities of the staff who will:
- use the systems;

- service the systems;
- to measure, indicate process, store and control the relevant parameters, as specified;
- to give clear warnings of dangerous and other abnormal conditions and to initiate plant safety procedures, shutdowns and corrective measures as specified to assure the safety of operations and maintenance‘ personnel and plant and to store and collate the data, as required;
- to derive, present and utilize, as required, such additional data as required to facilitate:
- the most efficient operation of the plant;
- the routine maintenance of the plant

2.6.2. Design Requirements for Instrumentation, Control and Automation Systems

The instrumentation, control, automation installations shall fully comply with design standards, regulations and the material and workmanship requirements of the Specification.

The electrical plant installations associated instrumentation control and automation systems shall also comply with and be tested in accordance with the latest edition of BS 7671 or equivalent Indian standards.

All equipment and materials incorporated in the system shall be selected, designed and rated to operate under the defined performance duties and specified site conditions and to maintain a high level of operational reliability.

The instrumentation control and monitoring system equipment and materials shall have an operational life of not less than 15 years, unless otherwise approved by the Engineer.

2.7 Site Conditions

A. Temperature and Humidity Range. The equipment shall be installed in an environment having a temperature range of 0 °C to 55 °C and a maximum relative humidity of 100 % (non condensing). The Contractor shall use, where required, fans, heaters, and air conditioning units to maintain a correct working temperature for his equipment. All Parts of the equipment shall be constructed of materials or treated to prevent the formation of mould, fungus or any corrosion over the temperature and relative humidity ranges specified.

B. EMI/RFI Noise Immunity. The equipment to be provided shall be adequately

protected against interference from the use of radio transmitters, at any point external to the equipment housings and no malfunction of the equipment shall result from this cause. Responsibility for the correct and reliable operation of the equipment shall rest with the Contractor, who must ensure that the equipment is adequately protected against the ingress of radiated, mains-borne signal-borne interference.

- C. Generated Interference.** The Contractor shall ensure that the computer, instrumentation and communications equipment conforms to BS EN 50081-1 or equivalent Indian Standard for noise emissions.
- D. Coordination.** The Contractor shall check with other trades to ensure that equipment and material can be installed in space provided. Provide other trades with information necessary for them to execute their work. Details on Drawings, which are specific regarding dimensions and locations, are for information purposes. Coordinate with other trades to ensure work can be installed as indicated.
- E. Sequencing.** The Contractor shall make applications to the local telecommunications Service Provider for provision of communications and coordinate with the sub-contractor responsible for installation of power supply services under this contract. Applications shall be made in time to ensure services are available for installation and commissioning of the telemetry equipment.

2.8 Enclosure/Panel Details

2.8.1. Enclosures and mounting boards

Enclosures shall be any form of board, cabinet, panel, desk, box or case used to protect, contain or group instrumentation, telemetry or control equipment.

All equipment in or on enclosures shall be arranged logically and, as far as possible, symmetrically, with projections kept to a minimum. Each enclosure and board shall be designed on ergonomic principles and shall permit in-situ and safe access for any normal adjustment, maintenance and servicing. The tops of plant-mounted enclosures shall be sloped downwards from front to rear. Enclosures mounted inside buildings shall have a minimum rating of protection to IP 54.

Enclosures for use outside buildings or in places where splashing may occur shall have a minimum rating of protection to 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. The sun shield shall prevent direct sunlight from reaching the instrumentation for the full day throughout the year, and shall have louvered ventilation.

Fixing arrangements for surface-mounting enclosures shall be external to the enclosure and shall ensure that the rear face of the enclosure is not in contact with the surface to which it is fixed.

Enclosures shall have hinged access doors, fitted with recessed lockable handles.

Doors shall be of rigid construction and provided with close-fitting flexible seals in recesses to prevent the ingress of liquids, moisture, dust and vermin. Hinges shall be of the lift-off pattern and one hinge shall engage before the other for ease of fitting. Wherever necessary, removable access covers secured by quick-release fasteners shall be provided to ensure ease of maintenance for all installed apparatus.

Mounting plates, brackets and racks shall be provided for all other internal equipment which shall be hinged or otherwise arranged with quick-release fasteners or captive screws to give quick and easy access to equipment, securing screws, terminals and wiring.

Enclosures for two or more devices with electrical circuits shall have gland plates and terminal blocks as specified elsewhere.

Each enclosure shall be designed for the safe testing and servicing of equipment with the power on. Each part which may be live under any circumstances shall be so covered or shielded as to prevent inadvertent contact.

2.8.2. Panel design and construction

Unless otherwise specified, all instrument panels, instrument cubicles, control panels, control consoles and desks, associated equipment and terminal racks, telemetry and electronic equipment racks and the like shall be free-standing, floor mounted units and shall conform to the requirements of this part and will hereafter be referred to as panels.

The design and dimensions of control consoles and desks shall be determined according to their intended function and shall be in accordance with the requirements of the Specification.

The height shall not exceed 1400mm above the finished floor level.

Unless otherwise specified the height of panels shall be not greater than 2130mm overall (excluding lifting devices) above finished floor level.

Controls, switches and push-buttons shall be positioned below or adjacent to any associated reading instrument. Panels for use in locations such as pumping stations and machinery rooms shall have antivibration 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.

2.8.3. Panels – Major

Panels shall be constructed generally as specified in the preceding clause. Panel material shall be prime-quality, cold-rolled and annealed mild steel or zinc-coated mild steel sheet, suitably braced and stiffened as necessary with flat bar or angle to form a rigid structure.

Panel fronts shall be flat and free from bow or ripple. Exterior corners and edges shall be rounded or welded and ground to give a smooth overall appearance.

Flanged edges shall be straight and smooth.

Materials shall be chosen with due regard to the panel size, number of cut-outs, instrument weight and position of centre of gravity and method of fabrication, with the following minimum thickness:

- instrument bearing surfaces, gland plates and pneumatic distribution plates, 3mm;
- internal mounting plates, 3mm;
- doors, covers and filler panels, 2mm.

No design involving the use of externally-visible assembly or fixing bolts and screws or any design resulting in dust or water-collecting crevices will be accepted.

When a panel is constructed in sections, the sections shall be designed for ease of assembly during installation and, in any case, shall not exceed 2m in length. All necessary nuts, bolts, washers and the like shall be supplied and included in the same shipment as the relevant sections. Sections exceeding 1m in length shall be provided with double doors.

Each panel shall be mounted on a self-draining base frame fabricated from 150mm deep, steel channel section which shall be drilled or provided with clamps for bolting to the floor. The base frame shall be set back from the panel front face to give a toe space of not less than 25mm. The outside of the base frame shall be covered with an approved kicking strip.

Ceiling and other filler panels shall be fabricated from sheet steel and adequately stiffened. Each section shall have 50mm returned edges along all four sides and shall be braced to the main steelwork of the panel.

A 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 un-drilled gland plates, in sections convenient for handling, shall be fitted close to the appropriate terminal blocks and not less than 230mm above the panel floor or not less than 230mm below the panel top. The gland plates shall have removable side covers giving access to both sides of the gland plate and ensuring vermin-proof and dust-proof construction. Gland plates of a surface mounted enclosure may form a part of the base or top.

Panels containing instruments using a fluid as the transmission medium shall have distribution plates with bulkhead unions for the termination of internal and external pipework.

All doors shall open outwards and all doors in one panel assembly shall use the same lock and key combination.

Panel design shall ensure adequate ventilation and air circulation without permitting the entry of vermin or dust. Panels installed in control rooms or other clean condition areas shall have 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 louvers shall be sealed.

No equipment other than front-of-panel items shall be mounted on panel wall surfaces.

If electrical and non-electrical instruments are mounted in the same panel, the panel shall be subdivided internally to separate the electrical and non-electrical sections.

All connections shall be arranged to ensure that no accidental damage to cabling or electrical components can occur in the event of failure of any non-electrical component or connection.

Provision shall be made for safe and easy handling during transit and installation.

If lifting eyes are provided, they shall be reversible and panel tops shall be reinforced where necessary.

Where equipment is specified to be installed at a future date, space shall be allocated, and cut-outs with removable masking plates, brackets, supports, wiring, terminals and piping and the like shall be provided.

Panels shall be finish-coated at the place of manufacture before commencing the installation of apparatus and other fittings.

2.8.4. Panels – Minor

Panels for installation on the Plant which contain relatively few items of equipment, or where so specified elsewhere, shall be classed as minor panels and shall be constructed generally as specified in the preceding clause and comply with this Clause.

Panels shall be fabricated from sheet steel or other approved material less than 2.5mm thick suitably braced to form a robust and rigid structure. Exterior corners and edges shall be rounded to give a smooth overall appearance and assembly bolts, screws or rivets shall not be visible on the front face.

The design shall be such as to ensure adequate ventilation and air circulation where required, without permitting the entry of vermin. Openings for cables shall be made vermin – proof. Doors shall be hinged and shall be provided with close-fitting flexible seals in recesses to prevent the ingress of liquids, moisture, dust and vermin. Unless otherwise specified, panels shall be suitable for floor mounting and shall not exceed 2130mm in height. Where surface-mounted panels are provided, the fixing shall prevent the ingress of moisture and the rear of the enclosure shall be not less than 10mm from the wall.

Lifting eyebolts shall be removed, issued to the Purchaser and subsequently replaced with bolts after installation.

Panels shall be extensible, and symmetrically arranged as far as possible with projections kept to a minimum. Where two or more panels are fitted together, they shall form a flush-fronted continuous panel of uniform height. Front door and top cover dimensions shall match. Instruments, relays, and control devices shall be mounted at a height not more than 2000mm and not less than 300mm from floor level.

The arrangement of equipment within each enclosure shall be such as to permit easy

access for installation and maintenance. No instruments, relays or other components shall be mounted on rear access doors or removable covers.

- (i) **Local control panel (LCP):-** Local Control Panel shall be provided for each Motor near the drive and shall be Interconnected with MCC. The Local Control Panel shall have the following Provisions.
- 3 Push buttons START / STOP / EMERGENCY STOP
 - Start / Stop push button operates when the switch on LCP is in — ANUAL position.
 - Emergency Stop push button operates irrespective of the position of the switch.

When the selector switch on LCP is in —LOCAL position, the motor will be operated by push buttons on LCP and will take into account only the specific fail-safe controls of the equipment (electrical protections, low level for a pump). When the selector switch on LCP is in —REMOTE position the drive will be operated from PLC.

➤ **Motorized Valves for STP's (Field Type):-**

Motorized valves will use fully integrated control Actuator. The actuator comes with integrated:

- Selector switch —Remote/ Local
- P.B's for: OPEN / CLOSE/ STOP.

Note:- Necessary Field Indicating devices (Where-ever process Interlocks are applicable) and LED's (Motor's, Actuator's etc., of feedback Indications) shall be provided on LCP's for Manual control operations.

2.8.5. Panels – Composite

In situations where space limitations preclude the use of separate instrumentation, control and automation (ICA) and switchgear panels and, at the sole discretion of the Engineer, ICA equipment may be combined within a single enclosure subject to the following conditions:

- The observance of all other clauses herein relating to enclosures, mounting boards and minor panels;
- The written assurance of each supplier of ICA equipment that the proximity of the switchgear will have no detrimental effect on the life or performance of any ICA component;
- The total segregation of ICA equipment and switchgear including the glanding and termination facilities;

- The absence of any voltage exceeding 250vac or 50vdc from any compartment containing ICA equipment;
- The use of the full height of the panel (excluding the bus bar chamber and Cable space) for any ICA equipment compartment.

2.8.6. Panel protection

Adequate facilities for isolation and protection by miniature circuit breaker or fuse for each instrumentation and control circuit and sub-circuit shall be provided and shall be so arranged that any interruption causes minimum disruption of plant, operates the appropriate alarm and cannot result in any unsafe operating condition.

All fuses shall be of the cartridge pattern and main fuses shall be of the high rupturing capacity type. Fuse and solid-link carriers and bases shall be of plastic molded insulating material of an approved make. Ceramic materials will not be accepted. Live connections shall be efficiently shrouded and it shall be possible to change fuses with power on without danger of contact with live metal. The fuses shall be rated to give maximum protection to the equipment in circuit and the rating shall be permanently inscribed on the fuse label and on the fuse carrier. Unless necessary for the protection of particular equipment, miniature circuit breakers used for individual circuits in a panel or control desk shall not trip on over-voltage or under-voltage.

Bases for solid links shall not be interchangeable with those for fuses. Fuses and links in the same circuit shall be mounted opposite each other in separate adjacent rows and shall not alternate in the same row. At least 10% and not less than two unallocated miniature circuit breakers or fuses and links shall be provided in each panel distribution board. Miniature circuit breakers and fuses of similar size and rating shall be of the same make and type.

At least 10%, and not less than two, spare fuses and links of each rating shall be provided and fitted in clips inside the panel.

Each instrument requiring a power supply shall be individually wired and protected so that, in the event of a failure in one circuit, the remainders are unaffected. Power supply circuits shall be of sufficient rating that any protective device may operate without reducing the voltage at the terminals of any other component to an unacceptable level.

2.8.7. Panel isolation

Clearly-labelled isolating circuit breakers shall be provided for each incoming power supply. Switches shall be of the quick make-and-break type with spring loaded contacts that close fully without requiring full operation of the handle. The handle and cover shall be interlocked so that the handle cannot be operated when the cover is open and the cover cannot be opened unless the switch is in the 'off' position. The 'on' and 'off' positions of each switch shall be indicated clearly.

Circuit breakers for panel power supplies shall be mounted near an access point and in positions where they may be operated easily from a standing position.

Plug-in isolating links or devices of an approved type shall be provided in any circuit that may still be live when the power supply isolators are in the 'off' position, as, for example, in circuits controlling equipment whose power supply is independent of the panel. Such links or devices shall be properly screened and, if not incorporated in or adjacent to their associated outgoing terminals, shall be project 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.

2.8.8. Panel terminal blocks

External wiring for panel power supplies shall be terminated on the appropriate isolator. Signal cables from strain gauges, analysers, resistance thermometers, retransmitting slide-wires and thermocouples may be terminated at their appropriate instruments.

A terminal block shall be provided as the interface between the corresponding conductors of each internal and external wire and each internal and external connection except those listed above. The terminal blocks shall be mounted vertically where possible and not nearer than 230mm to the floor or less than 230mm from an incoming cable gland.

Terminal block rows shall be spaced apart by not less than 150mm and arranged to permit convenient access to wires and terminals and to enable ferrule numbers to be read without difficulty.

Other circuits shall be grouped on the terminal blocks according to the classification given in the clause for 'Panel internal wiring' which shall be clearly marked along the corresponding section of each terminal board. Groups of different voltages on the same board shall be separated by insulated barriers.

All connections shall be made from the front of terminal blocks and no live metal shall be exposed at the back. All terminal blocks shall be of the type which clamps the wire securely and without damage between two plates by means of a captive screw and which permits removal of any terminal without disturbance to adjacent terminals. Pinch-screw type terminal blocks will not be accepted. Terminal moldings shall be in melamine to BS 1322, polyamide or equivalent. Terminal rails shall be hot-dip galvanised. Current bars between the two connection points of each terminal block shall be of copper or brass with tin/lead alloy plating. All steel parts shall be zinc-plated and passivated with a yellow chromate layer. Terminal blocks for input and output analogue signals and for circuits containing volt-free contacts internal or external to the cabinet shall be of the Klippon type SAKC or equivalent which permit the connection of a test milliammeter or continuity meter without disconnecting any wiring. Terminal blocks for power supplies for equipment external to the panel shall permit the isolation of the item of external equipment without affecting the operation of any other circuit within or outside the panel.

No more than one core of external cables or two internal wires shall be connected to any terminal. If terminal blocks are used as common points for two or more circuits, individual terminals with the appropriate number of permanent cross connections shall be provided. The lengths of exposed cable cores shall be sufficient to reach any terminal in the appropriate row or rows. The cores shall be formed into a neat loom and a separate loom shall be provided for each cable.

Each row of terminal blocks shall contain at least 25% spare terminals over the number required for terminating all cores of external cables in that row. Unless otherwise specified, each external cable shall contain at least 20% spare circuits, with a minimum of one spare circuit. Terminal blocks shall be numbered consecutively in a sequence different from that used for identifying wiring. The terminal numbers, voltage grouping and terminal board layout shall correspond precisely with wiring diagrams so that quick and accurate identification of wiring can be made.

All the terminal boards shall be provided with covers of transparent insulating material that does not sustain combustion and shall be sectionalised where possible to give access to groups of terminals without uncovering all boards. Terminals which may be live when the panel is isolated from its main supplies shall be suitably labelled to minimise the risk of accidental contact.

2.8.9. Panel internal wiring

Panel circuits shall be segregated into the following categories:

Group 1: Power control and very-high-level signal wiring (above 50V):

- 1.2 ac power supplies;
- 1.2 dc power supplies;
- 1.3 ac current signals above 50mA (such as CT circuits);
- 1.4 ac voltage and control signals above 50V (such as PT circuits).

Group 2: High-level signal wiring (6V to 50Vdc):

- 2.1 signals from conventional electronic transmitters and controllers (such as digital or 4mA - 20mA);
- 2.2 circuits to alarm annunciators and other solid-state devices
- 2.3 digital signals;
- 2.4 emergency shut-down and tripping circuits;
- 2.5 on/off control circuits;
- 2.6 intrinsically safe circuits;

Group 3: Low-level signal wiring (5V dc and below):

- 3.1 signals from thermocouples;
- 3.2 signals from resistance thermometers and re-transmitting slide-wires;
- 3.3 signals from analytical equipment and strain gauges.

For Group 3 wiring, internal connections to the instruments shall be made by one of the following methods:

- (a) The twisted, screened conductors of the external cable shall be led direct to their appropriate instruments via ducting systems installed for this purpose during construction of the panel
- (b) The conductors of the external cables shall be terminated on terminals segregated from all other categories and the connections to the appropriate instruments shall be made using twisted pairs with individual screening installed for this purpose during construction of the panel. Internal wiring for all circuits in Group 2 except those sharing a common connection shall be multi-stranded, twisted pair, 0.75mm² minimum copper conductor with HPDE or PVC-insulated cable of adequate

grade and rating.

Wiring for circuits in other Groups or sharing a common connection shall be run in stranded, 1.0mm² minimum copper conductor with 250V grade, PVC-insulated cable of adequate grade and rating.

Wiring sheath colors shall be black for ac circuits, and grey for dc circuits (excluding thermocouple circuits) and blue for Group 2.6 circuits. Circuits supplied at 240V, between 240V and 110V dc shall also be physically segregated from each other and from other circuits. Access to wiring and components of circuits having voltages exceeding 240V shall not be possible unless and until the circuit has been isolated.

Separate ducts, trunking, cable looms, tray work and the like shall be provided within the panel for each category with at least 150mm between parallel paths of Group 1 and those of any other Group. Intrinsically-safe circuits and their terminals shall be segregated from other circuits and terminals.

All wiring shall be neatly and securely fixed by insulated cleats, bunched and secured by approved plastic strapping or run in approved insulated wiring trunking or non-corrodible flexible tubing. Not more than 75% of the capacity of trunking, ducts, looming, 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.

2.8.10. Panel wiring identification and termination

Identification ferrules shall be fitted at both ends of each wire. The numbers or letters used shall correspond with the appropriate wiring diagram. The ferrules shall be of plastic insulating material with permanent black characters on a color coded background for numbers and on a white background for letters, unaffected by oil or water. They shall be so arranged that they can be read logically from left to right when viewed normally.

The system of wire identification shall be such that wires in the same circuit on opposite sides of a terminal shall have the same reference, and this system shall be continued through all external cabling.

Terminal ferrules (spade, tongue, crimped connections) shall be provided on each conductor.

2.8.11. Panel Earthing

A continuous copper earth bar of not less than 25mm x 6mm cross section shall run the full length of each panel and shall be securely fixed and bonded electrically to the main frame. The cable gland- plates and the earth bar shall be provided with suitable brass terminals of not less than 6mm diameter for connecting the metal cladding or armouring of all incoming and outgoing cables to the station earthing system.

A second continuous copper earth bar of not less than 25mm x 6mm cross section, electrically isolated from the steelwork of the panel and metal cladding and armouring of cables, shall be provided for earthing the signal earth connection of each instrumentation and control device and the screen(s) of each instrument cable not earthed elsewhere to the station instrumentation earth plate. The earth bar shall have sufficient brass terminals as specified above for each instrumentation and control device and the screen of every shielded cable plus 25% spare terminals.

In multi-section panels, each earth bar shall be electrically bonded to the corresponding bars in the adjacent section(s).

The earth pit for instrumentation system shall be separate. Electric earth pit shall not be used for earthing of instrumentation equipment. All signal cable screens (analogue and digital) shall be terminated onto the instrument earth bar. Signal cable screens shall be earthed at the control panel end only. Screens at the field end shall be tied back and insulated.

SPD s associated with the control and instrumentation system shall be earthed to the instrument earth in accordance with the SPD manufacturer's recommendations.

2.8.12. Panel lighting

Each panel shall be adequately illuminated internally, as evenly and as free from dazzle as possible, by fixed fluorescent lighting controlled from totally-enclosed light switches and by totally-enclosed door-operated switches positioned so as not to interfere with access. There shall also be one installed inspection lamp per three metres of panel length or part thereof with adequate flexible connection cable to reach any point in the panel. The control switch for an inspection lamp shall form part of the lamp assembly. Lighting circuits shall

be fused independently of any instrumentation and control circuit and designed to allow lamps to be replaced safely and shall be fed from a distribution board and circuit breaker connected on the live side of the main panel ac supply circuit breaker.

2.8.13. Panel ventilation

Each panel shall be provided with ventilation fans as required to ensure that equipment within the panel is maintained within manufacturer's recommendations, with due regard to the environment in which the panel will be mounted. Fans shall be controlled by a suitably-labelled enclosed switch mounted internally in an accessible position.

Fans shall be mounted with their axes horizontal and shall be arranged to draw clean air into the panel. Air entries shall have filters which can be renewed from outside the panel and shall be designed to prevent the entry of rain, spray, injurious fluids, sand or dust.

2.8.14. Panel labels

All control gear shall be fully labelled with the KKS code identifying the equipment designation/function, all external and internal components, all rating data, detailed equipment operating data and for danger and hazard warning.

Labels shall be provided for every panel to describe the duty or otherwise identify the panel and its sections and every instrument, component and item of equipment mounted internally and externally. Where applicable, front-of-panel labels shall be as detailed in the Specification. Wording shall be clear, concise and unambiguous and shall be subject to review by the Engineer before manufacture. Each label shall be permanently secured to the surface near the item to which it refers. Externally-fitted labels shall be of Perspex or other approved transparent plastic, with letters and numbers rear-engraved and filled with black.

The rear surface of each Perspex label shall be finished with a coat of paint of the same colour as the panel external finish. Instrument duty labels fitted externally shall be below the item to which they refer. Embossed tape or similar adhesive labels will not be approved.

Laminated materials or rear-engraved and filled plastic shall be used for internally fitted labels, which shall be white with engraved black letters.

Labels conforming to the requirements of the preceding paragraphs or other approved means shall be provided:

- To describe or identify circuits or circuit components;
- To identify dc polarity;
- To warn or remind about dangerous or potentially-dangerous circumstances;
- Wherever elsewhere specified.

Unless otherwise specified, all engraving shall be in plain block letters, 4mm high.

The minimum practicable number of different sizes shall be used. Manufacturers' nameplates shall not be fitted on panel external surfaces.

2.8.15. Panel finish

For control and instrument panels, desks and cubicles a hard, smooth, durable finish, free of blemishes, shall be provided. Before painting, all external welds and any rough areas shall be smoothed, and all surfaces shall be thoroughly cleaned and free from scale, contaminates, corrosion or grease. If rust-proof or Zintec steel has not been used in the construction, the panel shall be treated with a passivating agent such as phosphoric acid. All internal surfaces shall have a minimum of three coats of paint of which the first shall be an approved anti-rusting priming coat and the final coat shall be an opaque gloss white enamel. All external surfaces shall have not less than five coats of paint of which the first shall be an approved etch-priming coat, and the second and third suitable undercoats, all of which shall be rubbed smooth when dry before application of the next coat. The undercoats shall be easily distinguished in shade or colour from the priming and finishing coats. The two final coats shall be of stove enamel paint, gloss or semi-matt finish, to a colour and finish to be advised by the Engineer. Stoving shall be carried out in accordance with the recommendation of the paint manufacturer.

The overall dry film thickness (DFT) shall be between 85 and 120 microns.

Nuts, bolts, washers and other fixing devices which may have to be removed for transit or maintenance purposes shall be galvanised or otherwise finished to an approved standard.

2.9 Instruments and ancillaries

2.9.1. General

All instruments, gauges and control equipment which perform similar duties shall be of uniform type and manufacture throughout the Works in order to facilitate maintenance and the stocking of spare parts.

All equipment shall be fully projected and suitable for the worst environmental operating conditions. Panel-mounted instruments shall be of the electrically operated flush mounted type and shall have damp-proof and dust-proof cases.

Instruments mounted outside instrument panels shall have weather proof and dustproof cases. Instrument cases shall be of corrosion-resistant material or finish.

Instrument screws (unless forming part of a magnetic circuit) shall be of brass or bronze. Access to terminal compartments of instruments mounted outside panels or other enclosures shall not expose any working part. Moving parts and contacts shall be adequately protected from the ingress of dust. Where applicable instruments shall be easily withdrawable from its housing for maintenance without interrupting its signal.

Unless otherwise specified, instruments shall be finished in the manufacturer's standard colour. Instrument dials shall be of such material that no peeling or discolouration will take place with age under tropical conditions.

Plant-mounted indicators and gauges shall be sized to give full legibility when viewed from a position with convenient and easy access or from the point at which any operation requiring observation of the gauge is performed. The minimum diameter for any gauge shall be 150mm except where forming part of standard instruments and accessories such as air-sets.

Dials and bezels shall be of bronze and internal components shall be of stainless steel, bronze or other corrosion-resistant material.

Unless otherwise specified, all functions shall be transmitted electrically and all analogue signal transmission systems shall be in accordance with BS 5863: Part 1 or equivalent and shall use a signal of digital or 4mA to 20mA dc. Where possible, measuring systems shall be designed so that any necessary power supply is taken from the appropriate instrument panel.

Transmitting devices shall have integral indicators to monitor the output signal or connections suitable for use with a portable test meter, and shall be capable of meeting the performance requirements specified in the appropriate part of BS EN 60770-1 or equivalent. For the important and critical processes the transmitting devices, such as pressure, temperature and level gauges, shall have a reference gauge installed locally for easy reference for the operation and maintenance staff.

The transmitters shall be provided with LCD meters.

Equipment mounted in enclosures shall be suitable for continuous operation at the maximum internal temperature possible in service, due account being taken of internally-generated

heat and heat dissipated by other plant. All components shall be rated adequately and circuits shall be designed so that change of component characteristics within the manufacturers' tolerances shall not affect the performance of plant. All equipment shall be designed to operate without forced (or fan) cooling.

Equipment provided with anti-condensation heaters shall be capable of operating without damage if the heaters are left on continuously. Unless provided with unalterable factory **configured** ranges, measuring instruments shall have zero and span adjustment.

Field mounted instruments shall be mounted such that they are easily viewable and easily accessible for maintenance.

Instruments not mounted in panels shall be supplied complete with all brackets, stands, supporting steelwork and weatherproof enclosures (separate from the instrument cases) necessary for securing them in their working positions and affording complete protection at all times including periods of servicing, adjustment, calibration and maintenance.

Each installation shall incorporate a valve and pipework for obtaining a sample representative of the fluid at the position of the permanent meter and drain. If the measuring and sampling points are remote from each other, the test and sample facilities shall be provided at both points.

In order that maintenance and inspection may be carried out safely and conveniently instruments mounted in elevated and open work areas shall be provided with safety ladders and a sufficiently sized working platform with sun shading.

2.9.2. Indicating Instruments and Meters

General

All instruments and meters shall be flush mounted and generally of the same pattern and appearance throughout and those which perform similar duties shall be of uniform type and manufacture.

Indicating instruments shall be fitted with an externally accessible zero adjuster. They shall have no parallax error and their normal maximum reading shall be approximately 60% full scale deflection.

Ammeters in motor starter circuits shall be capable of withstanding the starting current and shall have a compressed overload scale. The ammeter shall have an adjustable and sealable red pointer set to indicate normal full load current. The ammeter physical size shall be in keeping with the size of the starter concerned. The minimum size to be used is 0.25 DIN.

Indicating instruments shall comply with IS 1248, BS 89 or IEC 60051 and shall be of industrial grade accuracy.

(i) Panel Mounted Digital Indicators For Field Instruments

Digital panel indicators shall be microprocessor based and modular in design. It shall accept 4-20 mA DC isolated input. The digital panel indicator shall provide an output of 4-20 mA DC proportional to input signal for retransmission. It shall have RS 485 communication port for connectivity to PLC.

Technical Particulars

Type	:	Microprocessor based.
Mounting	:	Front facia of Instrument Control Panel(ICP)
Display	:	Back-lit LED
Digit height	:	12.5 mm or higher
No. of digits	:	4
Input	:	4-20 mA DC (isolated)
Zero & Span adjustment	:	Required
Engineering units for display	:	As per site requirement
Weather protection class	:	IP-52 of IS 13947
Retransmission output	:	4-20 mA proportional to Process variables.
Relay outputs	:	Required 2NO+2NC for high level alarm and 2NO+2NC for low level alarm
Communication port	:	RS-485 (With Modbus protocol)

(b) Kilowatt-hour meters.

Kilowatt-hour meters shall comply fully with IS 722 or BS 5685 Class 2 and shall have industrial grade accuracy ($\pm 2.5\%$). Three element units shall be used for 3 phase 4-wire systems. Two element units shall be used for 3 phase, 3-wire systems.

: 1 No. for each pump and incomers of 0.433 kV (or more) Switchboard (each motors)
As per site conditions.

Purpose : Power and Energy Monitoring

It shall monitor voltage, current, kW, kVAr, kVA, power factor and frequency. Technical

Particulars

Data logging

Data storage and it shall be retrieved via RS 485 port Soft

Integration

The meter shall be integrated with SCADA system to provide remote display of all measured parameters and meter configurations. The metering shall be via. RS 485 port.

Measurement

- True RMS measurement
- Instantaneous phase voltages, line voltages, phase currents and line currents
- Frequency
- Active, reactive, apparent powers and power factor per phase and line
- Energy-Import and Export
- Maximum demand kVA, kW, kVAr

Communications

- RS 485
- Baud rates minimum 9600

Accuracy Class

- 0.5 S

Accuracy Standards

- IS-14697:1999

Front Panel Display

- LED with back lighting
- Display for all basic power and energy parameters

- Specifications

- Password protection for setup parameters

Ratings

Voltage Inputs

- 50 to 347 VAC
- Accuracy VL-N: 0.25% reading
- Accuracy Hz : +/- 0.1 Hz
- Support 3 phase 3 wire, 3 phase 4 wire connections Standard screw in terminals

Current Inputs

- 5 Amp. Nominal
- Accuracy current: 0.25% reading
- 20% over range full accuracy

Power Supply

- 110 V to 240 VAC & VDC Environmental Conditions
- As per process Requirement- Ambient Temperature.
- Humidity: upto 95% non condensing

Dimension: Appr. 96x96x96 mm

I Microprocessor based Alarm Annunciator

- (1) Microprocessor based alarm annunciator shall be provided for generating audio-visual alarms for each abnormal condition. Alarms shall be initiated by the opening and closing of volt-free contacts which shall remain unchanged throughout the periods in which the alarm conditions exist. Alarm circuits shall be capable of conversion from open-healthy to open-alarm or vice versa by a simple configuration after installation requiring no additional parts or special equipment. Each alarm shall initiate the operation of both visual and audible devices. The sound intensity (adjustable) of each audible device shall be suitable for the maximum sound level of its environment.
- (2) Each alarm shall initiate a visible and audible indication of the specified condition. Unless otherwise specified, alarm indicators shall be grouped together in annunciator units each having at least 20% spare windows. Each alarm window shall consist of minimum 2 nos. of bulbs having cluster of LEDs and shall have screens engraved with legends approved by the Engineer's Representative.
- (3) When any alarm condition occurs, an audible device common to an alarm annunciator system shall sound and the appropriate indicator shall flash on and off. The flashing rate shall be selectable. Facility for selection of type of sequence shall be provided.
- (4) The operation or acceptance of one alarm shall not inhibit the operation of the audible device or the flashing of the appropriate alarm indicator if a future alarm condition occurs
- (5) An integral 'test' pushbutton shall be provided to illuminate each lamp and to operate the audible device but shall not cause a spurious alarm condition.
- (6) Alarm circuitry shall be arranged so that spurious or transient alarm states persisting for less than 0.5 seconds adjustable do not initiate any action.

- (7) Isolation facility shall be provided for the hooters.
- (8) Alarm annunciator/indicator legends or labels shall be arranged with three lines of text as follows:

i.	top line	:	Location
ii.	middle line	:	Parameter
iii.	bottom line	:	Status
e.g.		:	RESERVOIR LEVEL LOW

- (9) Alarm annunciator shall have RS-485 communication port (Modbus protocol) for interfacing with the PLC system.
- (10) A LED shall be provided to indicate the 'ON' status of the alarm annunciator.

Technical Particulars

Alarm annunciator shall be provided on instrument control panel for annunciation of alarms in control room. The technical particulars of alarm annunciator are as follows:

i.	Type	:	Microprocessor based, split type with alarm windows mounted on the front door
ii.	Mounting	:	Flush with panel
iii.	Construction	:	Modular
iv.	Inputs	:	Potential free, NO/NC contacts
v.	Size of windows	:	60 mm X 26 mm
vi.	Operating sequences	:	First up (user selectable dip switch)
vii.	Bulbs per channel	:	2 (Cluster LEDs)
viii.	Push Buttons	:	For Test, Mute, Acknowledge & Reset
ix.	Hooter	:	Required, electronic type
x.	Power supply	:	24 V DC/240 V AC
xi.	Power supply status Indication	:	Required
xii.	Weather protection	:	IP-52 of IS 13947
xiii.	No. of Windows	:	8 / 12 / 24, As required with 20 % Spare
xiv.	Quantity	:	As per process requirement

2.9.3. Indicator Lights

Indicator lights shall be not less than 20 mm diameter and shall be panel mounted types with metal

bodies adequately fastened so that the lamps shall be capable of replacement from the front of the apparatus without disturbance to the lamp holder or panel wiring . Lamp holders shall be keyed into panels to prevent rotation. Lens colours shall comply with BS EN 60037 as follows:

- power on white*
- running - green
- tripped/alarm red
- status (open, closed, etc) blue
- ready to start blue
- warning (no imminent danger) amber

Note:*white may be used where doubt exists as to which other colour to use.

The lights shall be under-run to give long life either by use of a resistor to limit voltage to 90% normal value or by using higher voltage lamps.

The indicating lamps on control panel shall be cluster of LED's.

2.9.4. Pushbuttons

Colours of pushbuttons shall generally comply with IS 6875, BSEN 60947, 60037 or IEC 60073 and in particular shall be as follows:

- stop, emergency stop red
- start green
- jogging/inching black
- reset (when not also acting as a stop) blue
- lamp test blue
- override/alarm accept yellow

2.9.5. Specification For Junction Boxes:

(A) Junction box (instrument)

1	Construction	:	3mm sheet steel hot
2	Protection	:	IP 65
3	Paint and shade	:	One coat of red oxide primer Powder coated light grey as per shade 631 of is:5

4	Terminal strip	:	Elmex type capable of Terminating 0.5 sqmm to 1.5 sqmm Cable din rail mounted
5	No of terminal strips	:	30/40/70 Rating:600v 10 a ac
6	Conduit & cable entry	:	Lower side
7	Gland plant thickness	:	3mm
8	Door of JB	:	Hinged with proper locking Arrangement to avoid entry of Dust & moisture the design of Fixing screws of the lids of the Junction box shall be such that They do not come out of the lids When completely unscrewed (captive screws)
9	Dimension	:	Vendor to provide most Economic dimension of JB based On the no of Terminal bases and cable Entry
10	Mounting	:	Frame mounted
11	Earthing	:	Two no of earthing bolts for JB Earthing separate instrument Earth bus on insulating clits to be provided
12	Name plates	:	To be provided material: white Engraved letters on black Anodized aluminum sheet Fixing: stainless steel screws Lettering:- black with white Engraved

(B) Junction box (power & control)

1	Construction	:	3mm sheet steel hot
2	Protection	:	IP 65
3	Paint and shade	:	Power coated light grey as per Shade 631 of is:5
4	Terminal strip	:	Elmex type capable of Terminating 0.5 sqmm to 1.5 sqmm Cable din rail mounted
5	No of terminal strips	:	30/40/70
6	Conduit & cable entry	:	Lower side
7	Gland plate thickness	:	3mm
8	Door of JB	:	Hinged with proper locking Arrangement to avoid entry of Dust & moisture the design of Fixing screws of the lids of the Junction box shall be such that They do not come out of the lid When completely unscrewed (captive screws)
9	Dimension	:	Vendor to provide most Economic dimension of JB based On the no of Terminal bases and cable Entry clearly specifying GA Drawing

10	Mounting		Frame mounted
11	Earthing		Two no of earthing bolts for JB Earthing
12	Name plates		To be provided material: white Engraved letters on black Anodized aluminium sheet Fixing: stainless steel screws Lettering:- black with white Engraved.

2.10 Cabling

2.10.1. Instrumentation cabling

Cables from conventional measuring transmitters and analogue process controllers, such as digital or

4mA to 20mA dc output from a constant-current source, (hereinafter referred to as high-level signals) shall be polyethylene or PVC insulated with stranded conductors and laid up as twisted pairs with one twist per 30mm reject. Each cable shall have an overall screen of braided copper or mylar backed aluminium foil giving a minimum coverage of 85%, a steel wire armouring insulated from the screen and from any ducting and an overall PVC sheath. For runs exceeding 30 metres or for all inputs to a data logger, computer or microprocessor, multi-core cables shall have an individual screen of braided copper or mylar-backed aluminium foil for each signal pair. The minimum conductor size shall be 24/0.2mm but shall be of greater cross-sectional area if required for the satisfactory operation of associated plant. Cables for intrinsically safe systems shall comply with BS 5308 and the relevant certificate.

Cables from strain gauges, analysers and the like, such as 0 to 100mV (hereinafter referred to as low level signals — see also below) shall be as specified above and shall have an individual screen for each signal pair.

Cables from indicating devices to alarm or tripping circuits shall be as specified above for high-level signals but shall use cables, cable trays, ducts and conduit separate from those for other high-level circuits.

Cables for high-level signals, low-level signals, resistance thermometers and thermocouples shall be segregated from each other and each shall be separated from cables for power, communications and other electrical services. Other cables run in the vicinity of instrumentation cables shall be twisted at the rate of one twist per 50mm approximately and shall be separated from instrumentation cables by a distance of not less than 300mm.

Initiating devices for plant protection and personnel safety shall be connected by individual

cables direct to the tripping or safety device and shall not be routed via any intermediate junction, marshalling box, cabinet, relay or similar. The outer sheaths of such cables shall be coloured orange.

Technical particulars:

- (i) Contractor shall include in his scope the supply, laying of cables and associated civil/mechanical work.
- (ii) Cables shall be capable of satisfactorily withstanding without damage, transportation to site, installation at site, and operation under normal and short circuit conditions of the various systems to which the respective cables are connected when operating under the climatic conditions prevailing at the site as indicated in this specification.
- (iii) Cable joints in instrument signals and power supply cables shall not be permitted.
- (iv) Cables shall be capable of satisfactory performance when laid on trays, in trenches, conduits, ducts and when directly buried in the ground.
- (v) Cables shall be capable of operating satisfactorily under the specified power supply system voltage and frequency variation.

Cables for analog signals

a) The cables shall comply with the following requirements:

Cables of 1100V grade, multi-pair/multi-triad cable, annealed, tinned, high conductivity, 1.5 sq. mm. stranded copper conductor, extruded PVC insulated two/three cores twisted into pair/triad, laid up collectively, individual pair/triad shielded and overall shielded with aluminium mylar tape, ATC drain wire run continuously in contact with aluminium side of the tape, inner sheathed with extruded PVC, armoured with galvanised steel wire and overall sheathed with extruded PVC conforming to IS 1554, IEC 189 & BS 5308 shall be used for analog signals.

b) Cables for digital signals

The cables shall comply with the following requirements:

Cables of 1100V grade, multi core cables, annealed, tinned, high conductivity, 1.5 sq. mm. stranded copper conductor, extruded PVC, overall shielded with aluminium mylar tape, inner sheathed with extruded PVC, armoured with galvanised steel wire, overall sheathed with extruded PVC conforming to IS 1554, IEC 189 & BS 5308 shall be used for digital signals.

c) Cables for Instrument/Equipment power supply

The cables shall comply with the following requirements:

Cables of 1100V grade, multicore cable, annealed, tinned, high conductivity, 2.5 sq. mm. stranded copper conductor, extruded PVC, inner sheathed with extruded PVC, armoured with galvanised steel wire, overall sheathed with extruded PVC conforming to IS 1554, IEC 189 & BS 5308 shall be provided for Instrument/Equipment power supply.

2.10.2. Telemetry cabling

Telemetry cabling between a master station and an outstation, unless otherwise specified, shall consist of a minimum of 6 signal pairs, of which two pairs shall be allocated to the telemetry system, one pair shall be allocated to a speech circuit and three pairs shall be spare. Each conductor shall be multi- stranded with an equivalent diameter of not less than 0.9mm. Conductors shall be laid up in starquad formation. The dc resistance of any pair of conductors shall not exceed 88 ohms per loop mile at 10°C and the difference between the resistances of the conductors of any pair shall not exceed 0.5% of the loop resistance of that pair.

Telemetry cables shall be designed for burying in water-logged ground.

Conductors shall be plain annealed copper with aluminium/polythene laminate sheath moisture barrier, copper or brass tape pest barrier, single galvanised steel wire armour and overall polythene sheath. The cable shall have a solid filling of petroleum jelly.

The characteristic impedance of each signal circuit shall have a nominal value of 600 ohms at 800Hz and the circuits shall be suitable for signal input levels of between -30dbm to +4dbm (0dbm = 1mW into a load of 600 ohms). The overall attenuation between the terminations of any circuit at the mean frequency of the band width specified elsewhere shall not exceed 20dbm and the attenuation at any two frequencies within this band width shall not differ by more than 6dbm. The transmission time for any two frequencies within the band width specified elsewhere shall not differ by more than $1 / (4 \%$

B) seconds, where B is the transmission speed in bauds, as specified elsewhere.

The signal-to-noise ratio within the bandwidth specified elsewhere shall be better than 12db. The frequency of any received signal shall not differ from the frequency of the corresponding transmitted frequency by more than 1% of the transmission speed in bauds specified elsewhere.

Loading coils as necessary to meet the performance requirements detailed herein shall be supplied and installed at equally-spaced points.

(i) Fiber optic cable

To facilitate the proper and efficient co-ordination of the Works the Contractor shall sublet all

Cabling Works to one Sub-Contractor who has proven and successful experience in fiber optic cable installations on projects similar to the one now proposed.

If cable sizes are not indicated on Drawings or in schedules, determine the correct size based on total end to end signal attenuation not to exceed 40 dB, including all splices and termination losses, and after taking into consideration.

- i) Type of fiber
- b) Ambient conditions
- c) Method of installation
- d) The disposition of each cable relative to others

All cables and wires shall be suitable for installation and continuous services in the ambient conditions described elsewhere in this document.

Shop Drawings and Product Data shall be submitted for the approval of the Engineers as follows;

- Submit full technical details of each type of cable proposed.
- Submit copy of test certificates from the manufacturer or an independent testing authority confirming that cables comply with the specification.
- Submit exact route of the cable run and relevant Sections in the shop drawings.

Each drum length of cable shall be allotted a distinct and separate reference number. This number shall appear on the test certificate covering the respective length of cable and shall also be clearly marked on the cable drum.

The Contractor shall advise the Engineer upon delivery to site of each drum length, quoting the reference number, the test certificates shall be handed to the Engineer for examination and approval. All cables shall be delivered to site with the manufacturer seals, labels or other proof of origin intact. These labels and seals shall not be removed until the cable is required for use and shall be retained for inspection by the Engineer.

The Contractor shall be responsible for the off-loading and handling of the cables on site, and shall ensure that cables are delivered to site on drums and properly protected against mechanical damages. Where lengths are cut from cables, the open ends shall be sealed.

The contractor shall be aware of the need to supply and install all cables for this Contract which are most suitable for the special environmental conditions prevailing in this project.

The cable shall comprise 8 fibers, loose tube, two fibers per tube with central 1.5 mm

nominal steel central strength member, moisture barrier, steel tape armored in continuous lengths up to a maximum of 6.0 km or as dictated by cable joint chamber locations and route survey.

Single Mode	
Type of fiber	Single mode, doped silica
Core Diameter	9.0 ± 0.5 micro m
Cladding Dia	125 ± 2.0 micro m
Coating (outer) Diameter	250 ± 15 micro m Material UV curable acrylate
Numerical aperture	0.11 micro m
Attenuation	<0.4 dB/km @ 1300 nm <0.2 dB/km @ 1500 nm
Bandwidth	1000 MHz @ 1300 nm
Chromatic Dispersion	3.5 ps/nm x km @ 1300 nm 20 ps/nm x km @ 1500 nm
Operating temperature range	-30 to +80 deg. C
Crush resistance	>200N/cm
Weight	500 kg/km (maximum)
Tensile strength	2000 N (minimum)
Multi mode	
Type of fiber	Multi mode, doped silica
Core Diameter	62.5 ± 3.0 micro m
Cladding Diameter	125 ± 2.0 micro m
Coating (outer) Dia	250 ± 15 micro m Material UV curable acrylate
Numerical aperture	0.275 + 0.15 micro m
Attenuation	<3.2 dB/km @ 1300 nm <0.9 dB/km @ 1500 nm
Bandwidth	500 Mhz x km @ 1300 nm
Operating temperature range	-30 to +80 deg. C
Crush resistance	>200N/cm
Weight	500 kg/km (maximum)
Tensile strength	2000 N (minimum)

2.10.3. Cable termination boxes

Cable termination boxes shall have double-ended screw terminals with removable links to facilitate core isolation during testing. Each box shall contain sufficient terminals for every conductor plus 20% spare terminals. Cable termination boxes shall have cable sealing chambers and insulated glands with earthing terminals so that the armouring may be earthed or isolated from earth, as circumstances dictate.

Termination boxes for use within buildings shall be of sheet steel with hinged or removable front covers. All other termination boxes shall be cast steel or heavy gauge sheet steel

construction giving protection to IP55. All termination boxes shall be hot-dip galvanised or approved equivalent finish. Each terminal box shall have a removable, un-drilled gland plate and the Contractor shall supply and fit the requisite number of cable glands.

At each cable termination box, each cable core (including spares) shall be identified by a numbered slip-over type collet. The numbering for a particular cable core shall be the same throughout its length.

Cable joints shall be at points approved by the Engineer.

Each cable joint shall be of the straight-through type. The conductors shall be ferrule-jointed with the insulation maintained by heat-shrink sleeving. Joint closure shall be made with epoxy resin and the completed joint shall be impervious to water if submerged or in waterlogged ground. If cast iron joint boxes be used, they shall be provided with cable glands and, after installation and testing, shall be covered with Densomastic HD compound or equal; so that all sharp corners, bolts and projections are moulded to a smooth surface. Two lappings of Densopol grade ZN 50mm tape, or equal, shall then be applied overall. Jointing shall be carried out on each conductor, including any provided in excess of the minimum quantity specified. All materials and things of every kind required for the cabling jointing shall be provided by the Contractor.

2.10.4. Cable project

At each end of each cable, in a uniform and visible position, a label shall be fixed on the cable to indicate the site cable number and route, and the number and size of conductors. Labels shall be made of brass, aluminium, lead or copper strip, engraved and retained by suitable non-rusting or non-corrodible binding wire passing through two fixing holes, one at either end of the label. If the cable gland is not normally visible, then the label shall be fixed inside the panel by means of screws.

Three-phase power cable cores shall be identified A, B, C or colour-coded red, yellow, blue so that the correct three-phase sequence is preserved throughout the system. Single-phase power cable cores shall be colour-coded red and black.

Control cables shall have individual cores identified by means of suitable permanent ferrules bearing the same number at both ends. Core identification shall occur at every point of termination using an approved system of colour-coded ferrule markers. The size of these ferrule markers shall be such as to match the overall diameter of conductor plus insulation. Numbering shall read from the termination upwards on all cores.

Each cable and core shall bear the same number at both ends of the cable and core respectively.

(a) Power terminations — colour, number or letter.

(b) Control terminations — letter or number or both.

2.10.5. Cable terminations

All PVCSWAPVC, PVCPCVC and XLPESWAPVC cables shall be terminated with mechanical glands which shall comply with BS 6121. They shall seal the inner and outer cable sheaths against ingress of dirt and moisture and provide adequate mechanical support. Each cable gland shall be protected by corrosion-resistant molded PVC hoods, covering the entire assembly from the overall sheath to the gland neck.

Glands for armoured cables shall provide a positive armour clamp to the enclosure so that no tension is applied to the termination. The clamp shall also provide a high level of earth continuity and be of adequate size to withstand the full fault current of the system for one second.

All glands shall be provided with an earthing tag. For cables of 4mm² or less, a serrated washer may be used instead for earth continuity.

The cable termination and sealing equipment shall be obtained from the cable manufacturer, or other approved supplier, and shall be purpose-made for the type, size and grade of cable concerned. The application of these materials shall be strictly in accordance with the manufacturer's instructions.

Through joints shall be permitted only on long cable runs outside buildings. Where such joints are necessary; the cables shall be jointed with epoxy or acrylic resin Cold-setting compound which has been pre-measured and pre-packed ready for use.

The boxes shall be of a split moulded plastic type with filling vents for compound.

Bonding straps shall be fitted with armour clamps across the joint and inspected by the Engineer prior to filling the box with compound. Wrapped pressure type joints shall not be accepted.

Conductor cores shall be jointed number to number or color to color.

2.10.6. Cable installation-general

Cables which are to be run on walls, ceilings or other building structures shall, unless otherwise agreed by the Engineer, be secured on cable trays and ladders or enclosed in conduit or trunking.

Every cable shall be neatly run vertically or parallel to adjacent walls, beams or other structural members. Cables shall not be installed in areas of direct sunlight.

Where this is unavoidable, approved sun shields shall be supplied and installed.

Where the building structure incorporates purpose-built covered duct or trench systems for main cables, instrumentation cables shall be segregated and installed on tray work or otherwise secured to the sides of the duct or trench.

Where the structure incorporates general service ducts or trenches containing pipework, chemical lines and other services, all cabling shall be segregated from the other services and shall be run on the walls unless otherwise agreed by the Engineer.

Cables shall be spaced to prevent interference between power and signal cables, and to avoid unnecessary crossovers.

The spacing of clips, saddles and cleats shall prevent the sagging of the cables during their installed life. The method of fixing clips and the like shall be by means of non-corrodible screws inserted into approved wall fixings, such as raw lplugs.

Cable hangers, cleats, saddles, brackets and similar supporting devices shall be of an approved type and of adequate strength for the cables they are supporting. They shall be treated to withstand Site conditions without corroding. Self-locking plastic buckle clips and strapping shall not be used. The arrangement and fixing of each cable shall permit the removal and replacement of any cable without disturbance to any other cable or the fixings thereof.

When cables are terminated in any particular item of equipment, special care shall be taken to ensure that the cables finally approach the equipment from a common direction and are individually terminated in an orderly and symmetrical fashion.

Submissions which the Contractor shall submit the following in relation to cable installations in addition to submissions detailed elsewhere in the Specification.

2.10.7. Drawings and schedules:

- Block diagrams to show control cabling systems with each cable and terminal equipment being identified as in the cable schedules.
- Cable route and layout drawings. For those items which are underground, these drawings shall include the following:
- Route plans and sectional views for all cable runs, cable trays, cable ducts and cable trenches;

- The position of all marker posts, joints, draw pits and the like.
- Cable schedules shall detail the cable number, type, voltage, size, route length and number of cores or pairs. Control-cable schedules shall detail the connected and spare core numbers, diagram number for connected equipment, core ferrule and terminal reference number.

2.10.8. Data and calculations:

- Manufacturers' catalogues and data sheets for all cables and fittings.
Cable Sizing Calculations.

2.10.9. Test certificates:

- Test certificates for all witnessed and routine tests carried out at the manufacturer's works and at Site (calibration).

2.10.10. Cable trays and ladders

Cable tray and cable-support ladders shall be of heavy-gauge galvanised steel and with an overall

PVC coating when required to the approval of the Engineer.

Cable tray and ladder systems shall be installed using factory-made supports, joints and junction/bend pieces. Wherever tray and ladder sections are cut and shaped on Site, cut edges shall be dressed and painted with at least two coats of cold galvanising compound or lead-based anti-corrosive paint.

Ladder systems shall be secured to walls and ceilings by pre-formed galvanized interlocking channel.

2.10.11. Flexible conduits

Flexible conduit shall be of the waterproof galvanised type of PVC wire-wound type with cadmium-plated mild steel couplings. Lengths of flexible conduit shall be sufficient to permit withdrawal, adjustment or movement of the equipment to which it is attached and shall have a minimum length of 300mm. Flexible conduit shall not be used as a means of providing earth continuity. A single earth conductor of adequate size shall be installed external to the conduit complete with earth terminations.

Where conversion from rigid conduit to flexible metallic conduit is to be made, the rigid conduit shall terminate in a trough-type box. The flexible conduit shall extend from this box to the equipment; the earth continuity cable shall be secured to the box and to the piece of equipment. The use of lid facing screws and the like will not be permitted. Adaptors shall

incorporate a grub screw or a gland to prevent the flexible conduit becoming loose.

2.10.12. PVC conduit

Where galvanised conduit would be liable to corrosion, PVC conduit shall be installed.

PVC conduit shall be of the oval or round high impact non-flame-propagating type as specified and self-extinguishing, to BS EN 61386-21. Surface and concealed installations shall be generally as described for steel conduit.

PVC conduit fittings shall comply with BS 4607. They shall all be white unless specified otherwise.

Jointing shall be carried out using PVC solvent and socketed accessories.

Expansion couplers shall be fitted in straight surface runs every 12m. The free end shall be sealed with non-setting mastic to form a waterproof seal.

Purpose-made bends may be used providing that the cable bending radius is maintained. Cracked or crinkled conduit will be rejected.

The conduit shall be suitable for use in ambient temperatures of between -5°C and $+60^{\circ}\text{C}$ and shall not be installed in areas that receive direct sunlight. A separate protective conductor (earth-continuity conductor) shall be installed.

Adaptable boxes and accessories shall be made from heat-resistant insulating material. The minimum wall thickness of boxes having a nominal internal depth of 16mm or less shall be 1.5mm. For deeper boxes, the minimum wall thickness shall be 2mm. All boxes which are intended to support luminaires or other heat sources shall have either external fixing lugs riveted to the metal inserts or utilise steel insert clips.

2.11 Cable installation methods

2.11.1. General

All cabling installation methods shall be subject to the approval of the Engineer.

2.11.2. Installation directly into the ground

Where cables are buried in the earth, the bottom of the excavated trenches shall be freed of sharp stones and other projections and covered with sand to a depth of 50mm.

Cables shall be unrolled from drums without loops and kinks, and care shall be taken when laying to avoid damage to the outer sheath by drawing over sharp projections.

Cables shall be snaked into the trenches to avoid tension in the cables during backfilling or from subsequent settlement. After laying, cables shall be covered to a minimum depth of

100mm of compacted sand and shall have a layer of protective interlocking concrete cable tiles. The tiles shall be overlaid with marker tape.

When cables of different voltages are laid together at the same depth, vertical cable tiles shall be used to segregate the cables.

ICA and communication cables shall be laid not closer than 1000mm to high voltage cables.

A sufficient number of rollers shall be provided so that the cable does not touch the ground or twist during pulling.

2.11.3. Installation in underground ducts

Underground ducts shall be constructed of impact-resistant uPVC and laid at a minimum depth of 500mm (to the duct centre), surrounded by at least 75mm of sieved sand. At road crossings, uPVC ducts of minimum diameter 100mm shall be laid at a minimum depth of 1000mm (to the duct centre). The ducts shall be encased by 150mm concrete on all sides.

When installing cables in ducts, the following measures shall be observed:

- Cables shall be pulled in a straight line;
- Rollers shall be positioned at the edges of drawpits both at the drawing-in and drawing-out points over which the cables shall be drawn;
- uPVC pipes and cable sheaths shall be coated with an approved lubricant;
- Sufficient draw-in points shall be provided and adequate room allowed for installation of cables;
- The pulling rope shall be guided by rollers.

Only one power cable shall be drawn into each duct.

Whenever a duct is laid in the ground, a draw-wire shall be pulled through with at least 1000mm excess at each end and the draw-wire left in position if the duct is not to be used immediately.

2.11.4. Sealing cable entries into buildings

Whenever cables pass through walls below ground level, the point of entry shall be sealed against the ingress of water. This shall be achieved with silicone foam or similar.

All cable entries into a building shall be in ducts and where the cables pass in or out of ducts, together with any spare ducts, the ducts shall be sealed against the ingress of moisture by means of duct stoppers and bituminous compounds or by any other method approved by the

Engineer. The stopper shall have a fire resistance of at least 30 minutes.

2.11.5. Marking of underground cables

The location of all underground cables shall be identified by:

- Brass plates fixed to the exterior surface of all walls of buildings 300mm above ground level and directly above the point where cables pass through the wall;
- Marker posts in road verges and the like at intervals of not more than 100m and at all junctions and changes of direction along the route;
- Marker posts at 10m intervals within an enclosed site and at all junctions and changes of direction along the route.

Marker posts shall be of concrete, not less than 200mm high above ground with an inscribed brass or enamel metal plate. The inscription shall indicate the presence of a cable below, the depth, classification and voltage rating.

A drawing or sample of a typical marker post shall be submitted for the approval of the Engineer.

2.11.6. Installation in cable trunking

Cable trunking shall be manufactured from mild steel of not less than 1.25mm and shall be hot-dip galvanised. The Contractor shall ensure that the size of the trunking is adequate for the number of cables to be installed together with 50% spare capacity. Trunking shall have minimum dimensions of 50mm x 50mm.

Segregation of cables shall be carried out if required using continuous sheet steel barriers with the bottom edge welded to the trunking. The trunking shall have two return flanges for rigidity. Where necessary, additional strengthening straps shall be fitted internally. The cover shall overlap the trunking and be made of the same gauge. Fixing screws for covers shall be recessed and be of the self-retaining quick-fix type. All bends, tees and intersections shall be of the gusset type and shall, wherever possible, be purpose-made by the manufacturer and of a matching design to the main trunking. Cables shall be retained in the trunking when the cover is removed by means of straps. Internal connecting sleeves shall be fitted across joints in the trunking and earth continuity ensured by bonding each section of trunking to a continuous earth wire.

Non-flammable fire barriers shall be inserted where the trunking passes through walls or floors. Conduit connections to trunking shall be made by flanged couplings and male bushes.

Trunking shall be supported at intervals not greater than 2m horizontally or 2.5m vertically. Crossings over expansion joints shall be made in flexible conduit.

Should it be necessary to cut or drill a section of trunking, the bared ends shall immediately be given a coat of zinc-rich cold galvanising paint.

Cable and trunking runs shall be determined by the Contractor and agreed by the Engineer before any work is started. The run shall be at least 150mm clear of plumbing and mechanical services.

Trunking systems erected outside a building shall be weatherproof.

2.11.7. Installation in troughs and trenches

Where the building structure incorporates purpose-built covered trench systems, power distribution cables may be laid on the floor of the trench. Control and instrumentation cables shall be segregated and installed on supporting steelwork or cable trays secured to the walls of the trench. Where the building structure incorporates general service trenches containing pipework, chemical lines and other services, all cabling shall be segregated from other services and run on the trench walls. Crossovers shall be kept to a minimum and cabling shall be taken above wet service pipework.

Cable trays shall be of perforated steel with formed flanges and of minimum thickness not less than 1mm for trays up to 100mm width, not less than 1.25mm for trays from 100mm to 150mm width and not less than 1.5mm thickness for trays from 150mm to 300mm width.

Cable-tray supports shall be of sufficient strength to maintain rigid support to the fully-laden cable tray along its entire length. All brackets and tray work shall be suitable for withstanding a temporary weight of 125kg.

Wherever possible, cable trays shall be installed in full lengths without cutting.

Should it be necessary to cut or drill a length of tray, the bared ends shall be dressed and immediately be given a coat of zinc-rich cold galvanising paint. Similarly for PVC-coated trays, the bared end shall be immediately sprayed using a PVC aerosol.

All cables shall be firmly secured to the tray using purpose-made saddles, as approved by the Engineer, together with proprietary cable cleats.

2.11.8. Installation in buildings

Cables required to be run on walls, ceilings, or other structures shall be carried on substantial cleats, either in groups or simply at spacings determined by rating requirements, supported on tray or ladder racks or enclosed in conduit or trunking.

All cables shall be neatly run vertically or parallel to adjacent walls, beams or other structural members.

The spacing of clips, saddles and cleats shall be such as to prevent the sagging of the cables during their installed life. The method of fixing clips and the like shall be by means of non-corrodible screws inserted into approved wall fixings.

Cable hangers, cleats, saddles, brackets and similar supporting devices shall be of an approved type and of adequate strength for the cables they are supporting. They shall be treated to withstand site conditions without corroding. Self-locking plastic buckle clips and strapping shall not be used.

Hangers shall be spaced according to recommendations in the IEE Wiring Regulations. Allowance shall be made for expansion and contraction of the cables.

Cables shall be located between 50mm pegs spaced at 40mm centres across a rung so that a 40mm or 80mm space is maintained between cable centres. Cleats shall be used where the ladder racking is vertical.

Cables shall be run at least 150mm clear of plumbing and below heating and hot water pipework.

2.11.9. Cable installation in conduits

Conduits shall be either galvanised heavy-gauge steel screwed type or light-gauge steel non-screwed type, steel or PVC. Accessories shall either be malleable cast iron or pressed steel.

A space factor of 40% shall not be exceeded and, in any case, conduit shall have a minimum diameter of 20mm. The tubing is to be perfectly smooth inside and out and free from imperfections. Both ends of every length of tubing shall be reamed and all sharp edges removed before erection.

Where conduits converge, adaptor boxes shall be used. Conduits shall be connected by means of male brass bushes and couplings. Where conduits are greater than 25mm diameter, straight-through joint boxes shall be of the trough type. Where conduit or fittings are attached to equipment casings, the material of the casing shall be tapped for a depth of not less than 10mm or male bushes and flanged couplings may be used.

Hexagonal lock nuts shall be used at running joints. They shall seat firmly and evenly on to mating faces. All function boxes, draw-in boxes, and inspection fittings shall be placed so that the cables can be inspected, withdrawn and re-wired during the life of the installation.

Generally not more than two bends or offsets or one coupling will be permitted without a suitable inspection accessory. Fish wires shall not be left in conduits during erection.

The whole of the installation shall be arranged for a loop-in type of system with joints being carried out at switches, isolators or appliance fittings.

Ends of conduits which are liable to be left open for any length of time during building operations shall be plugged to prevent the ingress of dirt and covers shall be fitted on all boxes.

Generally, conduits shall not cross expansion joints of buildings. Where they cannot be installed in any other manner, a galvanised flexible conduit shall be used across the expansion joint. A total of 150mm movement shall be allowed.

2.12 Process Instrumentation

2.12.1. General

Instrumentation system shall be designed, manufactured, installed and tested to ensure the high standards of operational reliability. All electronic components shall be adequately rated and circuits shall be designed so that change of component characteristics shall not affect plant operation.

All instrumentation equipment shall be new, of proven design, reputed make, and shall be suitable for continuous operation. Unless otherwise specified, all instruments shall be rejected. The outdoor equipment shall be designed to withstand tropical rain. Wherever necessary space heaters, dust and water proof cabinets shall be provided. Instruments offered shall be complete with all the necessary mounting accessories.

Electronic instruments shall utilise solid state electronic components, integrated circuits, microprocessors, etc., and shall be of proven design.

No custom made hybrid type integrated circuits shall be used.

Unless otherwise stated, overall accuracy of all measurement systems shall be $\pm 1\%$ of measured value, and repeatability shall be $\pm 0.5\%$.

Unless otherwise specified, the normal working range of all indicating instruments shall be between 30% and 80% of the full scale range.

On resumption of the supply following a power failure the instruments and associated equipment shall start working automatically.

The instruments shall be designed to permit maximum interchangeability of parts and ease of access during inspection and maintenance.

Unless otherwise stated, field mounted electrical and electronic instruments shall be weatherproof to IP-65.

The instruments shall be designed to work at the ambient conditions of temperature, humidity, and chlorine contamination that may prevail but in any case not less stringent

than those conditions detailed in the Project Requirements. Instruments shall be resistant to corrosion in the atmosphere in which they are expected to operate.

Lockable enclosures shall be provided for all the field mounted instruments.

All field instruments, and cabinets/panel mounted instruments shall have tag plates/name plates permanently attached to them. Details of proposed inscriptions shall be submitted to the Employer for approval before any labels are manufactured.

All coated parts of sensors shall be made out of non corrosive material capable of working with chlorine content of 5 ppm.

For all instruments installed in the field, surge protection devices (SPD s) shall be provided at both ends of the connecting cable for protection against static discharges / lightning and electromagnetic interference.

Individual pair screened, overall screened, armoured cables shall be used for analogue signals and armoured, overall screened cable shall be used for digital signal cables.

2.12.2. Flow Measuring Systems

Flow measuring system shall consist of flow sensor / transducers, flow computer and flow transmitter. Flow transducers shall be rugged in construction and shall be suitable for continuous operation. Flow transducers shall have waterproof construction and shall be suitable for installation in underground/above ground pipelines.

To avoid the effects of disturbances in the velocity profile, a straight and uninterrupted run, upstream as well as downstream from the location of the flow sensor shall be provided in accordance with the requirements of the flowmeter manufacturer.

The flow transmitter shall be suitable for field or panel mounting and shall accept an input from the flow sensor. It shall process the input signal and provide 4-20 mA dc output proportional to flow rate. The flow range shall be adjustable.

A zero span adjustment facility shall be provided for flow transmitter and indicator.

Flow measurement shall not be affected by physical properties of sewage viz., temperature, pressure, viscosity, density etc., within given limits. Contractor shall provide compensating electronic circuits if required. The overall accuracy of flow measuring systems shall be at least ± 1.0 % of the measured value unless otherwise stated.

(i) Electromagnetic Flow Meter (Full Bore): General

The Electromagnetic Flow Meters shall be installed in RCC chambers / open pits or buried for indication of flow rate and total consumption of water in a transmission or

distribution pipe work of water supply system.

The Electromagnetic Flow Meters shall withstand maximum working temperature and working pressure shall be as per process requirement.

Electromagnetic Flow Meter

Full bore electromagnetic flow meters shall be designed, manufactured and calibrated to ISO standard. The flow meter shall be capable of measuring bi-directional flow.

General Specification

Electromagnetic Flow Meter shall be a velocity sensing electromagnetic type, microprocessor based signal converter, Flow Integrator and Totalizer sealed housing, flanged tube meter as per working pressure requirement. The meter shall be manufactured to highest standard available for mag-meters. The accuracy shall be inclusive of linearity, hysteresis, and repeatability, temperature and pressure effects. The meter assembly shall operate within a range of 0.3 m/sec to 5 m/sec and pressure rating shall be as per process requirement to be constructed as follows Meter tube shall have a constant nominal inside diameter offering no obstruction to the flow.

Signal Converter shall be pulsed DC coil excitation type with auto zeroing. The signal converter shall be remotely mounted away from the meter.

The converter shall indicate direction of flow and provide a flow rate indication and a total of flow volume for both forward and reverse directions.

The converter shall provide an isolated 4-20 mA output into minimum 600 ohm load and a frequency output of a maximum of 0-10 KHZ and a scaled pulse output.

The microprocessor based signal converter shall have a self-diagnostic test mode and backlit display that continuously displays Rate of Flow and Total Volume.

The converter shall be compatible with Microsoft Windows and other software programs with built in terminal communication capabilities of RS 485, HART or other protocols for interface.

The converter shall be remotely mounted maximum upto 200 m from the sensor, and shall be supplied with all calibration complete for desired requirements.

The converter cum transmitter shall be fully programmable from the front facia. The programming shall be user friendly, self-prompting menu driven.

The length of the sensor shall be strictly as per ISO upto DN 600 mm and for other sizes it shall be as per the manufacturer's standard. Only, one manufacturer shall make all meter size and styles required for this contract.

(b) Open Channel Flow meter

Open channel flow measuring systems shall consist of level transducer, flow computer and flow transmitter. The level of the fluid in the flume shall be measured by the ultrasonic level transducer. The level measured shall be used along with the physical characteristics of the flume to compute the flow rate.

The level transducer shall be suitable for flange or bracket mounting as required and shall be environmentally protected as per IP65. It shall have ambient temperature compensation and adjustable datum setting facilities.

The design and application of ultrasonic level meters shall take into account the channel construction, the material size, shape, environment, process fluid or material, the presence of foam, granules, size etc.

The installation shall avoid any degradation of performance from spurious reflections, absorption, sound velocity variations, sensor detection area, temperature fluctuations, specific gravity changes and condensation. For application where spurious reflections are unavoidable the control unit shall be provided with facilities for spurious reflection rejection.

The structure required for supporting the level sensor, platform, railings etc shall be in the Contractor's scope.

2.12.3. Level Measuring System

(i) Ultrasonic Level Meters

Ultrasonic level measuring devices applied for level measurement shall comprise a transducer, control unit and remote indicator.

The transducer shall be suitable for flange or bracket mounting as required and shall be environmentally protected to IP 65. It shall have ambient temperature compensation, adjustable datum setting facilities.

The accuracy of the sensor shall be $\pm 0.25\%$ or better.

It shall be programmable with an integral programming keyboard and provide a digital display of the measured variable. It shall be provided with diagnosis facilities and shall provide an isolated 4 to 20 mA dc output signal proportional to the range of measurement.

The design and application of ultrasonic level meters shall take into account the vessel or channel construction, the material, size, shape, environment, process fluid or material, the presence of foam, granules, size etc.

The installation shall avoid any degradation of performance from spurious reflections,

absorption, sound velocity variations, sensor detection area, temperature fluctuations, specific gravity changes and condensation. For applications where spurious reflections are unavoidable the control unit shall be provided with facilities for spurious reflection rejection.

If turbulence exists, shielding, stilling tubes or other measures shall be provided to avoid effects on the measurement.

(ii) Conductivity Level Switches

The electrodes used for conductivity level switches shall be stainless steel. Single electrode systems (one electrode per holder) shall be used (except where their use is impractical) with insulated electrodes such that only the tip of each electrode is exposed to the liquid at the operating level.

Relay or control units operating with level electrodes shall have adjustable sensitivity. Electrodes for use in fluids of low or variable conductivity shall be fitted with conductivity discs.

Where relay or control units are not mounted in control panels, they shall be provided with surface mounting enclosures with a degree of protection to IP 55 for indoor locations or IP 65 for outdoor locations.

2.12.4. Pressure gauges and transmitters

Pressure gauges shall comply with BS EN 837-1 or equivalent and have concentric scales. For specially arduous duty where the gauge is subject to pressure pulsations and/or vibration, it shall be provided with a glycerine-filled dial and line snubbers shall be used. Bourdon-tube type differential- pressure gauges shall be capable of withstanding full line pressure on any side with the other side vented to atmosphere without damage to or effect on the calibration. No plastic material shall be used in their construction. Internal parts shall be of stainless steel, bronze or approved corrosion-resistant material.

The minimum diameter for round pressure gauges shall be 100mm unless specified otherwise or where the gauge forms part of a standard item of equipment.

Unless specified elsewhere the accuracy for pressure gauges shall be 1% of range, for diaphragm gauges 1% of range and for differential gauges 1.5% of range or better.

Where compensation of more than 2% of the instrument span is needed for the difference in level between the instrument and the tapping point, the reading shall be suitably adjusted and the amount of compensation shall be marked on the dial.

The zero and span of a pressure transmitter shall not change by more than 0.1% of the span per Celsius degree change in ambient temperature. After application for 10 minutes of pressure at 130% of maximum pressure, the change in zero and span shall not exceed 0.1% of the span. Pressure transmitters shall have an accuracy typically better than 0.1% of span, depending on the application and shall be protected to BS EN 60529: IP 65 standard or higher standard. For transmitters installed in meter chambers liable to flooding or underwater applications, they shall be to BS EN 60529: IP 68 standard and shall operate up to maximum submergence of 20 metres of water. Pressure transmitters shall provide a digital or 4mA to 20mA dc output proportional to the pressure range.

Pressure gauges and transmitters shall have primary isolating valves, 2 or 3 way valve manifold and vents, in such a way that it has the facility to calibrate the gauges or transmitters without removal.

2.12.5. Strain-gauge pressure transducers and transmitters

Strain-gauge pressure transducers shall use thin film sensors without bonding.

Each instrument housing shall be of all-welded Grade X 4 CrNiMo 17 12 2 stainless steel or equivalent and hermetically sealed. Non-interacting, zero and span adjustments shall be provided on each transducer. The measuring diaphragm shall be isolated from the process fluid by a noncorrodible barrier diaphragm. The mean time between failure for any model of strain-gauge transducer shall be not less than 15 years, and the performance of the measurement system shall be as given below, or higher performance:

- Accuracy: $\pm 0.1\%$ of calibrated span, including linearity hysteresis and repeatability;
- Repeatability: $\pm 0.05\%$ at maximum span;
- Stability: $\pm 0.1\%$ of upper range limit over 6-month period;
- Over-pressure: sustain a 400% over-pressure without damage;
- RFI / EMI effect: less than 1% of span with 500MHz at 5W direct contact;
- Power-supply variation effect: 0.01% per volt variation.
- Load variation effect: $\pm 0.0002\%$ per ohm of loop-resistance variation.
- Temperature: -29°C to $+82^{\circ}\text{C}$ range; total thermal error of $\pm 0.75\%$ of span over 0°C to 50°C ; Protection: IP 65.

Strain-gauge transducers which do not have terminals for their cable connection, shall have integral sealed-cable assemblies, installed in conduit and terminated at weatherproof junction boxes, protected to IP 65 each mounted near to its associated process transmitter. A digital or 4mA to 20mA dc output signal proportional to the transducer range shall be provided.

Strain-gauge pressure transmitters shall be generally as the transducer except that it shall incorporate a waterproof pressure transmitter producing a digital or 4mA to 20mA output signal. Provision for transducer venting shall be provided.

2.12.6. Temperature Monitoring System

Microprocessor Based Multi-Channel Temperature Scanner and Indicators

Panel mounted microprocessor based multi-channel temperature scanner shall be provided to continuously monitor temperature at different positions in each pump-set. The scanner shall have provision of accepting RTD/ thermocouple inputs. Facility shall be provided for grouping of channels for generating alarm/trip signals. Each scanner shall generate two nos. of potential free contacts for each group. The scanner shall have facility for interfacing with Programmable Logic Controller (PLC).

Technical Particulars

a) General:

Service	:	As per Process requirement
Installation hardware and accessories	:	Required
Type	:	Microprocessor based
Mounting	:	Front facia of Instrument Control
Panel(ICP) No. of channels	:	16 / 24- channels, As required with 20 % Spare.
Quantity	:	As per Process Requirement.
Input	:	From Temperature measuring sensors
Display	:	Separate LCD/LED displays for channel
no. and corresponding temperature		
Auxillary Outputs (Relay's)	:	Two Nos. For each channel
Digit height	:	12.5 mm or higher
No. of digits	:	2 nos. for channel no.
4 nos. (minimum) for process value display		
Zero & Span adjustment	:	Required
Engineering units for display	:	Deg. Celsius
Accuracy	:	± 0.2 % of span or better
Weather protection class	:	IP-52 of IS 13947

Relay outputs : Required 2NO+2NC for each group
Communication port : RS-485 (With Modbus protocol) for
interfacing with PLC

Bearing and winding temperature system shall be provided for HT/LT motors.

2.13 Specifications for Online water Monitoring System for Sewage water Treatment Plant SCADA Automation Works

Keeping in view its commitment to maintain and to monitor the process and the water quality of the STP water, intends to setup an online Sewage water quality monitoring system that will be installed at its treatment plant to access the plant process performance and ensure the treated wastewater quality is within the prescribed limits set by the CPCB

The major prerequisites of efficient online analysers are:

- Should be capable of operating unattended over prolonged period of time.
- Should produce analytically valid results with precision and repeatability
- The instrument/analyser should be robust and rugged, for optimal operation under extreme environmental conditions, while maintaining its calibrated status.
- The analyser should have inbuilt features for automatic water matrix change adaption.
- The instrument / analyser should have on board library of calibration spectras for different industrial matrices with provision of accumulating further calibration matrices
- Should have data validation facility with features to transmit raw and validated data to central server.
- Should have Remote system access from central server provisioning log file access.
- Should have provision for Multi-server data transmission from each station without intermediate PC or plant server.
- Should have provision to send system alarm to central server in case any changes made in configuration or calibration.
- Should have provision to record all operation information in log file.
- For each parameter there should be provision for independent analysis, validation, calibration & data transmission.
- Must have provision of a system memory (non-volatile) to record data for at-least one year of continuous operation
- Should have provision of Plant level data viewing and retrieval with selection of Ethernet, wireless, Mod-Bus & USB.
- In case of TOC analyser, the empirical relationship between TOC to COD or BOD must

be authenticated for all industrial applications and the correlation calculation (for factor) provided.

- The software will give alarm, in case of the concentration of parameter exceeds the prescribed norms by 10% continuously.
- The correlation/interpretation factor for estimating COD and BOD using UV-Visible Absorption Technique shall be regularly authenticated/ validated and details provided.
- Record of calibration and validation should be available on real time basis on central server from each location/parameter.
- Record of online diagnostic features including sensor status should be available in database for user friendly maintenance.
- Expandable program to calculate parameter load daily, weekly or monthly basis for future evaluation with flow rate signal input.
- Must have low operation and maintenance requirements with low chemical consumption and recurring cost of consumables and spares.

System Validation

Online instrument operation will be evaluated using the known buffers, traceable standards and laboratory techniques.

By validating sensors and probes with known standards such as KHP (potassium hydrogen phthalate) for COD & TOC, Formazin equivalent standard for TSS & pH buffers have to be used to calculate a running variance of the measurements.

Parameter validation

Each parameter is validated with reference to standard laboratory analysis and known standards.

Parameter Accuracy: Allowed Variability

The relative difference between online and laboratory measurements has to be between

- COD Accuracy $\pm 10\%$
- BOD Accuracy $\pm 10\%$
- pH Accuracy ± 0.2 pH
- TSS Accuracy $\pm 10\%$

Operation & maintenance:

Daily Check – GPS Transmission, System Diagnostic alarms.

Monthly Check – Sensors & system cleaning, data backup, Parameter Calibration as specified in calibration schedule.

Periodic Check – System validation with known standards, Laboratory & Online parameters Comparative

Reporting :

The RT EQMS suppliers have to provide central server at CPCB and SPCB with latest software to view the data in graphical/ tabular format and also to compare the data features.

One minute data average must be transmitted/retrieved to servers every 30 minutes. In the event of transmission loss the time stamped data in the data-logger memory must be transmitted to fill from the last transmission break with a stamp of time delay.

The software should have two way communications, so that data from the system can be seen whenever desired and remote of controller/data logger can be taken to visualize the immediate status of the system.

2.13.1. Functional capabilities of software

- ✓ The system should be capable of collecting data on real time basis without any human intervention.
- ✓ The data generation, data pick up, data transmission; data integration at server end should be automatic.
- ✓ The submitted data shall be available to the Boards, SPCBs/PCCs and CPCB for immediate corrective action.
- ✓ Raw data should be transmitted simultaneously to SPCBs /PCCs and CPCB.
- ✓ In case of delay in collection of data due to any reason, the data transmission should be marked delayed data and reports of delayed data should be displayed on the portal
- ✓ At no point of time, manual data handling should be permitted. Data validation should be permitted only through the administrator and data changes recorded with date and time stampings.
- ✓ Configurations of the systems once set up (through remote procedure) and verified, should not be changed. In case any setting change is required it should be notified and recorded through the authorized representatives only.
- ✓ The data submitted electronically shall be available to the data generator through internet, so that corrective action if any required due to submission of erroneous data can be initiated by the industry.
- ✓ The software should be capable to verify the data correctness which means at any given point of time the regulatory authorities/data generator should be able to visualize the current data of any location's specific parameter.

- ✓ A system for data validation shall be incorporated in the software with two stage/three stage validation and fixed responsibilities of stakeholders as below;
 - a. Data Generator:
 - b. SPCBs/PCCs:
 - c. CPCB:
- ✓ System should have capability to depict data at the actual location of industry over the map. CPCB and or SPCBs shall develop a map based system for data integration at a single location.

Software Capabilities of Data Analyzing & Statistical Tools

The software should be capable of analyzing the data with statistical tools and shall have the following capabilities:

- i) Statistical data analysis (customizable) for average, min., max., diurnal variation
- ii) Comparison of parameters of different locations in user selectable time formats i.e. in graphical and tabular formats compatible to MS Excel, MS Word, *.txt etc.
- iii) Capability of comparison of data with respect to standards/threshold values.
- iv) Auto report and , auto mail generation etc.
- v) Providing calibration database for further validation/correction of data.
- vi) Transmitting data to different locations as per EC,CTE/CTO, and other directives inforce.
- vii) Channel configuration for range, units etc.
- viii) Providing data in export format on continuous basis through central/station computer system to other system.

Data transmission through different media like GPS, CDMA, Normal phone line, Datacards, Broadband, 3G etc. (at least any two media supported).

Data Storage for next five years.

System should be connected to a backup power source with adequate capacity to avoid any power disruption.

Parameters will be monitored at different location as mentioned below:

STP inlet and Outlet: pH, TSS, BOD, COD, Ammonical Nitrogen, Phosphate and Flow

Aeration: Dissolved Oxygen and Nitrate

Clarifier: TSS and Sludge level

Disinfection Treatment: Residual Chlorine

2.13.2. Multi-parameter Controller System Specifications:

It should be equipped with the following minimum features:

- USB-interface for data transfer, upgrading firmware etc.
 - Backup controller function to increase reliability (in terminal mode)
 - Control unit with keys and toggle switch for the quick selection of software functions
 - With large graphic display with backlight
 - With integrated backup controller function
 - Input voltage 90 – 264 VAC 50/60 Hz
 - Line power consumption . 25 VA
 - Max. power delivery 18 Watt
 - 6 Galvanically separated current outputs (0/4-20 mA) that can be assigned arbitrarily
 - MODBUS communication protocol for the data integration with PLC and SCADA
 - With Sensor ID recognition
 - High EMC interference immunity
 - Integrated lightning protection
-
- Should have the latest features of highly advanced Multiparameter Controller having capability of handling at least 18 sensors in a single controller configuration and more as and when required.
 - Should have the capability to be operated as Controller (having programmability feature) or just a terminal (that can display the data without any way to make changes).
 - Display should be with improved reading precision through special backlit graphic display
 - Easy User Intuitive operating keys: including keys for functions such as: Measurement, calibration, set/system settings, additional keys for: confirmation/switching menu O.K. (OK), Escape (ESC) etc.
 - Internal integrated Datalogger with minimum data memory for up to 500,000 data sets
 - The Controller should be able to power all the sensors and terminals or accessories attached to it without having to need any additional power sources in the system for increased protection against lightening and possible electromagnetic interference.
 - The system should start automatically after the power is reset to the system (in case of power failure).
 - The controller should be low power consuming with consumption of less than 5W.
 - Sensors connected to the system shall be automatically detected and initialized.

- No extra system configuration should be needed for substitute / replacement sensors.
- The system should have Service mode for cleaning/calibration/maintenance activities.
- It should be possible to download the data via the USB interface an extremely fast data exchange to USB memory stick.
- The system should be fully programmable with multiple levels of access control with help of Electronic-Key for data security and protection against non-authorized access to avoid any tampering or changes to the system configuration by unauthorized access
- The controller should storage the sensor configurations and calibrations
- The controller should have Logbook to record the data
- The supplier should provide the firmware update free of cost as and when they are available for the life time of the system.
- The system should have a status LED that gives reliable and fast information regarding function and status of system. And the Controller/controller should show a LED for diagnostic purposes on the front. This LED should show normal and malfunctions of the system at a glance
- Data Output to Control System: The System should have the capability to transmit the required 4- 20 mA Analog Outputs as a minimum.
- In addition to above, the system should have ability to output Profibus, Modbus/RS 485, RS 232, LAN, GPRS, GSM compatible signals in future with addition of respective module as and when required
- The system should be able to operate on AC Power (100-240 AC)
- Ambient Conditions Operating temperature: -4 °C ... +55 °C
- Storage temperature: -10 °C ... +65 °C
- Housing Material – Non corrosive e.g. Acrylonitrile-Styrene-Acryloester polymer or better
- Protection Rating IP 66 / equivalent to NEMA 4X for controller
- Electromagnetic Compatibility: EN 61326, Class B; FCC Class A, EMC for indispensable operation
- Integrated Lightning Protection: According to EN 61326 enhanced overvoltage protection for the entire system, implemented in each component

2.13.3. Sensor Specifications:

2.13.1.1 COD,BOD,TSS,TOC, NO3 and NO2 Analyzer :-

Principal: UV-Vis Full Spectrum as per the CPCB Guideline

Reagent Free :-The analyser should not use any reagents and spare parts like WIPERS and should be easy to use and operate without any running costs. The analyzer should be completely reagent free for operation.

Measurement : Must be direct In-Situ/ Extractive measurement in inlet and outlet of waste water treatment plant.

Inbuilt Cleaning :- For Analyzer with Distilled/DM Water Cleaning along with Sodium Hypochlorate for continuous disinfection of measuring windows

Light Source:-Xenon Flash Lamp.

Accuracy:-+/-5 % of the measured value

For Treated Outlet Measurement:- 50 mm Path Length

Measuring Range:- For Bathing Water Quality With 50 mm Optical Pathlength (For Bathing Water Quality)

MeasuringRange:-

- COD: 0 - 50 mg/l (Accuracy and Repeatability 0.2 mg/l)
- BOD: 0 - 35 mg/l (Accuracy and Repeatability 0.2 mg/l)
- TSS: 0 - 10 mg/l
- NO3: 0 - 40 mg/l
- NO3-N: 0 – 12 mg/l, NO2: 0 - 40 mg/l
- NO2-N: 0 – 12 mg/l

Operating Temperature:- 0 °C to +45 °C;

Storage temperature: - 10 °C to +50 °C.

For Inlet Measurement- 5 mm Path Length

Measuring Range:-

- COD: 0 - 3500 mg/l (Accuracy and Repeatability 0.2 mg/l)

- BOD: 0 - 3500 mg/l (Accuracy and Repeatability 0.2 mg/l)

- TSS: 0 - 1500 mg/l

- NO₃: 0 - 1000 mg/l

NO₃-N: 0 – 200 mg/l, NO₂: 0 - 1000mg/l

- NO₂-N: 0 – 200 mg/l

Operating Temperature:- 0 °C to +45 °C;

Storage temperature: - 10 °C to +50 °C.

Optical path length should be 50 mm for outlet measurement and 5 mm for inlet measurement (Measuring Range : 0 to 3500 mg/lit).

The analyser should be field repairable and optical pathlength should be able to be replaced at site.

Certifications :- TUV or equivalent.

pH Sensor Specifications:

Principal: Ion Selective

Reagent Free :- The pH combination electrodes should require very little maintenance and there should be no electrolyte replacement

MOC:-Stainless Steel or better.

Measuring Range:- Measuring Range: pH: 0.00- 14.00 at least considering the wastewater

Environment Cable Length 15 meters Measuring: -5 to 60 Deg

Operating Temperature:-Temp Compensation: -5 to +50 Deg C

The sensor should be directly connected to PLC via MOD Bus/ RS 485 Connections.

Pipe mounting installation kit should be included.

2.13.1.2 Conductivity/TDS Sensor:

- The sensor should have high measuring accuracy 4-electrode design with no influence by polarization effects at higher conductivity values.
- Should have measuring range of 0.00 µS/cm to 500 mS/cm.
- TDS and salinity measurement should also be integrated.

Technical Specifications:-

- Measuring Range: Conductivity: 0-200 uS/cm; Salinity: 0-70; TDS: 0-100000 mg/l KCl
- Signal Output –Digital
- Power Consumption: less than 0.5 Watt
- Temperature Sensor should be integrated with conductivity measurement.
- Temp Compensation: -5 to +50 Deg C
- Max Pressure for Sensor: 5 Bar
- Input Power: Powered by the Controller
- Transient Voltage Protection should be integrated into the sensor
- Sensor Body: SS or equivalent

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- Protection type : IP 68 for both Sensor and Cable
- Sensor Cable Length: 15 meters

The sensor should be directly connected to PLC via MOD Bus/ RS 485 Connections.

Pipe mounting installation kit should be included.

2.13.1.3 Ammonium Nitrogen Sensor:

Sensor:

Measuring principle should be ion selective

Three Electrode system with spray cleaner, Ammonium ISE (NH₄⁺- N) is the primary measurement.

The Potassium ISE and pH glass electrodes should be used to compensate the NH₄⁺ signal where ever inference.

The Sensor should water proof with an ingress rating of IP 68.

Pipe mounting installation kit should be included.

Measurement Range:

NH₄⁺- N: 0.1 to 14,000 ppm

Operating Temperature:

0° C to 50° C (32° F to 122° F)

Min/Max Flow Rate:

Minimum 0.1 m/s

Maximum 3.0 m/s

Wetted Materials:

PVC, PES, PVDF, PTFE, Viton, Glass, 316 SS

Accuracy:

± 2% of reading, dependent on Calibration

Response Time:

T90 1 minute

Transmitter:

Measurements:

Ammonium: 0.01 to 14,000 ppm as NH₄⁺- N

Potassium: 0.01 to 40,000 ppm

pH 0 – 14 pH

Temperature: 0° C to 100° C (32° F to 212° F)

Compensation:

pH 4 - 10 pH

Potassium: 0.1 to 1000 ppm

Display:

2.5" X 1.75" backlit LCD

Enclosure:

NEMA 4X, LxWxD: 5.7" x 5.7" x 3.5"

Outputs:

(2) 4-20 mA & MODBUS

Configured: 0.1 to 50 mg/l NH₄⁺- N

0 - 100 mg/l K⁺

Optional HART configuration

Input Power:

110/220 VAC @ 50/60 Hz

Alarm Relay Ratings:

(3) SPDT 230 VAC/5A

Relay(1) Spray Cleaner

2.13.1.4 Total coliform analyzer :-

Technical Detail:-

Principle: Principle Measurement of Specific Enzymatic activity – B – Galactosidase for

Total Coliform Measurement

Protection classification: IP 54

Weight: 25 KG (excluding airco)

Dimensions (h x b x d): 460 x 450 x 321 mm

Cabinet material: St. Steel Sample 160

pressure: max 0.05 bar

Sample connection: 4 mm ID Sample temp.: 10 - 35°C / 50F 95F

Sample flow rate: 3 l/h

Ambient temperature: 15 - 30°C / 59F 86F, > optional air-co necessary

Power consumption (average): < 0,05% active) prevents fouling and enables unattended deployment for several weeks. Same System should also be able to Measure Total Bacterial Count or Ecoli Activity with appropriate Enzyme.

2.13.1.5 Toxicity monitoring system

Measurement method : Determination of toxicity through the measurement of Bio Luminescence of Bacteria Bacteria: Vibrio Fischeri

Measurement range: 0 –100 %

Toxicity Response time: 15-30 Minutes

Technology Validation: Strictly USEPA as the requirement is for Sewage to Drinking Water

measurement

Housing : IP31 Power Supply: 230 / 115 V~, 50 / 60 Hz, 100 VA

Analogue output: 0/4– 20 mA

Serial interface: RS 232, Combined alarms, LifeZero, USB Remote Control: Through TCP/IP Protocol (Internet) Equipment Devices and Data Output: High resolution and backlit LCD touch screen graphic Display Autostart function Self-explanatory software and service checklist Standard data interfaces

Specification of Below Parameter:

Phosphate Analyzer specification:

USEPA approved Colorimetric Method: Colorimetric is the measured absorbance of a solution after adding a color stimulating reagent. The intensity of color observed is directly related to concentration.

Analysis Method: Differential Photometric Absorbance

Analysis frequency: Programmable, Batch Analysis

Repeatability: +/- 2% on absorbance value with turbidity < 80 NTU

Drift: +/- 2% per month on the absorbance measurement

Power supply: 110-220Vac, 50-60 Hz 80 VA

Mounting: Wall mounting or with bench support

Operating temperature: 45°C / 41 - 113°F

Cell diameter: 16 mm or 25 mm

Ingress protection: IP54

Cabinet: Cold rolled steel epoxy powder coated 380Lx606Hx209P mm

Dimensions: Weight: approx. 20 kg or 44 lbs

Access: 2 Level Password

Analog outputs: 4..20 mA

Alarm relays: Programmable Relays Automatic calibration, validation, cleaning.

2.13.4. Communication and Data Presentation/Display

The controller should be interfaced with a GSM/GPRS communication modem to seamlessly transmit the data from remote plants to a central location over a pre-defined interval.

The communication to the system should be two way for ability to view settings and make changes to the configuration over the air, as and when required.

The data should be received at a central location and should be displayed there in real-time in graphical and tabular format. The software as a minimum should have ability to print reports, archive data and make it available for export as a CSV file. The system should also have facility to generate alarm when set points are exceeded.

The Computer System to be supplied for this application should have enough configurations to accommodate data from at least 10 sites for at least 5 year duration with continuous monitoring of parameters every 15 min as minimum.

UPS of 2KVA capacity and internet connection with Static IP will be supplied along with the Computer.

2.14 Programmable Logic Controllers

2.14.1. General

Programmable Logic Controllers (PLC) shall be provided as a Hot Stand-by Controller to perform combinational and sequential logic functions, status monitoring and reporting functions with counter and timer facilities.

PLC shall comprise of necessary processors, Simplex input/output (I/O) modules, communication interface modules and Human-Machine Interface (HMI) required performing the desired functions.

PLC shall have the following attributes as a Hot Stand-by Controller.

- carry out sequential logic implementation for operations of plant;
- carry out computation and interfacing for data acquisition, data storage and retrieval;
- it shall accept downloaded program from a programmer;
- it shall have different functional modules to perform the desired functions;
- it shall scan the inputs in time cycles and update the status of its outputs.

The PLC system shall be expandable, OPC Compatible and shall be modular in construction, so as to be capable of future expansion without hardware modifications.

PLC s shall be microprocessor based. PLC s shall use standard known protocols and structures for communication outside the system.

In case of system failure or power supply failure the outputs shall attain a predetermined fail safe condition (this shall normally be 'off').

The PLC used shall have a proven record in the type of application concerned and in the prevailing environmental conditions.

PLC shall be of an approved type from a major international manufacturer. PLC System (Panel) should be housed in a dust free environment.

Redundancy: hot redundant processor, redundant Power supply, non-redundant I/O's, redundant communication between Processor and I/O's and redundant FO communication shall be considered.

2.14.2. Analytical Instruments

General:

This section covers individual elements to measure and transmit pH ANALYZER, BOD, COD ,TSS, TOC ANALYZER, TSS ANALYZER, ORP ANALYZER, DISSOLVED OXYGEN ANALYZER , AMONICAL NITROGEN ANALYZER , NITRATE ANALYZER, PHOSPHATE ANALYZER , OIL & WATER ANALYZER, FLOURIDE ANALYZER, CHLORIDE ANALYZER, ZINC ANALYZER, IRON ANALYZER, HEXAVELENT CHROMIUM ANALYZER, MERCURY ANALYZER, LEAD ANALYZER, CADMIUM ANALYZER, NICKEL ANALYZER, MANGANEASE ANALYZER, TOTAL RESIDUAL CHLORINE ANALYZER, TURBIDITY.

Transmitters shall convert the sensor measurement to a 4 to 20 mA dc signal capable of transmission into at least a 500 ohm load at 50 V or less. Power supply shall be 240 Vac, 50 Hz. Reference accuracy of the output signal shall be ± 1 percent of measured span or better. Output signal shall be electronically isolated from ground to permit connection to a receiver with a grounded input. Transmitters shall be provided with an indicating scale having at least a 0.1 meter calibrated length. Operating ambient temperature shall be -5 to + 50 degree C or better. Transmitted signals shall be linear with the measured variable excepting pH which shall be linear with pH.

Sensor Measurement Principles and Features: Each type of sensor shall use the measuring principle and incorporate the features appropriate to it as specified below:

pH and ORP sensors shall measure hydrogen ion activity and oxidation-reduction

potential respectively in the process medium. The pH sensor shall consist of a glass measuring electrode, a reference electrode, a solution ground and a temperature sensor for compensation in the transmitter. The reference electrode shall be the non flowing type with an electrolyte diffusion rate through a nonreactive porous membrane or plug which shall not require electrolyte refill more often than once per year. ORP sensors shall use the same elements specified for pH sensors except that electrode shall be platinum and no temperature compensation is required. pH and ORP sensor assemblies shall incorporate an integrally mounted preamplifier for the measuring electrode. Sensors shall operate over a temperature range of -5 to + 1000 C or better.

Construction Transmitter and sensor enclosures shall be rated NEMA - 4(National Electrical Manufacturers Association) unless explosion proof (XP) is specified on the Schedule. Enclosure materials and finish shall be as specified in the Schedule. If not so specified, they may be the manufacturer's standard which is compatible with the corrosivity of the atmosphere normally in contact with the enclosure. All parts of sensors, their assemblies and supporting parts which are wetted by the process medium shall be constructed of stainless steel and/or plastic unless specified otherwise on the Schedule. When specified on the Schedule, pH and ORP assemblies shall be provided with integrally mounted ultrasonic cleaners.

2.14.3. Surge Protection Devices

Surge protection devices (SPDs) shall be suitable for withstanding the surge arising out of high energy static discharge / lightning strikes and protect the instrument to which it is connected against damage. SPDs shall provide protection through the use of quick acting semiconductors like 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 minimise the down time of the measurement loop.

SPD s shall be provided to protect devices transmitting and receiving analogue and digital signals derived from field devices located outdoors.

The surge protection device shall be rated for surge rating of 10 KA.

2.15 Programmable Logic Controllers

2.15.1. General

Programmable Logic Controllers (PLC) shall be provided as a Hot Stand-by Controller to perform combinational and sequential logic functions, status monitoring and reporting functions with counter and timer facilities.

PLC shall comprise of necessary processors, Simplex input/output (I/O) modules, communication interface modules and Human-Machine Interface (HMI) required performing the desired functions.

PLC shall have the following attributes as a Hot Stand-by Controller.

- carry out sequential logic implementation for operations of plant;
- carry out computation and interfacing for data acquisition, data storage and retrieval;
- it shall accept downloaded program from a programmer;
- it shall have different functional modules to perform the desired functions;
- it shall scan the inputs in time cycles and update the status of its outputs.

The PLC system shall be expandable, OPC Compatible and shall be modular in construction, so as to be capable of future expansion without hardware modifications.

PLC s shall be microprocessor based. PLC s shall use standard known protocols and structures for communication outside the system.

In case of system failure or power supply failure the outputs shall attain a predetermined fail safe condition (this shall normally be ‘_off’).

The PLC used shall have a proven record in the type of application concerned and in the prevailing environmental conditions.

PLC shall be of an approved type from a major international manufacturer. PLC System (Panel) should be housed in a dust free environment.

Redundancy: hot redundant processor, redundant Power supply, non-redundant I/O’s, redundant communication between Processor and I/O’s and redundant FO communication shall be considered.

2.15.2. PLC Coding

The Contractor shall supply, install, program and commission the PLC using the PLC manufacturers recommended windows based PLC coding and documentation software. The PLC code shall be structured in the manner of the best industry standard and have comprehensive subroutine and rung annotation. PLC shall be coded using FBD language.

The Contractor shall provide a suitable PC complete with PLC coding and documentation software as specified in the bid document & as agreed with the Employer representative

based on the FDS submitted.

2.16 SCADA

2.16.1. General :

SCADA shall be provided at central monitoring Room, which shall be based in the administration building.

The SCADA system shall provide efficient and safe operation of the process plant by detecting alarm and error conditions, alerting the operator to these conditions both visually and audibly, monitoring and controlling all important system parameters and providing facilities for plant optimisation. The system will allow operators, technicians and engineers to issue commands to change system parameters, start and stop equipment, provide configuration tools and operate diagnostic facilities from Operator Workstations (OW) and Engineers workstation (EW), after successful log-on by security password.

The System shall perform all the necessary functions for the optimum monitoring, control and operation of the entire system.

The HMI shall be constructed to a high standard to provide a high profile feature and focal point for visitors to the Sewage Treatment Plant (STP).

SCADA system should be housed in an air-conditioned environment.

2.16.2. Scope of Work:

The scope of work includes design, supply, installation, commissioning and maintenance for 10 years of SCADA Automation of MCGM, Sewage collection & treatment facilities and SCADA automation shall be required to operate the submersible pumps of various capacities at various zone pumping stations.

The Instrumentation/ Analysers, monitoring system shall be place as follows.

For Inlet / Plant of STP: pH Analyzer, COD, BOD, TSS, TOC Analyzer, Total coliform Analyzer, Nitrate and Ammonical Nitrogen Analyser,

For out let of STP : pH Analyzer, COD, BOD, TSS, TOC Analyzer, Total coliform Analyzer, Nitrate and Ammonical Nitrogen Analyser ; Toxicity monitoring system For the following Parameters OIL & WATER ANALYZER , FLOURIDE ANALYZER , CHLORIDE ANALYZER ,ZINC ANALYZER , IRON ANALYZER , HEXAVELENT CHROMIUM ANALYZER , MERCURY ANALYZER , LEAD ANALYZER ,CADMIUM ANALYZER , NICKEL ANALYZER

2.16.3. System Integration & SCADA Automation Works: The major prerequisites of efficient online analysers are:

- Should be capable of operating unattended over prolonged period of time.
- Should produce analytically valid results with precision and repeatability
- The instrument/analyser should be robust and rugged, for optimal operation under extreme environmental conditions, while maintaining its calibrated status.
- The analyser should have inbuilt features for automatic water matrix change adaption.
- The instrument / analyser should have onboard library of calibration spectra's for different industrial matrices with provision of accumulating further calibration matrices
- Should have data validation facility with features to transmit raw and validated data to central server.
- Should have Remote system access from central server provisioning log file access.
- Should have provision for Multi-server data transmission from each station without intermediate PC or plant server.
- Should have provision to send system alarm to central server in case any changes made in configuration or calibration.
- Should have provision to record all operation information in log file.
- For each parameter there should be provision for independent analysis, validation, calibration & data transmission.
- Must have provision of a system memory (non-volatile) to record data for at-least one year of continuous operation.
- Should have provision of Plant level data viewing and retrieval with selection of Ethernet, wireless, Mod-Bus & USB.
- In case of TOC analyser, the empirical relationship between TOC to COD or BOD must be authenticated for all industrial applications and the correlation calculation (for factor) provided.
- The software will give alarm, in case of the concentration of parameter exceeds the prescribed norms by 10% continuously.
- The correlation/interpretation factor for estimating COD and BOD using UV-Visible Absorption
- Technique shall be regularly authenticated/validated and details provided.
- Record of calibration and validation should be available on real time basis on central

server from each location/parameter.

- Record of online diagnostic features including sensor status should be available in database for user friendly maintenance.
- Expandable program to calculate parameter load daily, weekly or monthly basis for future evaluation with flow rate signal input.
- Must have low operation and maintenance requirements with low chemical consumption and recurring cost of consumables and spares.

2.16.4. System Validation

Online instrument operation will be evaluated using the known buffers, traceable standards and laboratory techniques.

By validating sensors and probes with known standards such as KHP (potassium hydrogen phthalate) for COD & TOC,

Formazin equivalent standard for TSS & pH buffers have to be used to calculate a running variance of the measurements.

2.16.5. Parameter validation

Each parameter is validated with reference to standard laboratory analysis and known standards.

2.16.6. Parameter Accuracy: Allowed Variability

The relative difference between online and laboratory measurements has to be between

- COD Accuracy $\pm 10\%$
- BOD Accuracy $\pm 10\%$
- pH Accuracy ± 0.2 pH
- TSS Accuracy $\pm 10\%$

1. Operation & maintenance:

- **Daily Check** – GPS Transmission, System Diagnostic alarms.
- **Monthly Check** – Sensors & system cleaning, data backup, Parameter Calibration as specified in calibration schedule.
- **Periodic Check** – System validation with known standards, Laboratory & Online parameters Comparative

2. Reporting :

- The RT EQMS suppliers have to provide central server at CPCB and SPCB with latest software to view the data in graphical/ tabular format and also to compare the data features.
- One minute data average must be transmitted/retrieved to servers every 30 minutes. In the event of transmission loss the time stamped data in the data-logger memory must be transmitted to fill from the last transmission break with a stamp of time delay.
- The software should have two way communication, so that data from the system can be seen whenever desired and remote of controller/data logger can be taken to visualize the immediate status of the system.

3. Functional capabilities of software

- ✓ The system should be capable of collecting data on real time basis without any human intervention.
- ✓ The data generation, data pick up, data transmission; data integration at server end should be automatic.
- ✓ The submitted data shall be available to the Boards, SPCBs/PCCs and CPCB for immediate corrective action
- ✓ Raw data should be transmitted simultaneously to SPCBs /PCCs and CPCB.
- ✓ In case of delay in collection of data due to any reason, the data transmission should be marked delayed data and reports of delayed data should be displayed on the portal
- ✓ At no point of time, manual data handling should be permitted. Data validation should be permitted only through the administrator and data changes recorded with date and time stampings.
- ✓ Configurations of the systems once set up (through remote procedure) and verified, should not be changed. In case any setting change is required it should be notified and recorded through the authorized representatives only.
- ✓ The data submitted electronically shall be available to the data generator through internet, so that corrective action if any required due to submission of erroneous data can be initiated by the industry.
- ✓ The software should be capable to verify the data correctness which means at any given point of time the regulatory authorities/data generator should be able to visualize the current data of any location's specific parameter.
- ✓ A system for data validation shall be incorporated in the software with two stage/three

stage

- ✓ Validation and fixed responsibilities of stakeholders as below;

i. **Data Generator:**

1. SPCBs/PCCs:

2. CPCB:

- ✓ System should have capability to depict data at the actual location of industry over the map.
- ✓ CPCB and or SPCBs shall develop a map based system for data integration at a single location.

4. Software Capabilities of Data Analysing & Statistical Tools

The software should be capable of project the data with statistical tools and shall have the following capabilities:

- (i) Statistical data analysis (customizable) for average, min., max., diurnal variation.
- (ii) Comparison of parameters of different locations in user selectable time formats i.e. in graphical and tabular formats compatible to MS Excel, MS Word, *.txt etc.

Ensuring access to every intricate detail and real time information has become a necessity for control room operators. With Security and Surveillance, Video walls, round-the-clock vigilance and Monitoring in real time has become convenient and manageable. Features like true cube redundancy and long life hours of light source in a video wall ensure a long term performance in mission critical application

- (iii) Capability of comparison of data with respect to standards/threshold values.
- (iv) Auto report and , auto mail generation etc.
- (v) Providing calibration database for further validation/correction of data
- (vi) Transmitting data to different locations as per EC, CTE/CTO, and other directives enforce
- (vii) Channel configuration for range, units etc.
- (viii) Providing data in export format on continuous basis through central/station computer system to other system.

- Data transmission through different media like GPS, CDMA, Normal phone line, Data cards, Broadband, 3G etc. (at least any two media supported).
- Data Storage for next five years.

System should be connected to a backup power source with adequate capacity to avoid any

power disruption

5. Video walls, round-the-clock vigilance and Monitoring in real time

Premium range of video wall solutions to suit any specific needs of control room. In a wide array of sizes, dimensions and range of resolutions including Full HD (1920x 1080) and WUXGA (1920 x 1200), Video wall solutions can be aligned together to create large screens for life-size viewing.

6. Desktop PC with control desk

- 1) PC of reputed make (as shall be approved by MCGM) with minimum requirements as: Intel core i7, 8 GB RAM, 2 TB HDD, **with RAID Compatibility & 100% Redundancy Backups for all PC which are related to SCADA & AUTOMATION.** For Windows 7 professional OEM (or latest Operating System.) license version, 21” monitor, keyboard, mouse, at least two USB ports and all other accessories as may be necessary for operation of SCADA system.
- 2) A suitable control desk for housing the PC and placing the monitor, keyboard and mouse on top of control desk. Desk shall have sufficient space for the operator to use the system with convenience. MCGM approval shall be taken prior to procurement of the control desk.
- 3) Inkjet printer of HP or reputed equivalent as shall be approved by MCGM.
- 4) Licence Office software loaded in the PC
 - (a) Microsoft office 2010 or latest of OEM version to facilitate report preparation in word, excel, power point, etc.
 - (b) Basic software packages such as adobe acrobat reader etc
- 5) USB dongle license, as applicable
- 6) In-built web server, as applicable, for configuration/ data logging/viewing
- 7) SCADA software loaded in PC

7. Vendor scope of commissioning:

- (a) Vendor shall verify and make all the connections of communication cables that are laid by MCGM up to the entry point of string monitoring boxes, weather monitoring equipment, data station panel. All further operations such as un-sleeving, splicing, crimping, ferruling, routing, dressing and connecting to the respective terminals within the weather equipment / data station panels shall be in the scope of vendor. All necessary cable lugs, ferrules, hardware etc for this purpose shall be in vendor scope of

supply. All necessary tools for carrying out this commissioning shall be in vendor scope.

- (b) Interconnection of PC (SCADA) with its peripherals and accessories on the console (control desk) using appropriate cables, accessories and hardware as provided by vendor.
- (c) Installation and configuration of operating system (Windows), SCADA software, Microsoft office and all other software on PC.
- (d) Installation and configuration of remote monitoring features in SCADA. Customization, configuration and demonstration of following:
 - 1. SCADA screens showing plant-specific mimic diagrams, live display of parameter values, breaker On/Off displays, alarm indications, faults, events, etc based on interactive discussions with MCGM engineer at site.
 - 2. Daily, weekly, monthly reports on plant performance, based on interactive discussions with MCGM engineer at site.
 - 3. Trend graphs for plant monitoring and management reporting, based on interactive discussions with MCGM engineers at site.
- (e) (Service engineer shall be present at the site at the time of commissioning of the plant. The engineer shall support in trouble shooting and resolve in case of any problems.
- (f) Training to MCGM engineers on operation and maintenance of the Data station panel (data loggers / PLCs) and SCADA software.

2.16.7. DESIGN PARAMETERS

A. General:

Proposed automation system shall be designed, manufactured, installed and tested to ensure the high standards of operational reliability. Instruments mounted in field and on panels shall be suitable for continuous operation. All electronic components shall be adequately rated and circuits shall be designed so that change of component characteristics shall not affect plant operation.

All equipment shall be new of proven design, reputed make and shall be suitable for continuous operation. Electronic instruments shall utilize solid-state electronic components, integrated circuits, micro controllers etc., and shall be of proven design. The equipment/instruments such as flow meter, level sensor, underground depth sensors etc.

should as per site requirement and in tune with realistic conditions of site such as head, pressure etc.

For transmitting instruments, the output signal shall be 4-20 mA DC linear having two/three or four wire system.

Unless otherwise stated, overall accuracy of all measurement systems shall be $\pm 0.25\%$ of measured value and repeatability shall be $\pm 0.5\%$.

Unless otherwise specified, the normal working range of all indicating instruments shall be between 30% and 80% of the full scale range.

The instruments shall be designed to permit maximum inter-changeability of parts and ease of access during inspection and maintenance & must be compatible so that the system of similar or dissimilar technologies are added on in future, LCS , MCS must be capable to integrate all these addition like Additional Automated meter reading (AMR) or automation of distribution network & billing etc.

The instruments shall be designed to work at the ambient conditions of temperature, humidity, and chlorine contamination that may prevail. The instruments shall be given enough protection against corrosion.

All field instruments and cabinets/panel mounted instruments shall have tag plates/ name plates permanently attached to them.

The performance of all instruments shall be unaffected for the $\pm 10\%$ variation in supply voltage and $\pm 5\%$ variation in frequency simultaneously.

B. Data station panel (Main SCADA panel):

The data signals as listed above reach the SCADA room. These shall be integrated using a suitable Data station panel. Accordingly, the panel shall have following features:

i. All necessary devices such as

(a) Data loggers / PLCs :

Data loggers for logging (at software selectable logging intervals 0.1s to 24 hours) and storage of above data signals. Data loggers shall have minimum 10Hz sampling rate per channel, USB ports for independent data access, adequate flash memory, at least 64MB RAM, RS485, RS232 and Ethernet TCP/IP communication interfaces. (or) Alternatively, suitable PLCs for respective analog signals, digital signals, RS 485 MODBUS signals shall be used and integrated.

(b) Device servers, wherever required, as applicable, such as serial to Ethernet servers etc. with appropriate number of ports.

- (c) Ethernet I/O devices such as RTU microcontrollers, wherever required, as applicable, for processing the analog and digital signals, with appropriate number of input / output channels.
 - (d) Network switches such as Ethernet switches, etc., wherever required, as applicable, with appropriate number of ports.
1. Any other devices as may be necessary for the specific SCADA schematic design adopted by the vendor for accomplishing the objective of SCADA integration.
 2. **In** case of mV-based analog signals (ex: pyranometer), amp-box shall be provided to avoid distortion of signals due to long cable distance from roof-top to SCADA room
 3. Power supply units
 4. Other accessories such as DIN rails, terminal blocks, MCBs, surge arrestors, fuses, etc., as may be required for the system, based on the specific design.

5. Enclosure requirements:

- (a) Frame, doors with CRCA sheet of 2mm thickness
- (b) Gland plates with CRCA sheet of 3mm thickness Gland plates to be fitted with cable glands. Holes shall be punched by the vendor according to this requirement.
- (c) Cable lugs, hardware – nuts, bolts, washers, ferrules, cable ties for making cable interconnections to the panel shall be provided by the vendor.
- (d) Base frame of suitable ISMC channel
- (e) Cable entry from bottom side and through glands in gland plates
- (f) Grouting provisions in base frame for fixing the panel on ground
- (g) Earthing provisions
- (h) Painting colour shade RAL 7032 using seven tank process
- (i) IP42 (indoor)

C. Technical Specification for SCADA at MCS Architecture

The SCADA architecture shall provide the following:

Client / Server architecture based on TCP/IP networking and report-by-exception (RBE) technology

Standalone single server operation.

Additional servers for client load sharing and remote locations.

Permanent Standby Server designed to be placed outside corporate firewalls providing a read-only access to the server while ensuring corporate security.

Fully automated data transfer between servers to provide complete server redundancy. This

transfer shall include configuration, real-time data, historic data and event lists. Database updates shall be on an incremental basis with tuneable parameters.

A scalable fully distributable architecture providing:

- Unlimited number of server systems.
- Unlimited number of display clients.

Where multiple servers are deployed, the system shall be capable of being configurable from a single client.

All redundancy shall be handled by the database, with the operational state of systems preserved through a server changeover. The system shall not rely on driver redundancy for data transfer when providing redundant server. The system shall present a uniform view of data including communication status after a fail over.

Forced changeover between main and standby allowing seamless changeover without shutting down. Clients to connect to a synchronizing server as soon as the configuration and current data in the database has synchronized. Incomplete data sets as per clients request on event or trend provide indications that the synchronization is still in progress to ensure that conclusions are not drawn from incomplete data sets.

Configurable compression of data communications between client/server and server/server to allow optimisation of communications performance over WAN networks.

Change reporting on Client/Server and Server/Server links rather than polled communication to permit operation on WAN networks.

Capable of operating Client/Server and Server/Server links over low to medium speed channels depending upon database size.

Application shall be native 32-bit and 64-bit versions and supported on Windows® Server and Workstation operating systems including Windows 2000, Windows XP, Windows 2000 Server, Windows 2003 Server, Windows 7 (32 and 64 bit) and Windows Server 2008 R2 and later.

Database

The SCADA database shall be of true database design and optimized for real-time SCADA operation. The database shall be object oriented and organized in a hierarchical structure.

Templates of standard configuration shall support multiple object types including, but not limited to:

Point / Tag objects

PLC or RTU objects

Mimics or Graphic display objects

Trend objects Logic programs Schedules

Link objects

The SCADA database shall allow users to extend the database scheme to store custom data, in either the configuration or data stream. These changes can be performed online without need for server restart.

Operator Interface

SCADA software shall provide the ability to support multiple local and remote display clients. Display facilities shall be available via LAN, WAN and dial-up connection.

Rich Clients shall support database management and configuration changes.

Rich Clients shall support multiple monitors (multi-head display), allow logon for all heads from a single location. The system should also provide navigation facilities such that displays on each head can be controlled from any head.

Integrated Web Sever capability shall be available, providing all display and operational facilities of the Rich Client without the need for additional software to be installed.

Web Clients shall allow users to view Mimics, Trends, Database Objects, Reports as well as perform control functions using a standard web browser.

Changes made to the SCADA server shall require no additional steps to be performed in order for those changes to be available to Rich Clients and Web Clients.

Rich Client shall be configurable to connect to one, or multiple server systems

Full function display clients shall automatically fail-over & reconnect to a redundant server node when server change-over occurs.

Look and feel shall be provided by the SCADA system operator interfaces, including provision for “favourites lists” .

SCADA software shall provide the ability to support for Citrix Xen App and Windows Terminal Services.

Mimics / Graphics

SCADA system Mimics shall support a wide range of graphical facilities. Scalable Vector Graphics are required in order to permit operation of the SCADA system with different resolution clients operating simultaneously. Fixed resolution bitmap graphics are not acceptable.

Mimics shall be multi-layered, object oriented and permit mimics to be embedded in other mimics. 24-bit Colour shall be supported on mimics as standard.

Import of mimics shall be supported from DXF format, including integration of multi-layered DXF drawings in to native SCADA mimics.

Mimics shall support the ability to specify OPC data source information to display directly on the mimic. This permits data from other systems to be seamlessly integrated in to the SCADA display. Objects embedded and displayed on any mimic shall be viewable through both the full function client and web client displays.

Start-up

The SCADA system shall start-up unattended, and without compromising system security.

Configuration

The SCADA software shall provide full seamless On-line configuration of all database parameters including but not limited to:

- Communication channels
- PLCs
- Points / Tags
- Sequences
- Schedules
- Alarm redirection
- Mimics / Graphics
- Trends/graphs
- Reports

All aspects of the look and feel of the SCADA system, including default field values, shall be configurable. It is not acceptable for colour regimes, communication parameters and other aspects of the system to be hard-coded.

It shall be possible to add user defined fields to the SCADA database. These fields should be accessible both internally and externally to the SCADA system; being exposed via OPC, ODBC, OLE Automation, XML/SOAP, etc.

The SCADA server shall provide detailed diagnostics concerning its internal operation. The diagnostics shall be available through capture to a log file as well as online locally on a server and remotely via Telnet and Web interface.

Stored configuration records should be maintained in the historic database for a configurable time period, support redundant SCADA server configurations and allow access from standard database interfaces such as queries and simple mechanisms for displaying and filtering the

configuration records.

Alarm Management

The alarm system shall provide facilities where actions can be triggered by alarms. These facilities shall be provided as a built-in integrated part of the system and shall include, but not be limited to the following:

- Configuration criteria for alarm actions
- Escalate Alarm priority
- Delivery of alarm to users via SMS
- Delivery of alarm to users via E-mail
- Trigger other actions including sequences

Where a full function Rich Client is connected to multiple SCADA systems, alarms from all systems shall be combined and filtered, based on user privilege and areas of responsibility.

Consequential alarms to allow one (or more) alarms to be suppressed as the result of another alarm occurring. Suppressed alarms will be received and processed by the SCADA Server and recorded in the event journal for future auditing, however the operator shall not be forced to take an action on an alarm where the cause is known.

Event Journal

The system shall provide, as a built in feature and without the requirement for custom or external software, facilities for event logging. These facilities shall be separate from the alarm list and include the capability to insert user comments at any place in the event list.

Historical Data

The SCADA system shall provide a built in data historian with the following facilities as standard features. These shall be provided without the addition of external software modules:

- Time-series relational database
- ODBC / SQL interface to historical (trend) data
- Historical data to be stored with time-stamp, point quality, alarm status
- Historic storage is to be based on configurable criteria including time between samples, alarm state change
- Compression capability

System Security & Access

The SCADA system shall provide a high level of inherent security. To this end the SCADA

software shall provide security access down to data point level, and support individual Users, User Groups and a matrix of system capability and access to any level of the SCADA database.

Full function Rich & Web client interfaces shall require explicit administrative configuration to valid connection to the SCADA server.

The SCADA system security shall provide the ability to be integrated with Windows domains to authenticate logon attempts against a trusted domain.

Open Connectivity

To provide easy access for customized reports and external data manipulation the SCADA software shall provide inherent OPC and ODBC database connectivity without the need for additional software options or modules. Integration with desktop Microsoft products is essential.

Reports

An integrated reporting package shall be able to generate, print and export reports: Triggered by SCADA events

On user demand

On timed schedules.

Reports shall be able to be generated in a number of formats including: HTML for viewing via Web interface

PDF format

CSV format

MS Office® suite format.

Generated reports shall be able to be: E-mailed to assigned users

Standard Drivers

The SCADA system shall provide native support for fully integrated Wide Area SCADA PLC protocols. This shall include the capability for supporting all protocols in redundant SCADA server configurations and support redundant communication paths.

Apart from PLC and RTU communication drivers, the system shall also support as standard the following drivers:

SMS (with TAP and UCP service) to mobile phones

A full function system is required including calendar based rosters

SNMP – monitoring of network devices such as routers, computers, UPS, etc. NTP – time

server monitoring and alarming
ODBC – query data from other databases
Windows Performance Monitoring
OPC-DA driver

Logic

The SCADA system shall support logic sequences with full access to all SCADA system services at run time. Programming of sequences shall be to the IEC61131-3 international standard and support as a minimum the following languages:

Ladder Diagrams (LD) Function Blocks (FB) Structured Text (ST) Sequential Function Charts (SFC) Special scripting languages to perform the control strategy will not be accepted.

D. Zonal Pumping Station-PLC Specifications

Processor

The processors must have an internal non-volatile memory to store application and data. Processor must also have a reserved slot for a removable cartridge so that the application and data backup can also be performed on a mobile device.

It must be possible to connect a PC (programming terminal) or a human-machine interface via a USB port integrated in the processor.

The range must provide processors with at least 3 built-in Ethernet ports featuring a web server, compliant with various operating systems: minimum is Windows, iOS, and android.

Embedded web server must provide CPU diagnostic, including detailed information on Ethernet system networking.

The Embedded web server must be customizable by the user to display application variables and advanced diagnostics features. Each processor should have a saveable real-time clock which manages:

The current date and time

The date and time of the last application shut-down. The date and time should be managed even when the processor is switched off for 20 days.

NTP server must be provided within the CPU.

The processors must be equipped with ground connection contacts without additional cabling. The PLC must be able to load the program with the use of the memory cartridge.

Data Exchange through high speed link of 1Gbps

Possible to add modules or add remote I/O islands in the configuration without interrupting the running process.

The complete environmental footprint of the product must be known and all products must be designed with eco-design requirements (Green Premium) Operating system

The operating system (OS) must be capable of multitasking with up to 4 periodic tasks and more than 60 event or I/O tasks.

Physical input can be program to prohibit any modification or downloading of the program.

Outputs can be set to fallback position when the PLC switches to STOP mode via channel by channel parameter entry.

Able to set breakpoints and watchpoint in application to check all system and data when executing application for debugging. System must also provide Step-by-Step running feature to execute all operations one by one in the application. Engineering tool must provide a trending tool embedded to display variables at a minimum of 1ms sampling rate

Memory

Application memory execution can be done on through embedded or removable memory. No battery supply is needed for non-volatile backup.

The processor must provide up to 64 MB of integrated non-volatile memory as well as removable memory up to 8 GB.

Feature to store the program, comments and symbols in the PLC. The “empty terminal” functionality must be possible whichever IEC language is used. It must be also possible to use the memory extension to back up files (production data, recipes, etc)

Communication

The Ethernet connection must support SNMP agent functions for the standard MIB II base (RFC

1213). Synchronized and unsynchronized drops with PLC scan can be managed over standard and open Ethernet communication.

Must provide exchanges of variables:

Explicit exchanges (via function blocks integrated in the application)

Implicit exchanges (Using cyclical variables generated by the single declaration of the device)

Dedicated function blocks should be available.

The PLC must be accessible via Ethernet (from a remote site) using a standard Internet

browser or any other platform (android, iOS). These functions must not require any prior configuration or special software. In addition, the use of these functions must have no effect on the PLC scan time.

Variables or animated objects in the Internet browser's web pages must be refreshed automatically from the PLC using a standard Internet protocol, without having to update the entire page.

A device must be reconfigured automatically after replacement

The PLC must have serial links which support various types of communication: Modbus or open protocols.

Standards and certifications

The PLC must conform to the main national and international standards covering electronic equipment for industrial control systems:

CE marking according EN 61131-2

Be compliant with IEC – 62443 standard

Cyber Security

The system **MUST** be Achilles level 2 certified

The system must be able to secure communication between PLC and engineering workstation / SCADA providing authentication and integrity of data

The internal firmware of the CPU must be digitally signed and encrypted.

The integrity of the firmware must be checked before any application download and at startup of the system.

The integrity of the engineering software must be checked on demand

The user must be able to disable the following Ethernet services: FTP/TFTP/HTTP/EIP/DHCP/BOOTP/SNMP

The system provides an access control list for each protocol and each connected IP address

Any modification of the operating mode of the system (Run / Stop / Program modifications) must be authenticated real time memory Integrity Control.

E. SCADA FOR ZONAL PUMPING STATION

SCADA should be scalable & can be expandable as and when required as per requirement

It should support web browser on the WAN with the appropriate security settings. The web browser clients shall support view and control capabilities, controlled by both login security

and license types

The SCADA software shall be configurable as a single global database regardless of the number of stations in the system.

SCADA System should have true unlimited tag licensing Vendor has to submit customer name with running PQR for more than 70000 Tags running.

Cloud Based SCADA Not Acceptable.

SCADA System Run Time should have flexibility to operate in English or Hindi user Selectable. The trend page should have indication of alarms & values with moving cursor on the same page.

SCADA System should have inbuilt provision for development. No additional cost shall be charged by vendor to provide development facility.

The minimum tasks requiring include: I/O Device

Monitoring, alarm generation, distribution and acknowledgement of alarm

Collection, storing and distribution of historical trends

Processing, storing and distribution of reports in a web-friendly format Storing and distribution of configuration to remote client stations Network communications between SCADA stations

Field Device communications (where supported by the field device)

All currently available drivers should be included with the software and included in the price. Department will pay no additional license fee.

The software shall be able to group the users into Roles. Roles shall be able to be configured with clearly defined privilege levels and clearly defined plant areas.

The software shall support a large number of users. For each user, it shall be possible to define a password and a role for that user. Passwords shall be hidden both in the configuration and the runtime environment to ensure that other personnel cannot access another account.

Flexibility to define time-based or periodic scheduling for reading and writing of variables to and from field devices.

For remote field devices that are capable of supplying an historical log of alarms and tag value changes, if the communications link fails for whatever reason, on re-establishment of the remote link, all historical alarm, event and trend data archived by the PLC shall be automatically backfilled into the native SCADA alarm and trend history files.

The software shall not limit the number of graphic displays.

Graphic display pages shall be capable of a minimum of 2000 analog tags.

The software must support Historical Trend Graphs as part of a graphic display. The number of trend graphs per page shall not be limited and it can lay trend graphs on top of each other to provide comparisons.

The SCADA software shall include an integrated development package utilizing menu-driven, fill in the form style of configuration to develop the runtime system.

Add, modify and replace alarms, trends and reports online without restarting the server.

Feasible to integrate video cameras to allow viewing of live video.

Capacity Description	Size
Number of SCADA I/O Device Subsystem servers	255
Number of SCADA Cluster servers for Trending, Alarm and Reporting	255
Number of SCADA Client stations	255
Number of field devices	4095
Physical I/O tags being read/written to field controllers	Unlimited and demonstrable to >1000000
Internal I/O tags within the SCADA networked system	Unlimited
Alarm tags	> 100000
Analog trend tags	> 20000
Average refresh time on a graphic display	< 1s
Average recall time for historical trend values	< 5s per day of data

Specifications of PLC/ HMI/

Online Analytical Monitoring /Control panel

The hardware is a unique blend of rugged industrial I/O, real-time multi-tasking software and powerful communication capabilities. It shall be a locally intelligent unit having local memory and processor installed at a respective control and monitoring location in the water network; this can be a pumping station or a tube well station. The Redundant PLC hardware shall be programmable in SFC, IL, LD, ST & FBD.

The high performance modular Redundant PLC must be designed to log all the pumping station parameters with time stamping in its NON-VOLATILE memory at the defined logging interval.

The PLC shall be battery backed-up so as to maintain the parameters during power failure.

The PLC shall be designed to have communication compatibility for wireless mode viz. for GSM, GPRS, Radio, satellite or wired mode viz. Telephone and serial to transmit data and

receive commands remotely.

Following shall be the other minimum design features of the PLC for pumping plant:

16-bit or higher dual core processor based CPU

Data memory of 8 MB and program memory of 64 MB

128 mb flash memory for user program backup.

Having option of Data storage ≤ 32 GB

3 nos. of communication ports

RTC.

Timers and counters sufficient as required.

While the design of the offered PLC Hardware shall be as per the site design on case-to-case basis, the offer PLC shall have full expandability.

Surge withstand 1 kV for transistor output in common mode conforming to EN/IEC 61000-4-5

Environment

Standards CSA C22.2 No 142, UL 1604, UL 508, Resistance to conducted disturbances, induced by radio frequency fields

EN/IEC 61131-2 : 2007

Marine specification (LR, ABS, DNV, GL

1 kV for Ethernet line conforming to EN/IEC 61000-4-4

Digital Inputs with following feature

Input Voltage ranges: 24 VDC, Input current (max): 7 mA @24 VDC/channel • ON/OFF delay project:

1.6 ms

Conforming to IEC 61131-2 type 1

Input impedance 4.7 kohm Response time 50 usec Filtering time 1usec

Execution Time for 1 kinst. 0.7 msec and 0.3 for event and periodic

Analog Inputs with

Input Amplification: 1M Ohm for voltage & 50 Ohm for current input

Maximum allowed overload 13V DC & 40 mA.

HMI Specification

- Minimum 7" wide 800X480 Pixel LCD display with back-lit to display.
- Inbuilt Ethernet, USB mini port, USB type A for report generation, data logging, 485 Port embedded.

- 64000 color
- Real Time Clock
- Minimum Internal memory 48 MB
- Touch Screen
- Facility to connect printer directly
- Serial and parallel printing option
- Make:- Proface /Schneider/Allen Bradley/ ABB

2.16.8. Uninterruptible Power Supply (UPS)

The power for Programmable Logic Controllers (PLC) and Supervisory Control and Data Acquisition (SCADA/HMI) shall be derived from separate UPS. The central PLC based SCADA system and all the remote I/O systems shall be powered by UPS. This shall also include corresponding managed Ethernet switches, internal and external communication systems, monitors and LCD screens. The UPS provided shall be sized to provide sufficient power to maintain system functioning for a period of minimum 1 hour, in case of power failure.

The above feature should be demonstrated during Factory Acceptance Test (FAT) & Site Acceptance Test (SAT).

UPS shall be of stand alone online type not parallel redundant.

2.17 CCTV

The CCTV shall be suitable for day to day operation by semi skilled personnel in the monitoring and operation of the facility.

On completion of installation and commissioning, the facility shall be checked to receive the best clarity footages from both indoor and outdoor cameras.

The facility shall be supported with sufficient backup power facility to maintain system functioning for a period of minimum 1 hour, in case of power failure.

CCTV monitoring station shall be provided at central monitoring Room, which shall be based in the administration building. CCTV Viewer screens shall be fixed both at monitoring station and security centre.

The following location shall have CCTV installations, Inlet / wetwell, primary chamber, Process basins, membrane tanks, chlorination room, discharge unit, substation, panel & Control room. Common surveillance for external area of STP minimum 15 no of dome & bullet cameras of 5MP shall be provided all cameras shall be centrally connected with IP

based system. The system shall have minimum 60 days storage facility.

Compliance Table

The bidder shall fill in the following compliance tables fully detailing the level of compliance and how the level of compliance is achieved.

Description	Compliance
1. SCADA Architecture	√
Client / Server architecture	YES / NO
Standalone single server operation	YES / NO
Additional servers for user load sharing	YES / NO
Fully automated data transfer between servers	YES / NO
A scalable fully distributable architecture	YES / NO
Configurable from a single client	YES / NO
Redundancy shall be handled by the database	YES / NO
Configurable compression of data communications	YES / NO
Change reporting on Client/Server and Server/Server	YES / NO
Capable of operating Client/Server and Server/Server links over low to medium speed channels	YES / NO
SCADA should be having a capability to integrate with IP camera/CCTV and should able to display the remote images within	YES / NO
2. Operator Interfaces	
Multiple local and remote clients	YES / NO
Display facilities shall be available via LAN, WAN and dial-up connection.	YES / NO
Display clients shall be supported as Thin Clients	YES / NO
Integrated desktop Web capability	YES / NO
Changes made to the SCADA server shall require no additional steps	YES / NO
SCADA Software shall provide an Android™ and iOS™ based mobile client and server system	YES / NO
3. Configuration	

Description	Compliance
Seamless On-line configuration of all database parameters including but not limited to: <ul style="list-style-type: none"> <input type="checkbox"/> Communication channels <input type="checkbox"/> PLC/RTUs <input type="checkbox"/> Points <input type="checkbox"/> Sequences <input type="checkbox"/> Schedules <input type="checkbox"/> Alarm redirection <input type="checkbox"/> Mimics <input type="checkbox"/> Trends (historical and ad-hoc)/graphs <input type="checkbox"/> 3D Plots <input type="checkbox"/> Reports 	YES / NO
Configuration changes shall be capable of being made from local and remote workstations	YES / NO
Changes should be updated automatically in local caches where appropriate	YES / NO
Look and feel of the SCADA system, including default field values, shall be configurable	YES / NO
Possible to calculate the value of internal points without using logic	YES / NO
4. Alarm Management	
Facilities where actions can be triggered by alarms. These facilities shall be provided as a built-in integrated part of the system” <ul style="list-style-type: none"> <input type="checkbox"/> Configuration criteria for alarm actions <input type="checkbox"/> Escalate Alarm priority <input type="checkbox"/> Delivery of alarm to users via SMS <input type="checkbox"/> Delivery of alarm to users via E-mail <input type="checkbox"/> Trigger other actions including sequences 	YES / NO

Description	Compliance
Integrated paging facilities	YES / NO
Tracking of alarms	YES / NO
Alarms from all systems shall be combined and filtered, based on user privilege and areas of responsibility	YES / NO
5. Event Journal	
Built-in feature	YES / NO
Separate from Alarm List	YES / NO
Ability to insert user comments	YES / NO
Event lists shall be obtainable through an SQL-like query	YES / NO
Event data is to be stored in a time-series relational database	YES / NO
The event journal shall support the following: <input type="checkbox"/> ODBC / SQL interface to event data <input type="checkbox"/> Filter and browse via full function display client and Web Client	YES / NO
6. Historical Data	
In-built historian without the addition of external software components	YES / NO
Time-series relational database	YES / NO
ODBC / SQL interface to historical (trend) data	YES / NO
Historical data to be stored with time-stamp, point quality, alarm status	YES / NO
Historic storage is to be based on configurable criteria	YES / NO
Compression capability	YES / NO
Capability to backfill this data in to the historian	YES / NO
A programmable API	YES / NO
Fixed and user configurable views of the historic data tables	YES / NO
Validate historic data prior to exposing it externally to the SCADA system	YES / NO
Selectable archiving rates	YES / NO
Point-by-point storage compression regimes	YES / NO
Annotation on history samples	YES / NO

Description	Compliance
Modification of historic data for normalization and correction	YES / NO
Auditing of modified or annotated history	YES / NO
7. System Security	
High level of inherent security	YES / NO
Security access down to data point level	YES / NO
Support individual Users and User Groups	YES / NO
Restricted access to sensitive system information based on user privilege	YES / NO
Full function client interfaces shall require explicit administrative configuration to valid connection to the SCADA server	YES / NO
Web interface facilities shall provide the capability to operate the Web interface using SSL and encrypted data	YES / NO
Web functionality shall be provided in an integrated way with the web server facility tightly coupled with the SCADA database	YES / NO
Support for Windows Authentication	YES / NO
8. Open Connectivity	
Inherent OPC and ODBC database connectivity	YES / NO
Integration with desktop Microsoft products	YES / NO
OPC Data Access	YES / NO
ODBC	YES / NO
OPC Historic Data Access / Alarm & Event	YES / NO
OLE Automation interface	YES / NO
.NET support	YES / NO
ODBC / SQL to the SCADA historical database & event database	YES / NO
Support for specific database packages (e.g. Oracle)	YES / NO
SQL Export for creating csv files	YES / NO
9. Reporting	
Integrated reporting package	YES / NO
Report generation shall use latest technology in database access	YES / NO

Description	Compliance
Reports shall be able to be generated in a number of formats including: <ul style="list-style-type: none"> <input type="checkbox"/> HTML for viewing via Web <input type="checkbox"/> PDF format <input type="checkbox"/> CSV format <input type="checkbox"/> MS Office® suite format <input type="checkbox"/> Crystal Reports 2011 	YES / NO
Generated reports shall be able to be: <ul style="list-style-type: none"> <input type="checkbox"/> printed on a local or network printer <input type="checkbox"/> stored on disk file, locally or remotely <input type="checkbox"/> e-mailed to nominated users 	YES / NO
10. Standard Drivers	
Native support for fully integrated Wide Area SCADA PLC/RTU protocols	YES / NO
Redundant SCADA server configurations and support redundant communication paths	YES / NO
Monitor communication statistics, log driver diagnostics, and provide online access to driver and channel diagnostics remotely	YES / NO
Captured diagnostics shall be able to be translated to HTML for analysis in clear human- readable format	YES / NO
SMS / Paging	YES / NO
SNMP (supporting version 2 and 3)	YES / NO
NTP	YES / NO
ODBC	YES / NO
Windows Performance Monitoring	YES / NO
OPC-DA driver	YES / NO
11. PLC/RTU Protocol Support	
Local serial port communication	YES / NO
Terminal server serial port communication	YES / NO
Citrix XenApp and Terminal Services Support	YES / NO
Ethernet LAN communication via TCP and UDP ports	YES / NO
Time synchronization	YES / NO
Presetting output configuration points	YES / NO
Fully integrated incorporation of events from a PLC/RTU	YES / NO

Description	Compliance
Unsolicited exception reporting	YES / NO
update SCADA database point value / alarm state / point quality / timestamp	YES / NO
support the ability the backfill time-stamped data in to Event Logs, Historic Data	YES / NO
Driver architecture shall support user accessible interfaces to access major driver functions. <input type="checkbox"/> enable / disable outstation communications <input type="checkbox"/> trigger an integrity poll <input type="checkbox"/> alter communication parameters	YES / NO
maintain current state of target device information	YES / NO
redundant server architecture shall retain state information and be able to receive solicited and unsolicited information from the outstation immediately following a server transition	YES / NO
DNP3 protocol shall be fully supported natively	YES / NO
DNP3 Master and DNP3 Slave	YES / NO
Support for SCADA Pack E IEC61131-3 Target 5	YES / NO
Modbus Master / Slave serial	YES / NO
Open Modbus/TCP Master / Slave	YES / NO
IEC 60870-5-104 and IEC 60870-5-101 (KEMA certified)	YES / NO
Allen Bradley DF1	YES / NO
RS Linx	YES / NO
OPC-DA client	YES / NO
12. Logic	
Support logic sequences with full access to all SCADA system services at run time	YES / NO
Programming of sequences shall be to the IEC61131-3 international standard	YES / NO
functional block librarian	YES / NO
Sequences shall be able to me modified and started and stopped online	YES / NO
Sequence changes shall be a native part of the database and replicated to redundant SCADA servers	YES / NO

Description	Compliance
Data Grids/Data Tables/Data Sets. (Ability to store custom calculations/data)	YES / NO
Ability to integrate data storage elements (Data Set Row) into templates/instances	YES / NO
13. RTU / Tube well PLC	
RTU Processor, Dual Core Processor with processing speed of 22 ns to execute one Boolean.	YES / NO
Memory – 64 MB expandable upto 128 MB	YES / NO
Communication – 1 nos RS 485, 1 nos RS 232/RS 485, 1 Nos 10/100 base Ethernet port, 1 Nos USB Port	YES / NO
Web Server Integrated	YES / NO
3 gn (vibration frequency: 8.4...150 Hz)	YES / NO
Operating temperature:- (-10 to 55) deg C.	YES / NO
14. Master PLC (Zonal PLC's)	
Processor in the range must provide up to 64 MB of integrated non-volatile memory to save application and data	YES / NO
Processors with at least 3 built-in Ethernet ports featuring a web server	YES / NO
System compliant with various operating systems: minimum is Windows, iOS, and android.	YES / NO
No battery supply is needed for non-volatile backup	YES / NO
Processor and IO of same family and having same mounting arrangement	YES / NO
Rack based IO's and Processor	YES / NO
Modular IO structure arrangement	YES / NO
Hot-swappable IO's and independent of mounting arrangement	YES / NO
Control Panel Manufacturing setup	YES / NO
CPRI approved Panel Builder	YES / NO
ISO certified	YES / NO

3 SUB-SECTION: GENERAL MECHANICAL REQUIREMENTS

Specifications for Gate Pumping:

PART 1 GENERAL

3.1 DESCRIPTION

- A. Pumps shall be submersible & dry Non clog type installed wastewater pump(s) with watertight and totally encapsulated electrical 3-phase motor prepared for operation at a supply voltage of 415 volts in 50 Hz complete with adequate length of submersible rubber cable.
- B. The cable shall be sized to match the electrical consumption of the motor running at full load and dimensioned according the latest IEC 60335-1 standard or equivalent grade as per IS.
- C. Pumps and drives shall be rated for continuous duty and shall be capable of pumping the flow range specified.
- D. The pumps shall not overload the motors at any point of the performance curves. The pumps shall sized according to IEC 60034 and IEC 60335 / NEMA MG1 and UL 674 or equivalent grade as per IS with a service factor of 1.10 (+10%) in 50Hz.

3.2 SCOPE

- A. The pump(s) shall be designed, manufactured, selected and equipped with accessories suitable for above the purpose, the duty and the operation of the entire system.
- B. The pumps shall be tested and commissioned for the purpose of which the product is intended.

3.3 REFERENCE STANDARDS

The following standards are referred to in this Clause:

For 50 Hz pumps

1. Machinery Directive (2006/42/EC). Standard used: EN 809: 1998 + A1: 2009.
2. Low Voltage Directive (2014/35/EU). Standard used: EN 60204-1: 2006 + A1: 2009.
3. EMC Directive (2014/30/EU) or equivalent grade as per IS
4. Standard of enclosure class (IP) (IEC 60529) or equivalent grade as per IS

5. Referenced vibration standards: ISO5199:2002 and ISO10816 or equivalent grade as per IS
6. DIN flange standard (EN-1092-2): Pressure stage PN 10 or equivalent grade as per IS.

PART 2 PRODUCT

3.4 DESIGN & PERFORMANCE CONDITION

- A. The pumps shall be designed and constructed to operate in a media temperature of maximum 50°C and in the operating conditions they are designed for.
- B. The pumps shall be designed for a life of 100,000 operating hours given the recommended service intervals stated by the pump manufacturer.
- C. Pumps vibration levels shall refer to the principals stated in the equivalent grade as per IS.
- D. The submersible pump when establish on a discharge connection and operated in the system shall be free of leakage in the discharge connection. The pump's shall be installed according to pump supplier recommendations for respective distances between intake and ground floor, sidewalls and minimum water levels to ensure cavitation caused by either surface or submerged vortices is eliminated over the full area of operation.
- E. The construction should be designed so dismantling, service and re-installation can be accomplished easily.
- F. The controls and starting/drive equipment to be suitable for use with the pump/s motor's, taking into account all requirements including starting torque and starting currents and number of starts per hour.
- G. For the performance curve of the selected pump, the head shall continuously rise as flow decreases throughout the entire curve from run out to maximum allowable shutoff head.
- H. Pumps shall be with an uncompromised free spherical passage through the pump hydraulics. The minimum free spherical passage through the pump shall be 65 mm to 85 mm.
- I. The pump's shall be tested in test facilities standardized according grade as per IS or equivalent, with regularly calibrated instruments. Based upon selected test grades according to above standards, the manufacturer shall guarantee the following parameters:

- Flow rate
- Total head
- Power input
- Efficiency.

A. Performance curves:

1. For the pump(s) in question, the pump manufacturer shall supply a complete performance curve document in a readable size.
2. All performance curves shall be according to IS or equivalent and the curves shall be documented in a test report delivered with the pump in question.
3. Performance - and system curves of the pumps shall be supplied with a readable large scale, which shall show the capacity of the pumps under single and multi-pump operation at the duty point.
4. When tested at the manufacturer's facility, pump's can be tested based on system specific duty points (on request).

3.5 PUMP

A. Castings, fabrications, machined parts and drives shall conform to the industry standards for strength and durability and shall be rated for continuous duty over the entire operating range.

B. Pumps shall be manufactured of the following materials and standards as a minimum:

1. Volute castings shall be executed in either cast iron grade no less than EN-GJL-250 / ASTM A48 Class 40B or equivalent grade as per IS .
2. Impellers shall be executed in either cast iron grade no less than EN-GJL-250. Or equivalent grade as per IS
3. Pumpset should be IP 68 type with or without cooling jacket suitable for dry installation.
4. The wetted part of the rotor shaft shall be executed in stainless steel grade no less than EN 1.4401. or equivalent grade as per IS
5. Fasteners shall be executed in stainless steel grade no less than EN 1.4436 or equivalent grade as per IS
6. O-rings shall be executed in NBR rubber
7. Shaft seal shall be a single unit double mechanical seal of the cartridge type. The seal faces of the primary shaft seal shall be silicon carbide/silicon carbide

(SiC/SiC) and the seal faces of the secondary shaft seal shall be either carbon/ceramics or SiC/carbon.

8. The cartridge shaft seals shall be tested from factory before fitted in the pumps.
- C. The pumps shall be fitted with flanges according to IS or Equivalent
- D. The lifting system shall be manufactured of the following materials:
 - The guide rail system shall be stainless steel grade .
 - Lifting chains shall be certified and executed in electro stainless steel .
- E. For pumps that are to be installed partly submerged or dry on Gate installation: The pumps shall be equipped with cooling system with or without the need of motor liquid.
- F. For pumps that are to be installed fully submerged: The pumps shall be equipped without a cooling system.
- G. Bearings shall be greased for life and designed for an L10 life time with a minimum of 35,000 service hours at the best efficiency point (BEP).
- H. Painting and surface preparation: All cast iron parts shall be treated with cataphoresis and powder coating with a layer thickness of minimum 80 microns.
- I. All pumps shall be capable of starting minimum 20 times per hour no matter installation method.

3.6 ELECTRICAL MOTORS

- A. All motors shall be suitable for operation at a supply voltage of 415 Volts, 50 Hz 3 phase, AC supply. Motors shall be capable of giving rated output without reduction in the expected life span when operated continuously under the following supply conditions:
 - I. Variation of supply voltage from the rated motor voltage: +/- 10%
 - II. Variation of supply frequency from the rated frequency: +/- 2 Hz
- B. The motors shall not be overloaded at any point of the performance curves. The pumps shall have service factor of 1.10 (+10%) in 50 Hz applications.
- C. Motors shall be capable of starting up and operate in the event of a completely flooded pumping station. Motors shall be selected to meet the maximum power required for the selected pump impeller at all operating conditions.
- D. The pump motor shall be suitable for Variable Frequency Drive.

- E. Motor shall be capable of starting and accelerating the load with the applicable method of starting without exceeding the acceptable winding temperatures, when the supply voltage is in the range of 10% above of the rated motor voltage.
- F. The motor shall be compliant with the highest motor efficiency standard available in the market i.e. the IE3 classification with fulfilment of insulation class H (180 °C), temperature rise class B (60°C).
- G. The motor shall be water tight, totally encapsulated motor meeting enclosure class IP68 (IEC 60529).
- H. To minimize vibrations and the load on bearings and shaft seal faces the motor shaft shall be short and designed with a stainless steel conical shaft end.
- I. The motors shall be provided with proprietary monitoring and control units for inclusion in the motor such as;
 - 1. thermal switches built in to the stator windings
 - 2. Moisture switch in the stator housing for continuous monitoring of motor enclosure and automatic cut-out in case of leakage.
- J. Apart from the above sensor options, the pump should be capable of accommodating customized sensor options depending on the application.
- K. The terminal connections for the power and protective circuits shall be housed in a completely sealed and waterproof cable plug connection.
- L. The pump units shall be provided with power and protection circuit cables (single cable) of sufficient length to reach from the cable plug connection to the local isolator, located at the ground level.
- M. The power cable shall be 600/1000V grade flexible stranded copper wire, insulated and overall sheathed with under-water grade compound flexible insulation. The cable shall be rated to take the full motor current under the prevailing media and ambient temperature conditions.

3.7 CONTORLS & MONITORING

The pumps shall be provided with proprietary monitoring and control units for inclusion in the motor controls supplied strictly by the pump manufacturer.

- A. Analog inputs shall include the following:
 - 1. Winding temperature
 - 2. Water-in-oil monitoring or Water in Air monitoring unit.
- B. Digital inputs shall include the following :

1. High winding temperature
2. Seal monitoring
3. Over temperature

PUMP GATES SYSTEM

- General Details
- Hinge gate using electric wire drum is applied to design for forced exclusion of rainwater.
- The shape of the gate shall make it possible to keep the gravity centre point on the centre line, since the pump weight will compensate for the unbalanced weight of the gate. The remaining unbalance shall be equalized with weight blocks on the gate front.
- Calculations to demonstrate centred gravity shall be submitted with bids. Failure to submit the engineering calculations shall be deemed a failure to comply with the specification.
- Technical Specification
- Item: Gate
- Type: Wire drum type hinge gate
- Structure size: As per drawings
- Gate size: As per drawings
- Main material: Rolled steel for general structure + Epoxy
- Water-stop method: Entire 4-direction water-stop method
- Quantity: as required.
- Item: Windlass
- Type: Wire drum, Hinge type
- Main material: Casing- Rolled steel for general structure
- Motor:kW (Local control panel)
- Power: 415V x 3Ø x 50Hz
- Quantity: as required.

Local Control Panel

- The local control panel must be installed according to the equipment layout plan submitted by the contractor in a way that enables optimal operation and is suitable for the surroundings. The Control panel shall be of IP65 and higher grade of protection.

- The panel must allow both automatic and manual operation, and have a control meter for voltmeter, ampere meter, PLC, ultrasonic level transmitter , overload limiter, and other operations.
- Automatic operation must be performed based on data entered in advance.
- For manual operation, each operation is performed only by on/off switch on the local control panel.
- Structure: the electrical box of the local control panel must be made of steel sheet of minimum 2.0mm in thickness, and the support, made of stainless steel sheet, must have strong structure to withstand external pressure.
- The local control panel must have a handle with a lock and internal hinge, integrated into the door.

Painting

- Painting must be applied to all exposed steel material and components with the following exceptions:
 - Surface of stainless steel
 - Surface of plated steel
 - Surface of the covered with concrete
 - Other surfaces exposed to mechanical friction or welded on the site (within 1inch from the welded part

PUMP GATES AND ACTUATOR

General Details

- The gate will run on wheels, as a traditional gate.
- The shape of the gate shall make it possible to keep the gravity centre point on the centre line, since the pump weight will compensate for the unbalanced weight of the gate. The remaining unbalance shall be equalized with weight blocks on the gate front.
- Calculations to demonstrate centred gravity shall be submitted with bids. Failure to submit the engineering calculations shall be deemed a failure to comply with the specification.

Technical Specification

- Item: Gate
- Type: sluice type gate
- Structure size: As per interceptor/ site drawings
- Main material: As per manufacturer design and equivalent IS codes.

3.8 Pump Requirements

Pumps and drives shall be rated for continuous duty and shall be capable of pumping the flow range specified in the Specification without surging, cavitation, or excessive vibration to the limits specified.

For the dry pit installation / Open installation of submersible pump set shall be equipped with the cooling jacketing system or without cooling jacket but suitable for dry installation.

The selection of pump shall be as follows :

The capacity of a pump is usually stated in terms of Dry Weather Flow (DWF), estimated for the pumping station. The general practice is to provide 3 pumps for a small capacity for wet well pumping station comprising (a) 1 pump of 1 DWF, (b) 1 of 2 DWF and (c) 1 of 3 DWF capacity. For large capacity pumping station, 5 pumps are usually provided, comprising (d) 2 of 1/2 DWF, (e) 2 of 1 DWF and (f) 1 of 3 DWF capacity, including standby.

Whereas for the gate pumping configuration suits site condition with 100 % standby capacity.

The pump shall meet maximum allowable shut-off head. The pumps shall not overload the motors at any point on the maximum pump speed performance characteristic curve and the pump operating range, within the limits of stable pump operation, as recommended by the manufacturer, to prevent surging, cavitation and vibration.

To ensure vibration-free operation, all rotative components of each pumping unit shall be statically and dynamically balanced as per IS codes and the following requirements shall be met:

- The mass of the unit and its distribution shall be such that resonance at normal operating speeds is within acceptable limits.
- In any case, the amplitude of vibration as measured at any point on the pumping unit shall not exceed the below limits.

All units shall be so constructed that dismantling and repairing can be accomplished without difficulty. The vendor shall be responsible for proper operation of the pump.

The controls and starting equipment are suitable for use with the pump motor, taking into account all requirements including starting currents and number of starts per hour.

For the performance curve of the selected pump impeller, the head shall continuously rise as flow decreases throughout the entire curve from run out to shutoff head.

3.9 Design Conditions

Pumps shall be designed and constructed to satisfactorily operate and perform within the designated design conditions and the requirements specified herein. Castings, fabrications, machined parts and drives shall conform to the industry standards for strength and durability and shall be rated for continuous duty over the entire operating range. Pump maximum operating speed shall not exceed 1500 rpm.

Pumps shall be of non-clog design, capable of passing spheres of a minimum 65 to 85 mm diameter. Submersible pumps shall have the duck foot bends flanged for wet pit installation.

The motors shall be provided with proprietary monitoring and control units for inclusion in the motor such as;

1. thermal switches built in to the stator windings
2. Moisture switch in the stator housing for continuous monitoring of motor enclosure and automatic cut-out in case of leakage

The pump manufacturer should guarantee the following parameters.

- Flow Rate
- Total Head
- Power Input
- Efficiency

The lifting system shall be manufactured of the following materials

- The guide rail system shall be stainless steel; Type 316
- Lifting chains and cables shall be Type 316 .

3.10 Fabrication

General: Pumps shall be fabricated in accordance with the following requirements:

- Pumps shall utilize a guide system to permit easy removal and reinstallation without dewatering the pump sump.

- Discharge connections shall be made automatically with a simple downward motion without rotation when the pump is lowered into operating position. The pump shall be capable of being removed without disconnecting any fasteners. The auto coupling shall be with 2 nos of guide rails.
- An appropriate length of chain shall be connected to the motor eyebolts to permit rising and lowering of the pump.

Impellers shall be fabricated according to the rated motor size as follows :

- Non-clog type statically and dynamically balanced, keyed to the shaft
- Pumps must be equipped with a method of restoring impeller to casing clearance in the axial direction, to restore the pump efficiency, at site, without the need for dismantling of pump and machining for replacement of wear rings or only wear rings.
- Impeller clearance adjustment shall not be done unless approved by the Engineer
- Impellers shall be of closed, one or two vanes type.

Factory Inspection and Testing :

Third party inspection / Client Inspector shall witness factory test of the pumps prior to shipment, all the requisite charges for the inspection at testing facility shall be borne by bidder.

3.11 Site Inspection and Testing

The equipment delivered to the Site shall be examined by us to determine that it is in good condition and in conformance with the approved working drawings and certifications. All equipment shall be installed in strict conformance with the Specification and the manufacturer's instructions.

The pump manufacturer's representative shall supervise the installation, commissioning and start-up of the pumping equipment.

The commissioning tests shall be performance and reliability trails, mainly for the purpose of satisfying the Engineer that the pump **sets have been correctly assembled and installed as per the site condition.**

The site reliability trials shall include the following.

- **A record of all overload, timing relay and oil pressure relays shall be tabulated to show the "as-built" condition of each motor starter**

- All cables shall be ‘megger’ tested to confirm the integrity of the insulation. A tabulated record of results shall be made.
- The control panel shall be statically tested with motors disconnected to confirm the correct sequence of operation.
- Record the following :-
 - Motor phase currents
 - Power consumed
 - Power factor

The commissioning trials shall extend until each pump unit has run ‘continuously’ for at least 3 days under all operating conditions. The term ‘continuously’ shall include running at various speeds or on a start/stop basis as determined by the control system.

The Contractor’s supervisory staff, and the pump manufacturer’s representative, if required by the Specification or the above, shall be present during the period of the tests and trials. The Contractor shall be responsible for any failure of the whole equipment or any part thereof, whether such failure shall be determined by the methods detailed herein or otherwise. If the Contractor interrupts the pump test or trial, or through negligence on the part of the Contractor’s staff, it shall be completely repeated for the pumpset concerned.

3.12 Motors

All motors shall be suitable for operating on a 415v, 50 Hz, 3 phase, AC supply. Motors shall be capable of giving rated output without reduction in the expected life span when operated continuously under the following supply conditions.

- | | |
|---|---------------|
| I. Variation of supply voltage from the rated motor voltage | +/- 10% |
| II. Variation of supply frequency from the rated frequency | +/- 5% |

The motors shall be provided with proprietary monitoring and control units for inclusion in the motor such as;

1. thermal switches built in to the stator windings
2. Moisture switch in the stator housing for continuous monitoring of motor enclosure and automatic cut-out in case of leakage

The pump motor shall be suitable for Variable Frequency Drive.

Submittals for approval:

The manufacturer shall furnish the pump curves, system curves and necessary hydraulic calculations to justify the sizes of any pump selected.

The manufacturer shall also provide the following.

1. Pump Data Sheets
2. Performance curves
3. Quality Assurance Plan
4. O & M manuals.

3.13 Pre fabricated primary unit

Pre fabricated primary unit consisting of Fine screens, drum screens, micro strainers, Screening treatment with dewatering compaction , Grit separation grit removal and discharge with grit washing. The entire system shall have oil and grease removal system.

Principle of operation:

All pre-treatment process steps of the plant are integrated in one stainless steel tank. The wastewater flows into the plant either by gravity (channel) or from a pressure line. The inflow streams at first passes through a rotary drum screen installed in the first chamber which removes all the floating and suspended material. The screenings are discharged directly from the screen after transport and compaction in an integrated screenings press. In the following chamber of longitudinal grit trap, settleable material is separated through the reduction of flow velocity.

As an option the plant can be equipped with grit trap aeration for removal of FOG. A horizontal shafted screw conveyor transports the separated solids (grit and organic particles) against flow direction to a grit classifying shafted screw which is integrated at the beginning of the grit trap. During their transport in the grit classifying screw the solids are statically dewatered prior to being discharged into a container.

Constructional details, MOC, Flow, functional description :

Constructional details - The complete plant shall consists of units inclusive of longitudinal grit trap, fine rotary drum screen, screw conveyors for removal, transferring and dewatering the screenings and grit in shafted design.

Longitudinal grit trap shall be equipped with the provision of removal of FOG by means of aeration by rotary vane compressors/blowers.

Complete plant shall be pre-fabricated structure either in SS316 except the drives, motors. The plant shall be designed and fabricated so as to connect with the incoming sewer pipe by means of a flange connection.

Similarly the outlet of the plant shall be connected to the downstream treatment process via flange connection.

The rotary drum screen basket should be a precisely welded construction. The perforated plate/ wedge wire surface which retains the screenings should be welded onto a supporting structure. Spirals of metal strips on the inner drum surface transport the screenings upwards and drop them into the trough. A brush fitted to the inner drum surface cleans the trough edge as the basket rotates. The screen basket at the bottom end is to be fixed to the screw by means of a strut, while on the upper end support is to be provided with several rollers. A brush or a polyurethane sealing on the baffle plate is to be used to seal the gap between the screen basket and channel.

Functional description -The machine starts when the screen level control level (or any other start signal) is reached. The screen drive motor operates as long as the start signal is active and transports the solids out of the channel. The water level in front of the screen falls again. The screen running time must be individually adjusted to each plant by programming a (selectable) follow-up time.

If the inflow is low, screenings may accumulate in front of the screen if screen starting is not effected via screen level control. To prevent accumulation of screenings, a time can be programmed after which the screen drive motor is necessarily switched on after a selectable standstill time. The screen drive motor will then operate according to the freely programmable follow-up time. To protect the screen against mechanical damage, the electrical control is to be equipped with a over load relay. The machine stops immediately whenever the over load relay responds. After a pause of 2 seconds the screen drive motor is reversed for a programmable time. (To avoid damage of the bottom shafted screw flight screen reversal has to be limited. This applies also to manual operation, i.e. even in manual mode the screen can only be reversed for the pre-defined time even if the key or button is operated longer. A new reversal is only possible after prior forward operation.)

As soon as the start signal from the level control system responds, the machine starts to run forwards again after a waiting time of 10 s.

If the over load relay trips 3 times within 5 minutes, the machine is stopped and a trouble is reported. The machine can only be re-started after reset of the fault. If the Over load relay trips during screen reversal, the machine must immediately be stopped. A fault message is reported. The machine can only be re-started after reset of the fault. If the current relay trips during screen operation in manual mode (forwards or reversal), the machine must immediately be stopped and a fault message reported. The machine can only be re-started after reset of the fault.

MOC - Tank - SS 316, Grit trap – SS 3016, Screws - Shafted only (To have enough strength and durability for longer run), Rotary drum Screen - With 1,2,3, or 6 mm spacing, MOC of screen shall be SS 316

Flow - As per the design peak flow

Accessories :

Spray nozzle bar-

The spray bar solenoid valve is controlled parallel to the forward operation of the screen motor drive. While the screen basket rotates as it moves forwards, screenings are removed by means of the flat jet nozzles.

Press zone washing –

Activation of the press zone washing system effects cleansing of the press zone respectively press liquor collection chamber. For this purpose the solenoid valve for press zone washing is opened.

Integrated screenings washing IRGA –

The integrated screenings washing system (IRGA) washes out the faeces contained within the screenings and returns them to the biological process. Such screenings washing improves screenings dewatering efficiency.

IRGA consist of three washing stages: preliminary washing, washing with pressure, fine washing Preliminary washing / washing with pressure: Water supply is via the solenoid valve for IRGA preliminary washing.

Fine washing: 3 washing units on the rising pipe are connected with pressure hoses, The nozzles spray in an exactly defined angle onto the screenings while these are conveyed by the

screw. Water supply is via a second solenoid valve on machine size 1400 and bigger which is controlled separately (solenoid valve for IRGA fine washing). In all other cases: water feed via the solenoid valve for IRGA preliminary washing.

For smaller sizes an own valve may be used optionally.

Tank cleaning

Activating the tank cleaning system initiates cleaning of the tank. For this purpose the solenoid valve is opened.

Compressor

The compressor for grit trap aeration is permanently switched on. The individual air tubes can be adjusted to specific site requirements via separate ball valves.

Grease trap-

Only aerated Complete Plants are available with a grease trap. Floating particles are carried over to the attached grease trap more or less with the air roll of grit trap aeration. The grease is normally removed discontinuously by an integrated grease paddle (rest position at the end of the Complete Plant).

The grease paddle ensures uniform removal of grease over the entire grease trap surface. The grease paddle pushes the grease into a collection chamber at the beginning of the Complete Plant from where it is pumped by an eccentric screw pump. Grease removal is operated manually as standard. Fully automatic operation via PLC is available as an option. The required frequency of grease removal depends on the volume of generated grease.

Performance criterion :

90 % of grit removal for particle size $\geq 0,2$ mm specific gravity of grit particle shall be 2.65.

Motor :

Premium efficiency class(IE3 and above), with IP65 protection, Nominal voltage 400 V $\pm 10\%$ without Ex-motor

Nominal frequency 50 Hz, motors shall be without explosion protection, design ambience temperature shall be 40 Degree celcius

Control panel specifications:

Cabinet make Rittal or equivalent

Nominal voltage 400 V \pm 10%

Nominal frequency 50 Hz \pm 5%

Protection class IP 55

Automation with PLC by standard manufacturer

Material - CRCA

3.14 Data Sheet for Pre fabricated primary unit

Data Sheet for Pre fabricated primary unit consisting of Fine screens, drum screens, micro strainers, Screening treatment with dewatering compaction , Grit separation grit removal and discharge with grit washing. The entire system shall have oil and grease removal system.

Data Sheet for Pre fabricated primary unit	
Technical Data Sheet	To be filled by bidder
Capacity	
Total length	
Total width	
Tank height	
Total height	
Inlet	
Outlet	
Residue outlet	
Total weight empty	
Total weight under operation condition	
Total weight completely flooded	
Material	
Technical data screen	
Capacity	
Diameter of screen basket	
Perforated plate	
Installation angle	
Discharge height	

Material	
Drive, Asynchronous motor	
Make	
Type	
Nominal power	
Nominal current	
Voltage	
Frequency	
Protection class	
Insulation class	
Efficiency classes	
Automatic drum cleaning	
Wash water demand	
Required pressure	
Water quality (Particle size)	
Water connection	
Solenoid valve	
Make	
Material	
Quantity	
Grit trap type, aerated	
Capacity	
Separation degree	
Particle size	
Material	
Drive, Asynchronous motor (For horizontal grit screw and inclined grit screw)	
Make	
Type	
Nominal power	
Nominal current	
Voltage	

Frequency	
Protection class	
Insulation class	
Efficiency classes	
Rotary vane compressor	
Suction capacity	
Pressure	
Pressure connection	
Make	
Type	
Nominal power	
Nominal current	
Voltage	
Frequency	
Protection class	
Grease trap	
Material	
Drive, Asynchronous motor	
Make	
Type	
Nominal power	
Nominal current	
Voltage	
Frequency	
Protection class	
Insulation class	
Power factor	
Efficiency classes	
Weight	
overload protection	
Make	
Type	

Grease pump	
Medium to be transported	
Make	
Type of pump	
Capacity	
Pressure	
Nominal power	
Voltage	
Frequency	
Protection class	
Efficiency classes	
Suction connection	
Pressure connection	

3.15 Submersible Vertical Propeller Pumps

Application where larger volumes must be pumped up to relatively low heads Vertical Propeller Tube Type pumps should be used. Tube shall be of SS 316 material with minimum 8 mm thick. Design Requirements

(a) Pump

Pumps shall be compact, single stage, submersible propeller, vertical shaft, wear resisting, designed to install vertically in a Stainless steel tube with an automatic coupling, suitable for screened sewage applications.

Pumps shall be designed for continuous operation under submerged conditions as well as Intermittent operation.

Pumps shall be fitted with dynamically balanced non clog Propeller designed to pass coarse solids of at least 50 mm diameter.

The equipment shall be capable of developing the required total head at rated capacity. Total head capacity curve shall be continuously rising from minimum head to maximum head.

Pump operating speed shall be less than 1000 rpm.

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 1.8 M.

Pump should be equipped with double mechanical seals. Lower sealing between Impeller and Oil chamber and upper sealing between Oil chamber and motor winding.

(b) Submersible Motor

Motor should be water pressure tight encapsulated, fully flood -proof motor, 3 phase Squirrel Cage Induction Motor, 415V +10%, 50 Hz, with IP-68 Enclosure with Class H Insulation, Temperature Rise: according to class A, IE3 Premium Efficiency Motor accordance with IEC60034-30, ATEX Explosion Proof Version suitable for submergence upto 20 m.

Water pressure sealed connection chamber, with two stage cable entry, protected against excessive cable tension and bending. The cable shall be EPR insulated Double sheathed designed and certified for permanent use in sewage water and suitable for a conductor Temperature of 80 °C.

Motor should be of Low temperature rise so that it allows for high service factor. Minimum service factor should be 1.3. 30% safety margin against overheating when a motor is operated under full load:

- At low line voltage
- At generator sets, which are slightly over speeding
- In medium with temporarily higher temperature

Propeller pump, pumps the liquid upwards in the steel pipe which will flow around the motor with this action motor cooling happens automatically.

All Motors should be suitable for use with VFD.

The installed power rating of the motor should be the larger than 120% of the power required at the duty point.

Bi-Metallic Thermal sensors should be provided in the each phase of motor winding & both (Upper & Lower) bearings to monitor temperature rise in motor windings and bearings. The sensors shall be connected in series and shall be coupled to the motor contactor coil such that any one-switch opening will shut down the motor.

Moisture sensors should be provided in motor housing, Mechanical Seal Oil Bath & connection chamber of the motor. Moisture Sensors with Electronic amplifier trip the Motor in case of ingress of water.

- a. For Oil chamber - To detect the Mechanical Seal Failures.
- b. For Motor housing - To monitor leaks in Motor housing.
- c. For Connection Chamber - To detect failure through Cable entry.
- d. Mating surfaces shall be watertight and fitted with nitrile O-rings.

(c) Features of Construction

Pump should be Vertical Shaft, wear resisting, single stage, submersible Propeller type, suitable for screened sewage applications.

Pumps should be identical and suitable for parallel operation with equal load division. Components of identical pumps should be interchangeable.

Pump casing should be of robust construction Liquid passages should be finished smooth and designed so as to allow free passage of solids as specified below.

Axial propeller with 3 or 4 propeller blades and diffuser on discharge side. Pumps should be provided with anti-friction ball or roller type bearings, lubricated-for life, maintenance-free designed for a L10 bearing life of 100,000 hours at BEP and shall be of sufficient size to transfer all radial and axial loads to the pump housing and minimize shaft deflection. Maximum shaft deflection should be 0.05 mm at mechanical seal face.

Pump should be furnished complete with coupling ring for welding in the steel pipe to hold the pump in steel tube, Lifting chain, Power & Control Cable, Motor control system, control panel and level switches.

For lifting of pump Stainless Steel Lifting hoop/handle fitted on the motor top should be provided.

All mating surfaces of the pump and motor shall be machined and fitted only with Orings (NBR) where watertight sealing is required.

Pump should be equipped with double mechanical seals. Lower sealing by means of a SIC/SIC between Impeller and Oil chamber and upper sealing by SIC/SIC mechanical seal between Oil chamber and motor winding, independent of the direction of rotation.

Propeller and Rotor shaft should be dynamically balanced.

The Pump set shall be capable of withstanding the accidental rotation in reverse direction.

Description	Material of Construction
Cooling/oil chamber, Connection chamber	CI IS 210 Gr. FG.260
Motor	
Shaft	Stainless Steel AISI 431
Propeller Blades	SS ASTM A 743 Gr.CF8M
O-ring/Seals	Nitrile rubber (NBR)
Fasteners	SS 316
Lifting Chain	SS 316

3.16 Chemical Feeding Equipment

3.16.1 Chemical Dosing Pumps

- (a) Chemical dosing pumps shall be piston, piston diaphragm or mechanical diaphragm type as specified. Pumps may be simplex or duplex arrangements to suit the capacity or process requirements. The pump design shall incorporate positive stroke return. The maximum stroking speed shall not exceed 100 strokes per minute (spm). Pump, motor and driving arrangement shall be mounted on a robust combined baseplate.
- (b) Pump liquid ends shall be selected for compatibility with the pumped liquid. Suction and discharge valves shall be the single ball type allowing a free flow self cleaning action. Ball and seat materials shall be resistant to abrasion.
- (c) Pumps shall incorporate a variable stroke mechanism to allow the output to be varied while the pump is running. Stroke adjustment shall be manual or where specified by electrical or pneumatically controlled stroke positioner. A stroke length indicator and digital stroke counter shall be fitted. Pumps shall be driven by a flange mounted IP 55 motor, via an oil bath reduction gearbox and variable stroke mechanism giving stepless adjustment between zero and maximum stroke length. Where flow proportional dosing is required the variation of output shall be achieved by varying the speed of the pump motor and not the pump stroke length.
- (d) The normal operating range of dosing pump shall be not less than 6:1.

a.	Mechanical Diaphragm	Diaphragm rigidly coupled to the drive train Single suction Pumps and discharge valves Glandless.
b.	Piston Pumps	Cylinder and piston with packed gland Double suction and discharge valves can be fitted for greater accuracy at high pressure. Accuracy: 1% of stroke
c.	Piston Diaphragm Pumps	Diaphragm hydraulically operated by liquid displaced by a plunger and protected from excess pressure via a relief valve. Accuracy: 2% of stroke.

Materials shall be selected to suit the chemicals being pumped. Liquid ends shall be polypropylene, 316 stainless steel, glass, or Hastelloy C. Diaphragm materials shall be butyl rubber, PTFE, or Hypalon and glands shall be PTFE or Neoprene.

- (e) Each pump shall be provided with inlet and outlet isolating valves and with pressure relief and non-return valves. Dosing pumps shall be provided with back pressure loading valves and pulsation dampeners in the delivery lines.
- (f) A relief valve shall be incorporated in the delivery lines under conditions where the pump discharge pipe can be shut off or where pressure may rise to an excessive point. The relief valve shall be sized to handle the system pressure and to discharge maximum pump output freely, and shall be located in the discharge line between the pump and the first downstream isolating valve or in the case of dosing pumps the back pressure loading valve. Relief valves when used on pumps handling non-hazardous chemicals shall discharge the vented liquid to waste. When used on hazardous chemicals the valve outlet shall be piped back to the suction supply tank or bunded area. The open end of the return pipe shall be located where it is visible, so that any relief valve leakage/operation can be detected. Pump transferring/dosing chemicals to systems under pressure shall incorporate a pressure gauge on the pump delivery. Air cocks shall be provided for release of air where necessary.
- (g) Unless otherwise specified flushing connections shall be provided at each pump inlet and flushing shall be manual. When flushing, water shall be discharged either locally through a drain valve or to the point of application of the chemical. Facilities shall also be provided for flushing chemical pump suction and delivery manifolds and delivery lines to point of application.
- (h) Dosing pumps and motors shall preferably incorporate an integral reduction gearbox drive which shall be totally enclosed and oil bath lubricated. The gear box shall incorporate the cams for the diaphragm drive and shall be provided with filling and drain connections and visible oil level indication.
- (i) All dosing pumps shall have facility/terminals for pulse input & output (4-20 mA) to facilitate online control via plant PLC & SCADA.

3.16.2 Chemical Tank and Mixer

(i) General

This tank shall be used to dissolve the alum or polymer to a constant concentration and feed the solution to the outlet channel of the aeration tank or the dewatering equipment. It shall be a

vertical tank and shall be composed of tank main body, mixer, manhole, electrical level gauges, direct reading level gage, ladder, air exhaust pipe etc.

(ii) Fabrication

- (a) The tank shall be made of corrosion resistant material.
- (b) The tank shall be provided with a removable cover to prevent chemical scattering, and also with a vent pipe.
- (c) The tank shall be provided with necessary mounting seats for overflow pipe, etc.
- (d) The motor-driven mixer shall be vertical speed reducer, direct-coupled type of 2-stage propeller type, as a rule and shall be constructed to endure continuous operation free from vibration, etc. The mixer shall be at the center or at a position off the center according as the tank being angular or circular.
- (e) The mixer shall be protected by electrical prevention of dry operation.
- (f) The tank shall be constructed to seal gas and splash from below at the area where the mixer shaft drive portion passes through.
- (g) Alum feed cage of stainless steel shall be provided inside the alum solution tank.

(iii) Materials

- (a) Main Tank body : GRP/HPDE
- (b) Mixer frame : SS316
- (c) Mixer shaft :SS316
- (d) Blade : SS316L

(iii) Accessories (per Unit)

- (a) Foundation bolt and nut (SS304) x 1 set
- (b) Air vent pipe x 1 set
- (c) Mixer x 1 unit
- (d) Direct reading level gauge x 1 unit

3.16.3 Alum Dispersion Rapid Mixer

- (a) The alum dispersion rapid mixer shall be in-channel submersible chemical vacuum induction unit and consist of chemical induction unit with mount bracket, guide rail assembly, floor mount base, boom hoist with manual brake winch and SS 316 cable, hose assembly, control panel and submersible power cable.

- (b) The unit shall be provided instantaneous diffusion / mixing and the highest level of durability and performance required for chemical feed application.
- (c) The hermetically sealed SS 316 motor shall provide the highest level of durability and performance required for chemical feed applications. All wetted materials shall be constructed from Grade 2 Titanium (unalloyed) and shall be designed for use with all common water and wastewater treatment chemicals. The mounting bracket shall be engineered for installing in open-channel applications.
- (d) The material of construction of chemical induction shall be as follows:

S. No.	Component	Material
(i)	Vacuum chamber	Titanium
(ii)	Vacuum port	Titanium
(iii)	Vacuum enhancer	Non-metallic
(iv)	Propeller	Titanium
(v)	Propeller bolt	Titanium
(vi)	Shaft	Titanium
(vii)	Mechanical seals	Carbon /ceramic
(viii)	Hardware	SS 316

3.17 Induction Motor

3.17.1 Motor for Dry Pit Sewage / Sludge Pumps

3.17.1.1 Design Requirements

The motors shall be suitable for operating on a 415 V, 50 Hz, 3 phase, Ac supply.

The motors shall generally conform to IS: 325 or relevant equivalent internationally approved standards. Additionally the specific requirements mentioned in the following clauses shall also be met. All motors shall be EFF-1 energy efficient type.

3.17.1.2 Performance and Characteristics

- (a) Motors shall be capable of giving rated output without reduction in the expected life span when operated continuously under the following supply conditions:
 - (i) Variation in supply voltage $\pm 10\%$
 - (ii) Variation in supply $\pm 5\%$
 - (iii) Combined voltage and frequency variation $\pm 10\%$
- (b) Motors shall be suitable for full voltage direct-on-line starting or star delta starting. Minimum permissible starting voltage shall be 85% of the rated voltage.
- (c) The Power rating of the motor shall be the larger of the following :

- (i) 115% of the power input to the pump at duty point at a speed corresponding to the frequency of 49.0 Hz.
- (ii) Maximum power input while operating single pump corresponding to the speed of 50 Hz.

3.17.1.3 Insulations

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 hot, humid and tropical climate. The motors shall be provided with class F insulation with temperature rise limited to that of class B insulation. The degree of enclosure protection of motors shall be of minimum IP 55.

Motors shall be given power house treatment. This comprises an additional treatment to the winding over and above the normal specified treatment. After the coils are placed in slots and all connections have been made, the entire motor assembly shall be impregnated by completely submerging in suitable insulating compound or varnish followed by proper baking. At least three such submersions and backings shall be applied to the assembly.

3.17.1.4 Constructional Features

The motor construction shall be suitable for easy disassembly and reassembly. The enclosure shall be sturdy and shall permit easy removal of any part of the motor for inspection and repair.

- (a) Motors weighing more than 25 kg shall be provided with eyebolts, lugs or other means to facilitate safe lifting.
- (b) The rotor bars shall not be insulated in the slot portion between the iron core laminations for squirrel cage motors.

3.17.1.5 Terminal Box

Terminal boxes shall be of weather proof construction designed for outdoor service. To eliminate entry to dust and water, gaskets of neoprene or approved equivalent shall be provided at cover joints and between box and motor frame. It shall be suitable for bottom entry of cables. It shall be capable of being turned through 360 degrees in steps of 90 degrees.

The terminals shall be of the stud type with necessary plain washers, spring washers and check nuts. They shall be designed for the current carrying capacity and shall ensure ample phase to phase and phase to ground clearances. Suitable cable glands and cable lugs shall be supplied to match specified cables.

Separate terminal boxes shall be provided for the following:

- (i) Starter leads; and
- (ii) Space heater

3.17.1.6 Accessories

Two independent earthing points shall be provided on opposite sides of the motor, for bolted connections. These earthing points shall be in addition to earthing stud provided in the terminal box.

3.17.1.7 Heating during Idle Period

For motors rated below 30kW, during idle periods, the stator winding will be connected to required single phase, 50 Hz, AC supply for heating and elimination of moisture. The supply will be connected between any two terminals.

Motors rated 30kW and above shall have space heaters suitable for 230V, single phase, 50 Hz, AC supply. Space heaters shall have adequate capacity to maintain motor internal temperature above dew point to prevent moisture condensation during idle period. The space heaters shall be placed in easily accessible positions in the lowest part of the motor frame.

3.17.1.8 Earthing Pad

Two independent earthing pads of non-corrodible metal shall be welded or brazed at two locations on opposite sides complete with suitable bolt and washers for earthing. These earthing pads shall be in addition to earthing stud provided in the terminal box.

3.17.1.9 Rating Plate

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

Rated voltage, kW rating, frequency, efficiency, power factor, temperature rise of windings in degree centigrade at rated load, and ambient conditions.

Type of bearings, recommended lubricant, lubricating interval & re-lubricating quantity.

3.17.1.10 Tests

Motor shall be subjected to all the type test (one from similar rating of each lot) and routine tests as per applicable standard in the presence of the Engineer. Copies of test certificates for all brought out items shall be furnished at the time of inspection for the Employer's approval. The Contractor shall ensure to use calibrated test equipment / instruments having valid calibration test certificates from standard laboratories traceable to National / International standards.

3.17.2 Low Voltage Motors

Motors shall be suitable of starting and accelerating the load with the applicable method of starting, without exceeding acceptable winding temperatures, when the supply voltage is 85% of the rated motor voltage.

The locked rotor current of the motor shall not exceed 600% of full load current (subject to tolerance as per the applicable standard).

Motors shall be designed to withstand 120% of rated speed for two minutes without any mechanical damage, in either direction of rotation.

Stator leads shall be brought to the terminal box as insulated cable through a suitable barrier and terminated in clamp type terminals.

Motors rated 30 kW and above shall be provided with space heaters with adequate capacity to maintain motor temperature to prevent moisture condensation on the insulation during idle condition. The space heaters shall be suitable for 240V single phase 50 Hz supply. The degree of enclosure protection of motors shall be of minimum IP 55.

3.17.3 Induction Motor (Submersible Pump & Mixers)

3.17.3.1 Performance and Characteristics

- (a) The submersible motor shall conform to IS: 9283:1979 and the submersible cable shall conform to clause no. 4.4 of the IS: 9283:1979. The motors shall be suitable for operating on a 415 V, 50 Hz, 3 phase, Ac supply. Pump motor shall be of the squirrel cage submersible type; protected to IP 68. Motor for submersible pump shall be capable of start up and operation in the event of a completely flooded wet well. Motor cooling for submersible pump must be achieved by a cooling jacket, using the pumped media to cool the motor. The pump impeller must be equipped with a system to ensure a pumped flow of liquid through the cooling jacket and also incorporate a device to prevent the liquid channels from blocking with hair and foreign material. This motor

shall be capable of starting 10 times per hour. The insulation class of motor winding shall conform to class F / H as specified in the pump or mixer specification. .Additionally the specific requirements mentioned in the following clauses shall also be met. The motor shall be of Eff-2 energy efficient type.

(b) Motors shall be capable of giving rated output without reduction in the expected life span when operated continuously under the following supply conditions :

- (i) Variation of supply voltage from rated motor $\pm 10\%$
- (ii) Variation of supply frequency from rated $\pm 5\%$
- (iii) Combined voltage and frequency variation

The starting current of motor shall not exceed 300% of rated full load current for soft starter starting and 600% of rated full load current for DOL starting, under any circumstances. Motors shall be suitable for full voltage direct-on-line starting or soft starter starting.

Motors shall be capable of starting and accelerating the load with the applicable method of starting, without exceeding acceptable winding temperatures, when the supply voltage is in the range 85% of the rated motor voltage to maximum permissible voltage.

The locked rotor current of the motor shall not exceed 600% of full load current (subject to tolerance as per the applicable standard) unless otherwise specified.

Motors shall be designed to withstand 120% of rated speed for two minutes without any mechanical damage, in either direction of rotation. The motor vibrations shall be within the limits specified in applicable standard unless otherwise specified for the driven equipment.

Except as mentioned herein, the guaranteed performances of the motor shall be met with tolerances specified in applicable standard, IS: 9283-1979.

Motor insulation shall conform to Class F / H as specified in the pump or mixer specification and the maximum temperature rise shall be limited to class B. The motor windings shall be protected with a waterproof material and shall incorporate a thermal sensor in each phase to safe guard against high winding temperatures. The thermal sensor shall be connected into the control circuit of the starter and signals taken for continuous monitoring of winding

temperatures. The motor shall incorporate a cut out device to detect the presence of any liquid in the motor enclosure, in the form of non-resetting moisture switch. The terminal connections for the power and protective circuits shall be housed in a completely sealed and water proof junction box, complete with all external corrosion resistant cable glands. The pump units shall be provided with power and protection circuit cables of sufficient length to reach from the motor junction box to the local isolator located at the panel floor level.

Protection against increase in stator winding temperature bearing temperature, leakage in stator housing and terminal box shall be provided. Minimum three number thermistors are to be provided to sense the stator winding temperature. Sensors are to be provided to detect if leakage of sewage into the oil housing is above 30 % concentration.

Bimetallic thermal switch to trip the motor against increase in temperature shall be provided. The power rating of the motor shall be larger of the following:

- (i) 115% of the power input to the pump at duty point at a speed corresponding to the frequency of 49 Hz.
- (ii) Maximum Power input while operating single pump corresponding to the speed of 50 Hz.

Motor shall be offered for routine and type tests in accordance with IS: 4029 and IS: 325 at the manufacturer's works.

3.17.3.2 Submersible Cable

- (a) The submersible cable shall conform to clause no. 4.4 of the IS: 9283:1979. The power cable shall be PVC insulated and PVC sheathed, flexible, 3.5 core flat type. The size of the conductor shall be adequate for continuous use under water and air. The half core shall be used for earthing.
- (b) The control cable shall be PVC insulated PVC sheathed, flexible, flat type and shall be adequate for continuous use under water and air. The control cable for stator winding temperature sensor (Thermistors) 3 core x 2.5 sq. mm copper conductor and for bimetallic thermal switch 2 core x 2.5 sq. mm copper conductor shall be provided.
- (c) In case a joint is required to be made between the lead cable supplied with the motor and the user's cable connectors, a detailed procedure of cable jointing to make a watertight joint shall be provided by the manufacturer.

- (d) The size of the conductor and length of cable should be suitably selected so that the voltage drop at motor terminals does not exceed 3 percent of the rated voltage.

3.17.3.3 Earthing

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

3.17.3.4 Insulation

- (a) Any joints in the motor insulation such as at coil connections or between slot and end winding sections, shall have strength equivalent to that of the slot sections of the coil.
- (b) The insulation shall be given tropical and fungicidal treatment for successful operation of the motor in hot, humid and tropical climate. The tropicalising treatment shall be as per the applicable standard.
- (c) The stator winding shall be made from high conductivity annealed copper conductor, PVC insulated winding wires conforming to IS: 8783:1978 for wet type motors. The stator winding shall be of high conductivity annealed copper enameled insulated wires conforming to IS: 4800 (Part-VII):1970 for dry type motors.

3.17.3.5 Temperature Rise

The temperature-rise test of the motor shall be carried out with the motor coupled to the suitable pump as per relevant standard.

3.17.3.6 Constructional Features

The motor shall be suitable for continuous use in fully or partially submerged condition. A built in cooling system must allow the motor to operate continuously at its rated output regardless of whether the electric motor is submerged or not, by providing either external or internal cooling arrangement.

3.17.3.7 Terminal Box

Terminal box shall be of weather proof construction to eliminate entry of water and dust. The terminals shall be of the stud type with necessary plain washers, spring washers and check nuts. They shall be substantially designed for the current carrying capacity and shall ensure ample phase to phase and phase to ground clearance.

3.18 Sluice Gate & Weir Gates

3.18.1 Cast Iron Gate:

- (a) Design Requirements and Construction Features
The construction of sluice gates shall be in accordance with the specification and generally as per IS: 13349. All sluice gates shall be of the rising spindle type.
- (b) Frame
The frame shall be of the flange back type and shall be machined on the rear face to bolt directly to the machined face of the wall thimble.
- (c) Seating Faces
Seating faces shall be made of full width, solid section; dove-tail strips of stainless steel. They shall be secured firmly by means of counter sunk fixings in finished dove-tail grooves in the frame and slide faces in such a way as to ensure that they will remain permanently in place, free from distortion and loosening during the life of the sluice gates.
- (d) Wedging Devices
Sluice gates shall be equipped with adjustable side, top and bottom wedging devices as required providing contact between the slide and frame facing when the gate is in closed position.
- (e) Lifting Mechanism
 - i. Sluice gate shall be operated through suitable lifting mechanism which shall incorporate suitable gearing if required, to keep the torque requirement within 7 kg.m.
 - ii. Lifting mechanism shall incorporate a strong locking device suitable for use with a padlock or padlock and chain.
 - iii. Lift mechanism shall be provided with a suitable position indicator to show the position of the gate at all times.
- (f) Wall Thimbles
The cross section of the thimble shall have the shape of the letter 'F'.
- (g) Lifting Lugs
Lifting lugs shall be provided for all gates.
- (h) Flush Bottom Seal
 - I. When sluice gates are provided with flush bottom seals, the wedging device and facing along the bottom edge of the slide and frame shall be omitted.

II. A solid square cornered, resilient rubber seal shall be provided on the bottom facing of slide. The seal shall be securely fastened to the bottom face of the slide by a retainer bar and corrosion resistant metal fasteners. The top surface of the bottom facing of frame shall be flush with invert of the gate opening. Bottom facing of the slide shall be accurately machined to make contact with the seal when the slide is closed.

- (i) All the sluice/Weir gates in Hydropower Screw turbine area, STP Headworks (Screen channel & grit mechanism area), Primary and Secondary Clarifier distribution & inlet and outlet control area, All Bypass/Weir gate arrangement, Filter area and others shall be provided with permanently fixed electric actuator under this contract.
- (j) Two Nos. of Portable type of electric actuator and one nos. of battery operated actuator for emergency operation shall be provided for opening and closing of sluice gates, so that the closing and opening operation time shall be maximum of 10 minutes only for Chlorine Contact Tank and Aeration Tank area.
- (k) The material of construction of sluice Gate shall be as follows:

S. No.	Component	Material
(i)	Wall Thimble	Cast Iron : IS 210 Gr. FG 200
(ii)	Frame and Slide	Cast Iron : IS 210 Gr. FG 200
(iii)	Seating faces	Stainless Steel : ASTM Countersunk fixing A276 type 316
(iv)	Wedge	Stainless Steel : ASTM A743 CF8M or SS316
(v)	Stem	Stainless Steel: ASTM extension A276 type 316
(vi)	Stem nut	Stainless Steel : ASTM A743 CF8M
(vii)	Stem Coupling	Stainless Steel : ASTM A276 type 316
(viii)	Fasteners, anchor	Stainless Steel : ASTM bolts and nuts A276 type 316
(ix)	Lifting mechanism, Pedestal gear house cover and stem guide	Cast Iron : IS 210 Grade FG 200

(x)	Lift nut	Bronze : ASTM B 148 (CA952, CA954 or CA958)
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3.18.2 Modulating Sluice Gate

It shall be as per IS: 13349-1992.

Wall thimble mounted Sluice gates shall be used for isolation of flow from a chamber to a closed conduit. It shall be suitable for modulation application.

Salient Features

- It shall be of flange back frame gate suitable for mounting on the face of a Cast iron Wall thimble using studs and with a gasket between gate frame and wall thimble flange.
- Wall thimble shall have cross section “F” and depth of 300 mm. Gates having square / rectangular opening to be provided with thimble having square/ rectangular opening aperture with square / rectangular flange for gate frame mounting.
- It shall have Square/Rectangular shaped natural rubber Gasket with predrilled holes for positioning in between machined face of wall thimble flange and frame flange.
- It shall have open top frame provided with short length extension guides to support ½ vertical height of the slide when the slide is in full open position.
- Frame will be provided with liners for modulating duty application.
- Frame specially designed to permit front access for tightening of thimble mounting nuts so as to enable mounting of gates side by side or near corners.
- Rigid shutter designed to withstand the applicable water head. Shutter to be provided with cast integral pocket to house the stem-connecting block, which connects the spindle to the shutter for up and down operation.
- Seat facing fitted on machined plain surface of frame and shutter-using counter sunk screws for better fitments.
- The type of bottom closing offered is Flush bottom closing (FBC). In flush bottom closure gates, sealing to be metal to rubber for bottom side and metal-to-metal on balance three sides.
- Adjustable type individual side wedging arrangement for gates meant for seating water head application and adjustable type individual side as well as top & bottom wedging arrangement for gates meant for unseating water head application.
- Adjustable Channel type stem guide brackets in requisite quantity to prevent buckling of spindle in event of over-closing of gate.

- Rising stem / spindle to suit the distance between centre line of gate opening and top of operating platform as stated below in price schedule. The spindle shall be provided with square / trapezoidal threading with the threaded length being approximately 400mm more than the height of waterway opening.
- Spindle couplings to connect multiple stem / spindles in case the maximum length of one-piece stem / spindle exceeds 4.5 to 5 meters resulting into provision of more than one stem / spindle.
- Rising spindles are provided with Stem cover of Polycarbonate tube to protect spindle threads from effect of dust, dirt and weather.
- Rising spindles are provided with gate opening indicating arrangement to indicate the position of shutter.
- Provision of safety stop nut on spindle to prevent the chances of over-closing of gate, which may otherwise damage either the spindle or the lifting platform.
- Lift mechanism mounted on separate platform above gate frame so that gate operating thrust comes on to the platform.

Operation of gate by means of electric lift mechanism comprise of pillar mounted Electric Actuator with manual override unit. These actuators should have an inbuilt with local control push buttons and suitable for modulating application.

Sl.No.	Part Description	Materials of Construction
a	Frame & Shutter	CI IS: 210 Gr. FG 200
b	Wall Thimble	CI IS: 210 Gr. FG 200
c	Seating Faces & Counter Sunk Fixing	Stainless Steel ASTM A240 type 316
d	Wedging Device (with SS 304 Linings)	CI IS: 210 Gr. FG 200
e	Stem, Stem Extension & Coupling	Stainless Steel ASTM A276 type 316
f	Stem Block	Stainless Steel ASTM A743 CF8M
g	Fasteners, Anchor Bolt, Studs & Nuts	Stainless Steel ASTM A276 type 316
h	Lifting Mechanism, Pillar, Head Stock	CI IS: 210 Gr. FG 200
i	Stem Guide	CI IS: 210 Gr. FG 200
j	Stem Guide Bracket	Structural steel

SI.No.	Part Description	Materials of Construction
k	Stem cover with Indicating Arrangement	Polycarbonate Tube
l	Lift Nut	Bronze IS: 318 Type LTB-2

3.18.3 Mechanically Operated Stop logs

The construction and general design of Aluminum Stoplogs shall be in accordance with the specifications mentioned here under. They shall be so constructed that there is no undue wear or deterioration during its operative life and so designed that the maintenance is kept to a minimum.

The stoplogs shall be capable of performing the isolation duties in waste water treatment plant and pumping stations for those applications where the side water depth is at least 300 mm less than the height of stoplogs.

The stoplogs as well as stoplog frame shall be made of extruded sections and not fabricated so as to keep welding to minimum.

The Stoplogs shall be designed for seating water pressure equal to the height of the topmost log.

The Stoplogs shall have an on-seating leakage rate of not more than 1.25 liters / minutes / meter length of sealing perimeter.

The Stoplogs shall be supplied along with all accessories such as Stoplogs, lifting system, storage rack etc and miscellaneous items like fasteners, gaskets, anchor bolts etc required to erect and install these items.

Each Stoplog shall be manufactured as detailed hereunder and shall be supplied duly tested as per requirement. The Stoplog assembly shall be supplied as a factory assembled unit and shipped to site as a ready to install unit.

This assembly shall be uncarted at site and installed as complete assembled unit without stripping down into components. This is to ensure that the performance integrity of the stoplogs remains as factory tested and supplied condition, thus minimizing the influence of the installation process to achieve optimum performance at site after installation.

(a) Constructional Features

The constructional features and details of components of the required stoplogs are to be as under:

The stoplogs shall be made of extruded section of Aluminum material of grade 6061 T-6 and having minimum thickness of 5 mm. The sections used shall have adequate strength to

prevent distortion during normal handling, installation and while in service.

The extruded stoplogs section shall be sufficiently rigid to withstand the designated water head. Maximum bending stress shall not exceed 7600 PSI at the maximum operating head.

The extruded stoplog section shall be designed for adequate and prompt drainage while removal. The stoplogs shall be provided with lifting pins to enable lifting of stoplogs using mechanically operated lifting beam.

The total height of stacked stoplogs shall be approximately 300 mm above the maximum height of water.

The stoplog sectional height shall not be less than 250 mm and not more than 1250 mm so as to ensure that minimum sectional pieces are provided to achieve the required total height.

Stoplogs suitable for lifting manually using lifting rods should not weigh more than 50 kgs to enable 2 persons to lift them and transfer to storage rack. Stoplogs suitable for lifting using mechanically operated lifting beam, which can engage / disengage automatically with lifting pins provided on logs, shall be so designed that the total lifting load does not exceed 1000 kgs including the water pressure acting on the stoplogs.

The aluminium stop logs shall be provided with minimum 120 micron thick coat of suitable epoxy paint to prevent oxidation of aluminium material.

(b) Stoplog Frames

The stoplogs frames shall be made of extruded section of aluminium material of grade 6061 T -6 and having minimum thickness of 5 mm. The sections used shall have adequate strength to prevent distortion during normal handling, installation and while in service.

The stoplogs frames shall comprise of bottom invert section and two vertical side guide section for housing the stoplogs. The frames shall be suitable for embedment in two parallel walls on sides and in floor invert at bottom.

The vertical sides of the frame shall extend up to the top of the operating platform to facilitate in removal and insertion of stoplogs. For lengths above 3 meters the vertical side guides can be provided in sectional construction.

The aluminium frame shall be provided with minimum 120 micron thick coat of suitable epoxy paint to prevent oxidation of aluminium material.

(c) Seals

The stop logs sealing arrangement shall comprise of continuous resilient seal along the

bottom and both sides to restrict leakage in accordance with the requirement listed in this specification. The resilient seals shall be of EPDM or Neoprene rubber as per ASTM D2000. The side seals shall be mechanically retained and all the seals shall be easily replaceable. Seals fixed by gluing will not be accepted. The fasteners used shall be of stainless steel material as specified.

(d) Lifting Beam

Lifting beam shall be provided to insert and pull out the stoplogs using an electric hoist arrangement. If the hoisting weight of stoplog is over 50 kgs then suitable provision for handling the stoplogs with the lifting beam should be provided by the contractor. The lifting beam shall be designed to automatically engage with an installed stoplog and lift the same out of frame. The lifting beam also shall have arrangement to disengage the stoplogs by an operator standing on the platform. One lifting beam shall be provided for stoplog having same / equal width in the plant. The lifting beam shall be constructed of Carbon steel material with epoxy painted and shall be designed to lift a load of minimum 1500 kgs.

(e) Storage Rack

A movable storage rack shall be provided to house the stoplogs and lifting beam when they are not in use. The storage rack shall be constructed of Stainless Steel material. The storage rack shall be so designed that the resilient seals of the log shall not remain under compression during storage.

The material of construction for various components shall be as under:

Component	Material
Stoplogs& Frame	Aluminum alloy 6061 T-6
Resilient Seals	EPDM ASTM D2000
Rubber seal retainer bar	Stainless Steel ASTM A 240 type 316
Assembly bolts, nuts and fastener	Stainless Steel ASTM A 276 type 316

3.18.4 WEIR GATES

The downward opening weir gates shall be manufactured from Cast Iron and shall be Flange back type suitable for wall mounting and generally manufactured in line with provisions of AWWA C-560 / IS 13349 with improvements as desired and specified hereunder for weir application.

The weir gates shall be capable of performing continuous weir duty in plant and shall be so constructed that there is no undue wear or deterioration during its operative life and so

designed that the maintenance is kept to a minimum.

The weir gates shall be designed for water tightness at any level of opening for off-seating pressure equal to depth of shutter. The weir gates shall have off-seating leakage rate of not more than that permitted under AWWA-C560 / IS 13349.

All the weir gates shall be shop tested to verify the leakage performance at operating head, torque tested at operating head to verify the suitability of actuating mechanism and PMI tested to verify the correctness of the material used. This testing will be done in presence of client / client representative or approved third party inspection agency.

The weir gates shall be rising spindle type and the operation shall be by means of Manual / Electric operating mechanism.

The weir gate shall be supplied along with all accessories such as gates assembly, gasket between wall and gate assembly, studs and nuts for mounting on wall, stem connecting block, spindle, spindle couplings, spindle guides, pedestal, operating mechanism as required, gate opening indicating arrangement and required anchor bolts and fasteners for stem guides and pedestal.

The main gate assembly comprising of frame, guides and shutter will be supplied as a factory assembled unit and shipped to site as a ready to install unit on the wall. This gate assembly will be uncrated at site and installed as complete assembled unit without stripping down into components. This is to ensure that the performance integrity of the weir gates remains as factory tested and supplied condition, thus minimizing the influence of the installation process to achieve optimum performance at site after installation.

(a) Constructional Details :

The weir gates shall be manufactured generally as per provision of AWWA C-560 / IS-13349 with suitable changes for weir application. The constructional features and details of components of the required gates shall be as under:

(b) Gate Frame

The gate frame will be made from cast iron and shall be sufficiently rigid to withstand the designated water head. The gate frame shall be flange back type to suit the designed head and site condition. Back flange of the gate aperture frame to be precisely machined flat and drilled to engage with the face wall. A rubber gasket will be provided between the wall and the gate for ease in future dismounting of the gate for repairs / replacement and seal any leakage between the flange of frame and the wall. The gate frame of these sluice gates shall either be self contained type or non self contained type

depending upon site requirement. In case of non self contained gates the frames shall be without yoke at their top. In case of self contained gates the frames shall have extension guides of requisite length and shall be provided with a yoke at their top. The length of guides shall be sufficient to engage at least half the overall vertical height of door when the gate is fully lowered to open and shall be in accordance with the relevant provisions of AWWA C-560 / IS-13349.

(c) Gate Slide / Shutter/Door

The gate slide / shutter will be made from cast iron and shall be sufficiently ribbed to withstand the designated water head. The gate slide / shutter will be provided with integral pocket to house the thrust nut used to connect the stem with the slide.

(d) Seating/Sealing Faces:

Seating face shall be of Stainless steel. The seating / sealing faces on door shall be secured in place using taper screws which cannot be mechanically removed after fitting on facings. The taper screws adopted for facings shall be of same material as that of the seat facings.

To enable continuous sealing at any level of opening of the downward opening weir gate so as to achieve precise level control, the full face of the shutter will be fitted with specified seating / sealing faces and the sealing faces on shutter will always be in full face contact with corresponding metal / resilient sealing arrangement mounted on frame perimeter.

The mating seating/sealing faces on the gate frame and door shall be precisely finished for proper contact. They should be so finished that the clearance or gap, if any, between the mating sealing faces does not exceed 0.1mm at any level of weir gate opening.

(e) Manual Gate Operating Headstock/Lift Mechanism

The operating headstocks shall be designed in such a manner as to permit the gate operation by a single Person under the specified maximum operating head with an effort of less than 18 Kgs. on the crank /handwheel.

The headstock may be ungeared or geared type and the geared headstock may be either of single speed or of double speed, as might be necessary to make it convenient for one person to open or close the gate as fast as practicable. Two speed headstocks shall be supplied with gates requiring higher hoisting capacities. In this type of headstock the low speed is meant for crack opening the gate when the effort required to open the gate is maximum and the high speed is meant for further faster opening after the gate is crack opened.

Geared headstock shall be supplied with easily removable crank handle or handwheel with a radius not exceeding 375mm.

All the gears of geared headstock shall be kept completely encased in cast iron housing to protect them from damage, dirt, dust, water etc. and other atmospheric effects and thus ensure their smooth operation. Grease Nipples shall be provided at proper places for lubricating with grease.

Headstock meant for mounting on operating platform shall be supplied with a pedestal/floor stand to provide a convenient operating height of approximately 900 mm. The pedestal of the headstock shall be provided with a covered window opening to enable cleaning and greasing of stem threads.

(f) Lifting Spindle/Stem

The sluice gates shall be supplied with Rising type lifting spindles/stems. The stem shall be provided with acme / square threading, length of threaded portion being about 400mm more than the height of waterway opening. This much extra length is required to allow for a minor variation of approximately 100 mm on either side of the specified height of operating platform.

The design of stem will be done as per the provision in AWWA C-560 / IS-13349.

(g) Stem Block/ Thrust Nut

The rising type stem shall be connected to the door through a stem block/thrust nut housed in a ribbed pocket cast integral with the door. The bottom end of stem shall thread into the stem block and is locked in place by a set screw to prevent the stem from unscrewing. The Stem block shall be cast bronze or Gunmetal.

(h) Safety Stop Nut

The stem shall be provided with a safety stop nut to prevent the chances of over opening of gate which may otherwise result into spindle unscrewing from the operating nut and falling of shutter. The stop nut shall be furnished with a set screw for setting it in a fixed position after the gate is installed. Upon installation the safety stop nut should be set in such a way that its bottom remains about 1 to 2 mm away from the top of headstock, in gate open position. In case of stainless steel stem, the stop nut shall also be of stainless steel material of the same grade.

An adjustable stopper arrangement will be provided on the frame and this stopper will engage with corresponding arrangement on shutter so as to prevent over closure of the shutter.

(i) Stem Coupling

For ease in transportation and handling, maximum length of one piece stem shall be restricted within 5 meter length. Where the stem are required to be furnished in more than one piece,

threaded stem couplings shall be furnished to interconnect different sections of the stem. The couplings shall have provision for pinning after inserting in the threaded end of the stem. In case of stainless steel stem, the couplings shall also be of stainless steel material of the same grade.

(j) Stem Guide Bracket

Longer stems shall be provided with sufficient number of stem guides to prevent buckling of stem. The stem guide bracket to be provided shall be Adjustable Centre Type - wherein a separate stem guide is bolted on to the wall bracket. The stem guide shall be adjustable in the slots on wall bracket in a direction perpendicular to the face of wall. Wall bracket should also offers minor adjustment in the direction parallel to the wall. The stem guides shall have machine bored split journals to facilitate erection. The journal shall be lined with brass/gunmetal bush.

(k) Pipe Hood For Stem

A Pipe hood shall be provided on the top of headstock in case of rising spindle/stem gates to cover the spindle threads for protection against damage, dirt, dust, water etc. It shall be made of transparent fracture resistant polycarbonate material. The pipe hood shall have vent holes to prevent condensation.

(l) Gate Opening Indicating arrangement

Gate opening indicating arrangement shall be provided to indicate the position of the shutter. This shall comprise of scale mounted on the pipe hood and an indicator nut mounted on the rising spindle to show the extent of the opening and closing. The minimum scale graduation shall be 25 mm.

MATERIAL OF CONSTRUCTION:

The material of construction for various components shall be as under:

Component	Material
Gate frame, Shutter	Cast Iron to IS:210 Gr FG 200
Headstock, Stem Guides, Stem Guide Bracket	Cast Iron to IS:210 Gr FG 200
Seating faces,	Stainless Steel ASTM A 240 type 316
Rubber Seals	EPDM Rubber to ASTM D 2000
Rubber seal retainer bar	Stainless Steel ASTM A 240 type 316
Assembly bolts, nuts and fastener	Stainless Steel ASTM A 276 type 316
Stem & Coupling	Stainless Steel ASTM A 276 type 316

Yoke	Steel Epoxy painted
Thrust nut and Lift nut	Gunmetal / Phosphor Bronze

3.19 SPECIFICATIONS FOR SCREENS:

3.19.1 DESIGN & CONSTRUCTIONAL DETAILS:

- Screen segment consists of its sides, top & bottom frame members, back support stiffeners & vertical trapezoidal flats/bars of stainless steel 316.
- The screen shall move vertically up or down in SS guide channels that are either securely fixed to the sidewalls of the inlet chamber by means of suitably sized and spaced rag bolts/mechanical anchor fasteners or embedded in the two vertical side walls and bottom floor of the channel using grout as per actual site requirement.
- The offered side guide frame shall be closed top self-contained type having full length extension guides sufficient to engage the overall vertical height of screen segment when the screen segment has cleared the given top water level normally present in the channel i.e. maximum water level in the channel without specified free board.
- A yoke shall be provided across the top of extension guides and the operating arrangement shall be mounted on the yoke. The yoke shall be designed to take the operating thrust.
- The screen field shall be of continuous solid taper-section bars placed in slots of SS 316 plates bolted to screen segment's top & bottom frame members. The bars shall be sized to withstand the differential head requirement as stipulated in the specification but shall be of dimensions 12x6x50 i.e. 50 mm deep x 12mm thick at front x 6mm thick at back spaced at 20 mm clear bar spacing at an inclination angle of 90 degree to the horizontal plane.
- The bar rack shall be individually replaceable without dismantling the screen or the rest of the screen field Structure. The screen field bars shall be of sufficient length to suit the flow.
- The design of screen shall be such so as to permit change in bar spacing at a later date to suit the changing incoming waste requirement.
- Bottom member of guide frame shall remain flush with the bottom level of channel.
- Perforated tray/bucket shall be bolted to the bottom of each screen segment.

- One no. manual cleaning rake/comb shall be offered for screen for each screen to manually clean the screen while screen segment is brought up / lifted up at top of channel level.
- The side of the screen shall have replaceable wear shoes of gunmetal.
- Stainless steel roller shall be provided on the screen frame, two on each side, to enable the screen to move smoothly in the guide channels. The framework shall be provided only on the downstream side of the screens.
- Stem of suitable length as required for connecting the screen segment to the operating arrangement mounted on yoke, shall be provided.
- The stem shall be provided with stub-acme threading, single start threads or two start threads, length of threaded portion being about 50 mm more than the height of travel to clear the specified normal water height in the channel.
- Trash Rack coarse bar screen shall be electric actuator operated. This operating mechanism shall comprise of electric actuator with integral starter and manual override unit, technical details of which shall be as per tender specifications for electric actuators.
- In case of rising spindle / stem, pipe hood shall be provided on the top of headstock to cover the spindle threads for protection against damage, dirt, dust, water etc.
- Pipehood shall be made of transparent fracture resistant polycarbonate material/ galvanized steel pipe. The pipe hood shall have vent holes to prevent condensation.

3.19.2 ELIGIBILITY CRITERION FOR MANUFACTURER:

Only such screen manufacturer will be considered as eligible who are ISO: 9001-2008 and above certified for quality system and must be in this business for last 10 years.

3.19.3 GENERAL MATERIAL AND EQUIPMENT REQUIREMENTS:

As screens are required in Stainless Steel material to withstand the corrosive and aggressive sewage Environment, the screen manufacturer shall follow the best manufacturing practice mentioned here under to further eliminate the possibility of corrosion of screen in such a corrosive atmosphere.

- i. The screens shall be manufactured in a stainless steel clean area i.e. in a plant where no ferrous material is cut or welded or handled. This is required for ensuring that no

ferrous contamination / pick up takes place leading to corrosion of stainless steel screens.

- ii. To ensure best workmanship, screen manufacturer must have welding PQR, WPS & Qualified welders as per ASME Section 9. The manufacturer shall be required to provide workers' welding certification. The welding is to be done in such a way that corrosion, especially fissure corrosion, is avoided. Intermediate seam-welding and open fissures are not permitted.
- iii. The manufacturer shall ensure that the entire weld joints be tested by Dye penetration test by qualified inspectors.
- iv. As an additional precaution the manufacturer of screen shall have the facility for Pickling and Passivation to remove any ferrous contamination that might have taken place during manufacturing / handling / movement of raw and fabricated material.
- v. Since corrosion resistant property of stainless steel gets reduced when exposed to heat while cutting by plasma, all the cutting of stainless steel material shall be done using heat less water jet cutting procedure.
- vi. All the stainless steel material used on the assembled product shall be checked for correct chemical composition using Positive Material Identification equipment. This shall be re-verified at the time of inspection.

3.19.4 MATERIAL OF CONSTRUCTION:

The materials of construction of important components of removable trash rack screen shall be as stated below.

	Description	Minimum Criteria for section of MOC
1.	Screen Segment Support Stiffeners	Stainless Steel ASTM A240 type 316
2.	Screen Bars	Stainless Steel ASTM A276 type 316
3.	Replaceable wear shoes	Leaded Gun Metal
4.	perforated Tray	Stainless Steel ASTM A240 type 316
5.	Roller Assembly	UHMWPE / Stainless Steel 316
6.	Stem, Hinge Pin / Stem Connection	Stainless Steel ASTM A276 type 316
7.	Guide Frames (at Two Sides & Bottom)	Stainless Steel ASTM A240 type 316
8.	Screen Assembly Fasteners	Stainless Steel ASTM A276 type 316

9.	Lift Nut/ Drive Nut	As per Manufacturer Specification
10.	Bench / Thrust Plate / Pillar	Stainless Steel ASTM A240 type 316
11.	Yoke	Stainless Steel ASTM A240 type 316
12.	Pipe hood/Stem Cover	As per Manufacturer Specification
13.	Manual cleaning rake/comb/hand scrapper	As per Manufacturer Specification

3.19.5 MISCELLANEOUS:

- a. Packing of screens and allied accessories shall be transit worthy to avoid any possibility of damage during the transportation to the site(s).
- b. The installation and commissioning of screens has to be done in the presence of an engineer who have experaince of execution of various type of screens so as to avoid any possibility of misalignment and faulty installation

3.19.6 TECHNICAL DATA SHEET:

Electrically operated manually cleaned removable Trash Rack coarse bar screens:

Sr. No.	Item description	Unit	Technical particulars	Technical particulars
1	General			
	Make			
	Quality system		ISO 9001:2008 and above	
	Quantity of screens	Nos		
2	Design Requirements			
	Plant flow	MLD		
	Average flow capacity / Screen	MLD		
	Design Flow capacity /screen	MLD		
	Channel Width	mm		
	Channel Depth	mm		
	Upstream water level-Max	mm		
	Average bar spacing	mm		
	Angle of inclination	Deg		
	Taper bas section size	mm	-----x----- x-----	

Sr. No.	Item description	Unit	Technical particulars	Technical particulars
3	Movement of screen segment vertically up or down in guide channels	Through	electric actuator with manual override unit	
4	Cleaning the screen	Through	Mechanical means	
5	Material of Construction			
	Guide Frames (at Two Sides & Screen bars			
	Screen Segment Support Stiffeners			
	Replaceable wear shoes			
	perforated Tray			
	Roller AssemblyF			
	Stem, Hinge Pin / Stem Connection			
	Screen Assembly Fasteners			
	Lift Nut/ Drive Nut			
	Bench / Thrust Plate / Pillar			
	Yoke			
	Pipe hood/Stem Cover			
	Manual cleaning rake/comb/hand scrapper			
6	Shop Testing			
	Dimension verification as per		Required	
	Review of material test certificate as per Approved GA drawing		Required	
	Functional Test at the manufacturer's end		Required	
	PMI test of SS Component		Required	

3.20 Mechanical Medium Bar Screen

3.20.1 General

- (a) The screen shall be installed in raw sewage inlet channel, and the screen shall be of the back raking type. Inclined Bar screen at 45-50 degree and the minimum bar thickness shall be 6 mm x12mm with 50 mm width of the bar.
- (b) The screen shall be capable of performing the duties set out in this Specification.

All the materials and sub-assemblies used shall be suitable for outdoor application. They shall be constructed so that maintenance is kept to a minimum.

- (c) Ideally, any moving parts such as sprocket, bearings, etc should not be immersed in sewage. In case immersed, the parts shall be of such materials that they require little or no maintenance. All lubricating points shall be conveniently accessible from the deck level.
- (d) The screen shall be suitable for discharging 75% of the screened material lifted from the screen into the chute.
- (e) The screen shall be designed such that in case of heavy accumulation of solids the same is to be removed gradually without overloading or damaging the screen bars or mechanism.

3.20.2 Frame work

The frame work of the screen shall be of robust construction with intermediate cross bracing. The lower ends and sides of the frame shall be grouted in concrete. Each screen shall have an independent canopy at the top for weather protection. Framework of screen shall be constructed of Grade 316 stainless steel and cross section with a minimum thickness 6 mm. Various parts fastened by welding or bolting shall be braced as necessary to insure a rigid structure. The side frames shall be minimum 6 mm formed to a channel profile. The bottom thickness shall be minimum 6 mm. The frame shall have support beams with U-profile minimum thickness of 6 mm on the front above the maximum water line. The Screen Frame shall be supplied in one piece, requiring no field assembly. Bars shall be supported from framework.

3.20.3 Screen bar assembly

Screen bar assembly shall be fitted across the screen chamber. Screen shall have a series of vertically oriented bars spanning the inlet channel and spaced as specified. Bars shall be sufficiently rigid to prevent vibrations in stream-wise and lateral modes and to withstand the maximum differential head that will occur with the screen totally blinded. Bars shall have tapered cross section to prevent jamming of screenings between bars. Bars shall have supports only at both ends.

3.20.4 Rake carriage

The design shall be multi rake and the rake carriages shall comprise a stiffened frame work to

which is attached replaceable rake tines.. Rake carriage shall incorporate suitable devices to enable the rake to ride over any small obstacles wedged in the screen and automatically stop the drive motor in the event of the rake jamming against a large obstruction. There shall not be any mechanical damage resulting from obstruction wedged in the screen bars. The rake carriage shall always come to rest in a parked position with the rake above the sewage level. The raking tines shall have the tooth profile precision cut from a single continuous bar of sufficient thickness and depth to insure adequate stiffness and strength to cope with the specified duty cycle. The rakes shall run in guides on both sides to ensure engagement and clean the bars from the upstream side of the screen. The rakes shall be fabricated from stainless steel Grade 316L. The rake material, thickness of material, and capacity of rake is similar to the entire construction. The rake tines shall be suitable to accommodate bulky screenings

Thickness of rake blade	10mm Reinforcement profile
6 mm Rake Side Plates	6mm

The screen shall be cleaned automatically through an adjustable timer. The rake lowered will clear screen bars at the beginning of a cycle and accurately engage with the screen bars at the bottom of the channel. The tine profile and rake motion shall be designed to elevate screenings to the discharge chute at deck level and will not wrap around the tines or the stationary bars, and also will not fall into the sewage flow during the cleaning cycle. The rake shall be suitable for elevating debris encountered at any level. Rake tines shall be replaceable.

Screenings transported to the top of the screen shall be discharged positively by means of a scraper mechanism to the discharge chute leading to a conveyor belt. A scrapper blade made of a combination of synthetic and other material shall be provided on the scraper. The rake tines shall then be retracted and the unit ready for the next cycle. Drive chains, chain guides, chain sprockets, bearings, and axles shall be fully replaceable without having to remove the screen from the channel.

3.20.5 Rake Lifting Mechanism

Lifting mechanism chains shall be roller type chains and made of SS 316L and SS 316 sprocket of high tensile strength and resistance to corrosion. The maximum chain take up is 112.000 Newton. Chain Pins shall be a Stainless Steel and hardened.

Chain guide shall be securely fixed to the Screen frame for the full height of travel and shall not protrude into the flow. The type of chain guide, thickness of material and size is an

L-Profile, Material Grade 316 Stainless Steel. Upper Bearings shall be of UCF Type or equal; housed bearings are grease-lubricated, mounted the Take-Up Frame assembly. No Bearings shall be submerged in the waste stream.

3.20.6 Inspection Platforms

An inspection platform shall be provided for periodic checking and maintenance of the drive and other critical parts. A ladder with handrails for access to this platform shall be fixed. Suitable hand rails shall be provided for safety on the inspection platform and also at deck level.

3.20.7 Dead plate

SS316L dead plate extending from the top of the bars to the deck level shall be provided to ensure that screenings do not fall back. Dead plate shall be made of minimum 5 mm thick plate. The clearance between the tines and the dead plate shall not exceed 5 mm.

3.20.8 Discharge Chute

A discharge chute shall be of minimum 3mm thick provided for each screen to divert screenings discharged from the screen to a conveyor mechanism. The discharge chute shall be made of SS 316. The discharge chute shall be mounted at an angle of 30 degrees. Panels are positioned on both sides to protect from splashing.

3.20.9 Covers

Covers which are easily removable shall be provided for easy maintenance. Covers shall be constructed of clear impact-resistant Polycarbonate material thickness 6mm and SS316 thickness is 2mm to allow for visual observation during screen operation.

3.20.10 Driving Mechanism

The driving mechanism shall consist of a sturdy reduction gear unit driven through multiple 'V' belts or directly by an electric motor. Motor shall be mounted in such a way that the tension of the 'V' belts can be adjusted. A manually reset torque limiter shall be provided between the motor and gear unit, incorporating a limit switch to cut off the supply to motors in the event of an overload The drive mechanism for the rakes shall incorporate a solid shaft constructed of SS 316.

3.20.11 Installation

The screen shall be designed for installation to either (a) pivot out of the channel, (b) be pulled

out of the channel. Non-metallic side flaps seal the screen to the channel walls, or (c) The Screen shall be grouted in a wall recess and/or floor recess.

3.20.12 Gear Reducer

- a) The reducer shall be sized and selected with a minimum service factor of 2.0 times the motor nameplate horse power rating in accordance with applicable American Gear Manufacturer's Association Standards. The reducer shall have a life of 40,000 hours based on the motor name plate horse-power. The reducer shall have an efficiency of not less than 90% based on reducer input.
- b) All gear meshes shall be oil lubricated. All gears shall be provided with an oil reservoir for instant lubrication on starting. The gear reducer housing shall be provided with an oil level indicator and oil drain with necessary fittings.
- c) The gear reducer shall be of cast iron construction. The reducer housing shall also include suitable lifting lugs and external gear train inspection covers for each gear train. The gears shall be matched for maximum tolerance variation. The gear reducer shall be suitable to reduce the motor asynchronous speed to achieve the required speed of raking.

1.1.1. Control System

- (a) The screening operation shall be carried out through adjustable timers which are adjustable at site for 0-60 minutes for interval between two operations.
- (b) Control system for the conveyor shall be designed to achieve the following:
 - (i) Conveyor shall be started when any of the rakes starts it's upwards travel.
 - (ii) Conveyor shall be stopped with a time delay (by adjustable timer) after rake is stopped.
- (c) Weatherproof, lockable, emergency mushroom headed stop push buttons shall be provided near each motor for screen and conveyor belt, operation of stop push button, and overload prevention for screen and belt conveyor shall be included in the control scheme.

3.20.13 Conveyor System

- (a) For the disposal of screenings, a common motor driven endless belt conveyor shall be provided. The conveyor shall be designed in accordance with IS11592 or equivalent. The conveyor and chutes shall be suitable for handling occasional heavy objects which will cause shock loads.
- (b) The construction of the frame and support shall be robust and torque resistant. Belt conveyor shall be of 20 deg. trough type complete with drive assembly structures, idlers, pulleys and belt cleaners. Idlers and pulley shall be provided with anti-friction bearings.
- (c) The belt material shall be two ply nylon or equivalent with minimum 3 mm neoprene covering on carrying side. Splicing shall be employed to make the belt endless. The belt shall operate over three roll twenty degree, troughing idlers. The idlers shall rotate on precision type, deep groove, single row ball bearing with built-in close fitting triple labyrinth grease seal. The ends of the outer shell shall be counterbored and a full length centre tube journalled concentricity. The outer shell, centre tube and precision die formed steel ends shall be brazed into an integral unit to provide concentricity. The ends of the centre tube shall be bored concentrically with each other after roll assembly to provide correct bearing alignment and to provide prestressing of boring. The centre tube shall be grease fit after assembly. Troughing idlers shall have means of adjustment or ensuring belt tracking. On the return run the belt shall operate over flat roll idlers having bearing, shaft and lubrication arrangements as above for carrying idlers. Spacing of idlers shall be of 1200 mm on carrying run and 2400 mm on return run.
- (d) The head and tail pulleys shall be manufactured from welded steel/any alloy steel and shall be provided with rubber lagging. Lagging for drive pulleys shall have herringbone grooving. Pulleys shall be equipped with taper lock bushings. The tail pulley shall incorporate a screw rake for adjusting belt tension. Head and tail pulleys shall be adequately guarded.
- (e) Shafting for pulleys shall be of heat treated carbon steel. They shall be forged, ground and polished to obtain close diameter tolerances. The head shaft shall be provided with roller bearing pillow blocks.
- (f) The belt conveyor shall be driven by a squirrel cage, TEFC motor. A V-belt drive arrangement shall be provided between the motor and a helical speed reducer, the latter shall be mounted on the end of the head shaft. The driving pulley shaft shall have back stops to prevent backward movement of the belt.

- (g) The conveyor shall be supported on 150mm channel sections with 14 gauge steel deck plate between the two runs of the belt and the necessary supports to the floor. The floor supports shall be made out of steel plates having minimum 6 mm thickness. The conveyor shall be protected from weather by a 'dog box' type canopy.
- (h) An adjustable belt scraper shall be provided on the hopper end of the conveyor belt. The scraper and attachments shall be of fiber reinforced plastic.
- (i) Screenings discharge chutes shall be provided to transfer screenings from the screens to the troughed belt conveyor and from the conveyor discharge to skip. The latter chute shall extend beneath the belt scraper and shall allow access for maintenance of the belt scraper. Chutes shall be designed to minimize the accumulation of rags and stringy materials
- (j) The conveyor shall be fitted with an emergency stop operated by wire rope at foot level. Two Nos. belts way switches shall be provided on conveyor.
- (k) The collected waste from grit /screening shall be stored in enclosed container and the conveyor mechanism shall have covering with FRP /polycarbonate /tensile fabrics covers.

3.20.14 Portable Screenings Container

Portable screenings containers made of galvanized steel shall be provided to store the screenings until time of pick up. Minimum two Screenings Containers shall be provided at the screening chamber. The container shall have capacity of approximate 2.0 cu.m and shall be of a convenient height to permit the discharge of screenings directly into the container without having to transfer the screenings manually. The containers shall have hinged covers and their design shall permit their being lifted by an overhead hoist or packer truck. The container will have four wheels each of about 20 cm diameter and two of which shall be swivel castors. The maximum height of container including wheels shall be 66 cms. The sides shall be constructed of 12 gauge steel. The bottom of container shall be made of 5 mm plate steel. The containers shall be reinforced with 50 mm x 50 mm x 5 mm angle.

3.20.15 Automatic Jam removal system

The screen shall have automatic electronically controlled Jam removal facility to ensure

smooth operation.

1.1.1.1. Motors

Motors shall be squirrel cage type conforming to IS 325. The Drive Motor shall be controlled by a Full Voltage Reversing Motor Contactor mounted on a Back Panel to be mounted in an Enclosure or MCC (Motor Control Center) in the main Panel. The power rating of motor shall be at least 125% of maximum power requirement. The other features of motors shall be as follows:

- (i) Type of duty : Intermittent (S4)
- (ii) Method of Starting : Forward reverse starter
- (iii) Class of insulation : F (Temperature rise limited to class B)
- (iii) Type of enclosure : TEFC
- (iv) Degree of protection : IP 55

(a)The material of construction of Mechanical Raked Screen shall be as follows :

S. No.	Component	Material
(i)	Screen	Stainless steel SS316L
(ii)	Frame (Side and Bottom Portion)	Stainless steel SS316
(iii)	Raked tines	SS316L
(iv)	Fasteners including Anchor bolts	Stainless Steel : SS316
(v)	Screen canopy	Stainless Steel: SS316L
(vi)	Chutes	SS316

3.21 Mechanical Fine Bar Screen

The screen shall be installed in inlet channel to grit chamber, and the screen, shall consist of Continuously moving perforated stainless steel panels. Inclined Bar screen at 45-50 degree and the minimum bar thickness shall be 12mm. The aperture size of the screen shall be 6 mm and shall be of tapered section. Other specification shall remain as mentioned in above para.

3.21.1 Construction

(a) **Frame work:**

(b) The frame work of the screen shall be of robust construction with intermediate cross bracing. The lower ends and sides of the frame shall be grouted in concrete. Each screen shall have an independent canopy at the top for weather protection. Framework of screen shall be constructed of Grade 316 stainless steel and cross section with a minimum thickness 4 mm.

Various parts fastened by welding or bolting shall be braced as necessary to insure a rigid structure. The side frames shall be minimum 4 mm formed to a channel profile. The bottom thickness shall be minimum 4 mm. The frame shall have support beams with U-profile minimum thickness of 4 mm on the front above the maximum water line. The Screen Frame shall be supplied in one piece, requiring no field assembly. Bars shall be supported from framework.

3.21.2 Screen bar assembly

Screen bar assembly shall be fitted across the screen chamber. Screen shall have a series of vertically oriented bars spanning the inlet channel and spaced as specified. Bars shall be sufficiently rigid to prevent vibrations in stream-wise and lateral modes and to withstand the maximum differential head that will occur with the screen totally blinded. Bars shall have tapered cross section to prevent jamming of screenings between bars. Bars shall have supports only at both ends.

3.21.3 Rake carriage

The design shall be multirake and the rake carriages shall comprise a stiffened frame work to which is attached replaceable rake tines. Rake carriage shall incorporate suitable devices to enable the rake to ride over any small obstacles wedged in the screen and automatically stop the drive motor in the event of the rake jamming against a large obstruction. There shall not be any mechanical damage resulting from obstruction wedged in the screen bars. The rake carriage shall always come to rest in a parked position with the rake above the sewage level. The raking tines shall have the tooth profile precision cut from a single continuous bar of sufficient thickness and depth to insure adequate stiffness and strength to cope with the specified duty cycle. The rakes shall run in guides on both sides to ensure engagement and clean the bars from the upstream side of the screen. The rakes shall be fabricated from stainless steel Grade 316L. The rake material,

thickness of material, and capacity of rake is similar to the entire construction. The rake tines shall be suitable to accommodate bulky screenings.

Thickness of rake blade	10mm Reinforcement profile
4mm Rake Side Plates	6mm

The screen shall be cleaned automatically through an adjustable timer. The rake lowered will clear screen bars at the beginning of a cycle and accurately engage with the screen bars at the bottom of the channel. The tine profile and rake motion shall be designed to elevate screenings to the discharge chute at deck level and will not wrap around the tines or the stationary bars, and also will not fall back into the sewage flow during the cleaning cycle. The rake shall be suitable for elevating debris encountered at any level. Rake tines shall be replaceable.

Screenings transported to the top of the screen shall be discharged positively by means of a scraper mechanism to the discharge chute leading to a conveyor belt. A scraper blade made of a combination of synthetic and other material shall be provided on the scraper. The rake tines shall then be retracted and the unit ready for the next cycle. Drive chains, chain guides, chain sprockets, bearings, and axles shall be fully replaceable without having to remove the screen from the channel.

3.21.4 Rake Lifting Mechanism

Lifting Mechanism Chains shall be roller type chains and made of SS 316L and SS 316 sprocket of high tensile strength and resistance to corrosion. The maximum chain take-up is 112,000 Newton. Chain Pins shall be a Stainless Steel and hardened.

Chain guide shall be securely fixed to the Screen frame for the full height of travel and shall not protrude into the flow. The type of chain guide, thickness of material and size is an L- Profile, Material Grade 316 Stainless Steel. Upper Bearings shall be of UCF Type or equal; housed bearings are grease-lubricated, mounted the Take-Up Frame assembly. No Bearings shall be submerged in the waste stream.

3.21.5 Inspection Platforms

An inspection platform shall be provided for periodic checking and maintenance of the drive and other critical parts. A ladder with handrails for access to this

platform shall be fixed. Suitable hand rails shall be provided for safety on the inspection platform and also at deck level.

3.21.6 Dead plate

SS316L dead plate extending from the top of the bars to the deck level shall be provided to ensure that screenings do not fall back. Dead plate shall be made of minimum 4 mm thick plate. The clearance between the tines and the dead plate shall not exceed 4 mm.

3.21.7 Discharge Chute

A discharge chute shall be of minimum 3mm thick provided for each screen to divert screenings discharged from the screen to a conveyor mechanism. The discharge chute shall be made of SS 316. The discharge chute shall be mounted at an angle of 30 degrees. Panels are positioned on both sides to protect from splashing. Screenings are delivered down an enclosed chute.

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

3.21.8 Covers

Covers which are easily removable shall be provided for easy maintenance. Covers shall be constructed of clear impact-resistant UV resistant Polycarbonate material thickness 6mm and SS 316 thickness is 2mm to allow for visual observation during screen operation.

3.21.9 Driving Mechanism

The driving mechanism shall consist of a sturdy reduction gear unit driven through multiple 'V' belts or directly by an electric motor. Motor shall be mounted in such a way that the tension of the 'V' belts can be adjusted. A manually reset torque limiter shall be provided between the motor and gear unit, incorporating a limit switch to cut off the supply to motors in the event of an overload. The drive mechanism for the rakes shall incorporate a solid shaft constructed of SS 316.

The drive to the main shaft shall be TEFC weatherproof IP65 motor fitted with an anti - condensation heater. The motor shall be flanged to a shaft mounted gear unit giving the final output speed. This shall produce a linear speed for the screen panels of about 3 m/min. The drive shall be protected from mechanical overload by an electrical

current sensing device in the screen control panel. Overload prevention switches shall be provided to annunciate screen jamming. Suitable conveyer arrangement shall be provided to transfer the screenings to the nearest container/trailer. A spray system shall be provided to backwash the screen panels and to help in cleaning the screenings. Water / treated sewage shall be used for back wash purpose.

3.21.10 Installation

The screen shall be designed for installing to either (a) pivot out of the channel, (b) be pulled out of the channel. Non-metallic side flaps seal the screen to the channel walls, or (c) The Screen shall be grouted in a wall recess and/or floor recess.

3.21.11 Gear Reducer

- (a) The reducer shall be sized and selected with a minimum service factor of 2.0 times the motor name plate horse power rating in accordance with applicable American Gear Manufacturer's Association Standards. The reducer shall have a life of 40,000 hours based on the motor name plate horse-power. The reducer shall have an efficiency of not less than 90% based on reducer input.
- (b) All gear meshes shall be oil lubricated. All gears shall be provided with an oil reservoir for instant lubrication on starting. The gear reducer housing shall be provided with an oil level indicator and oil drain with necessary fittings.
- (c) The gear reducer shall be of cast iron construction. The reducer housing shall also include suitable lifting lugs and external gear train inspection covers for each gear train. The gears shall be matched for maximum tolerance variation. The gear reducer shall be suitable to reduce the motor asynchronous speed to achieve the required speed of raking.

3.21.12 Control System

- (a) The screening operation shall be carried out through adjustable timers which are adjustable at site for 0-60 minutes for interval between two operations.
- (b) Control system for the conveyor shall be designed to achieve the following:
 - (i) Conveyor shall be started when any of the rakes starts its upwards travel.
 - (ii) Conveyor shall be stopped with a time delay (by adjustable timer) after rake is stopped.

- (c) Weatherproof, lockable, emergency mushroom headed stop push buttons shall be provided near each motor for screen and conveyor belt, operation of stop push button, and overload prevention for screen and belt conveyor shall be included in the control scheme.

3.21.13 Conveyor System

- (a) For the disposal of screenings, a common motor driven endless belt conveyor shall be provided. The conveyor shall be designed in accordance with IS 11592 or equivalent. The conveyor and chutes shall be suitable for handling occasional heavy objects which will cause shock loads.
- (b) The construction of the frame and support shall be robust and torque resistant. Belt conveyor shall be of 20 deg. trough type complete with drive assembly structures, idlers, pulleys and belt cleaners. Idlers and pulley shall be provided with anti-friction bearings.
- (c) The belt material shall be two poly nylon or equivalent with minimum 3 mm neoprene covering on carrying side. Splicing shall be employed to make the belt endless. The belt shall operate over three roll twenty degree, troughing idlers. The idlers shall rotate on precision type, deep groove, single row ball bearing with built-in close fitting triple labyrinth grease seal. The ends of the outer shell shall be counter bored and a full length centre tube journalled concentricity. The outer shell, centre tube and precision die formed steel ends shall be brazed into an integral unit to provide concentricity. The ends of the centre tube shall be bored concentrically with each other after roll assembly to provide correct bearing alignment and to provide prestressing of boring. The centre tube shall be grease fit after assembly. Troughing idlers shall have means of adjustment or ensuring belt tracking. On the return run the belt shall operate over flat roll idlers having bearing, shaft and lubrication arrangements as above for carrying idlers. Spacing of idlers shall be of 1200 mm on carrying run and 2400 mm on return run.
- (d) The head and tail pulleys shall be manufactured from welded steel/any alloy steel and shall be provided with rubber lagging. Lagging for drive pulleys shall have herringbone grooving. Pulleys shall be equipped with taper lock bushings. The tail pulley shall incorporate a screw rake for adjusting belt tension. Head and tail pulleys shall be adequately guarded.
- (e) Shafting for pulleys shall be of heat treated carbon steel. They shall be forged, ground

and polished to obtain close diameter tolerances. The head shaft shall be provided with roller bearing pillow blocks.

- (f) The belt conveyor shall be driven by a squirrel cage, TEFC motor. A V-belt drive arrangement shall be provided between the motor and a helical speed reducer, the latter shall be mounted on the end of the head shaft. The driving pulley shaft shall have back stops to prevent backward movement of the belt.
- (g) The conveyor shall be supported on 150mm channel sections with 14 gauge steel deck plate between the two runs of the belt and the necessary supports to the floor. The floor supports shall be made out of steel plates having minimum 6 mm thickness. The conveyor shall be protected from weather by a 'dog box' type canopy.
- (h) An adjustable belt scraper shall be provided on the hopper end of the conveyor belt. The scraper and attachments shall be of fibre reinforced plastic.
- (i) Screenings discharge chutes shall be provided to transfer screenings from the screens to the troughed belt conveyor and from the conveyor discharge to skip. The latter chute shall extend beneath the belt scraper and shall allow access for maintenance of the belt scraper. Chutes shall be designed to minimize the accumulation of rags and stringy materials.
- (j) The conveyor shall be fitted with an emergency stop operated by wire rope at foot level. Two Nos. belts way switches shall be provided on conveyor.

3.21.14 Portable Screenings Container

Portable screenings containers made of galvanized steel shall be provided to store the screenings until time of pick up. Minimum two Screenings Containers shall be provided at the screening chamber.

The container shall have capacity of approximate 2.0 cu.m and shall be of a convenient height to permit the discharge of screenings directly into the container without having to transfer the screenings manually. The containers shall have hinged covers and their design shall permit their being lifted by an overhead hoist or packer truck. The container will have four wheels each of about 20 cm diameter and two of which shall be swivel castors. The maximum height of container including wheels shall be 66 cms. The sides shall be constructed of 12 gauge steel. The bottom of container shall be made of 5 mm plate steel. The containers shall be reinforced with 50 mm x 50 mm x 5 mm angle.

3.21.15 Automatic Jam removal system

The screen shall have automatic electronically controlled Jam removal facility to ensure smooth operation.

3.21.16 Motors

Motors shall be squirrel cage type conforming to IS 325. The Drive Motor shall be controlled by a Full Voltage Reversing Motor Contactor mounted on a Back Panel to be mounted in an Enclosure or MCC (Motor Control Center) in the main Panel. The power rating of motor shall be at least 125% of maximum power requirement. The other features of motors shall be as follows:

- (i) Type of duty : Intermittent (S4)
- (ii) Method of Starting : DOL
- (iii) Class of insulation : F (Temperature rise limited to class B)
- (iii) Type of enclosure : TEFC
- (iv) Degree of protection : IP 65

The material of construction of Mechanical Raked Screen shall be follow;

S. No.	Component	Material
(i)	Screen	Stainless steel SS316L
(ii)	Frame (Side and Bottom Portion)	Stainless steel SS316
(iii)	Raked tines	SS316L
(iv)	Fasteners including Anchor bolts	Stainless Steel : SS316
(v)	Screen canopy	Stainless Steel: SS316L
(vi)	Chutes	SS 316

3.22 Back Rake Multi Rake Bar Screen

3.22.1 General construction features

Panel type Multi Rake, Back Rake bar screens with continuous raking type electrically driven/ hydraulically operated mechanical screen cleaning mechanism.

The Contractor is required to provide appropriate design of Bar screens which are suitable for installation at the inlet location, for screening out all floating materials,

suspended materials, plastics, bottles, rags, tree branches, debris, solid waste, dead animal bodies etc. having dimensions greater than 50 mm from reaching the stilling basin during continuous operation.

The Contractor shall take into consideration the following factors while selecting the Material of Construction and designing the bar screens and Mechanical screen cleaning mechanism and offer the most suitable, functionally appropriate and robust design of Bar screens and the mechanical screen cleaning mechanism:-

- (a) The screen cleaning mechanism shall be multiple rakes of the back raking type.
- (b) The screens shall be installed slightly inclined position to the vertical and shall be designed to facilitate back raking arrangement. In case of multiple screens, each screen shall be of the same size. Width of screen cleaning mechanism shall cover the entire width of each screen panel. The screen is to be installed at least 9° inclination to the vertical. No screenings are allowed to fall behind the screen into the Screen Effluent Channel.
- (c) The tines should travel in a vertical path in the downstream side of the channel. There should not be any gap between the working platform and the back of screen.
- (d) The spines should protrude out of bar screens not less than 600 mm.
- (e) The material of construction of complete screen & screen cleaning arrangement parts subjected to wear and tear, complete screen shall be of SS 316L to take care of Raw Sewage.
- (f) The components of bar screen and the mechanical screen cleaning mechanism / arrangement will be subject to alternate drying and wetting during the course of operation.
- (g) The Bar screen and the mechanical screen cleaning mechanism shall be designed for continuous duty. The screens will be subject to continuous flow during pumping operation.
- (h) The screen bars shall be spanning as a single piece from top to bottom of the screen and shall be designed to withstand the operation of raking mechanism, impact of floating and suspended materials, flow and water level during the pumping / non pumping operation. The bars of the screen shall span from the invert level of the screen channel upto the screening conveyor and then discharged to Screening Collection Bins. The screen panel assemblies and bars shall be structurally designed for a head of water equal to their height assuming the screen panel to be fully blinded

- (i) The maximum velocity through screen shall not exceed of 1.5 m/s when the maximum water level to be maintained at the Inlet just upstream of the screen.
- (j) The head loss across the screens shall not be more than 0.3 m at any given point in time.
- (k) Screen cleaning mechanism shall be raking type designed to continuously clean the bar screens and shall be able to clean the entire screen front with minimum of 7 to 8 mtr/min speed. The movement of the tines downward after removal of the screenings be parallel to the screen installation and perpendicular to the ground. The transmission system should have cyclo type gear motor, the torque limit switch with greasing pump and automatic operation device.
- (l) There shall be Differential level sensors mounted on the upstream and the downstream of the screen at appropriate location that is easily accessible for maintenance.
- (m) The operation of the screens shall be automated based on the differential levels. The operation of the belt conveyor shall extend for a period of minimum 5 minutes after the stopping of all the screens.
- (n) It is contractor's responsibility to generally ensure that the screens are not blocked during any of the pumping operations and the screen area in front of screen panels is kept free from deposits including sand, silt, plastics, gunny bags, tarpaulin, tree branches, logs, mattresses, dead bodies etc. thereby ensuring that the raw sewage flow reaches smoothly to the pumps. The Contractor shall also take all safety precautions in carrying out above operation.
- (o) The screens shall be easily removable and replaceable in their position. The screen parts and assemblies shall be easily accessible from all sides for cleaning as well as for any attendance during maintenance requirements.
- (p) Moving parts and rotating parts of the screen assemblies which are partly or fully suspended in water during operation cycle shall be of permanently lubricated type. The design shall ensure that the functioning of moving / rotating parts of screen/screen cleaning equipment are not jammed or affected due to presence of silt, debris, plastic bags etc.
- (q) The Bar spacing shall ensure that all objects above 20 mm size is stopped from going through the screen. The spacing and depth of bars shall also ensure that mineral water bottles, cold drink bottles etc. are also removed during screening operation.
- (r) The bars shall be spaced at equal intervals across the width of Inlet waterways and shall permit uniform size of openings.

- (s) Fabrication of screens shall be such that bolts, cross bars/stiffeners will not interfere with raking operations.
- (t) The contractor shall also provide two numbers of screening collection bins of minimum 2 cu.m, for collection and disposal of removed screenings.
- (u) All drives including motors, gear boxes, chains etc used for mechanical screen cleaning and conveying arrangement shall be of heavy duty type suitable for outdoor installation in corrosive environment, and continuous duty
- (v) The entire screening and screenings conveying area shall have safety provisions like hand rails, toe guards, chain covers, drive covers etc.
- (w) Successful Installations of Min. 5 Nos of screening Units for the peak flow offered as per this tender, shall be furnished by the Screen manufacturer along with full scale field test result /reports for each Installation performed by qualified personnel having at least 3 years" experience.

3.22.2 Conveyor System

- (a) For the disposal of screenings, a common motor driven endless belt conveyor shall be provided. The conveyor shall be designed in accordance with IS11592 or equivalent. The conveyor and chutes shall be suitable for handling occasional heavy objects which will cause shock loads.
- (b) The construction of the frame and support shall be robust and torque resistant. Belt conveyor shall be of 20 deg. trough type complete with drive assembly structures, idlers, pulleys and belt cleaners. Idlers and pulley shall be provided with anti-friction bearings.
- (c) The belt material shall be two poly nylon or equivalent with minimum 3 mm neoprene covering on carrying side. Splicing shall be employed to make the belt endless. The belt shall operate over three roll twenty degree, troughing idlers. The idlers shall rotate on precision type, deep groove, single row ball bearing with built-in close fitting triple labyrinth grease seal. The ends of the outer shell shall be counter bored and a full length centre tube journal led concentricity. The outer shell, centre tube and precision die formed steel ends shall be brazed into an integral unit to provide concentricity. The ends of the centre tube shall be bored concentrically with each other after roll assembly to provide correct bearing alignment and to provide prestressing of boring. The centre tube shall be grease fit after assembly. Troughing idlers shall have means of adjustment or ensuring belt

tracking. On the return run the belt shall operate over flat roll idlers having bearing, shaft and lubrication arrangements as above for carrying idlers. Spacing of idlers shall be of 1200 mm on carrying run and 2400 mm on return run.

- (d) The head and tail pulleys shall be manufactured from welded steel/any alloy steel and shall be provided with rubber lagging. Lagging for drive pulleys shall have herringbone grooving. Pulleys shall be equipped with taper lock bushings. The tail pulley shall incorporate a screw rake for adjusting belt tension. Head and tail pulleys shall be adequately guarded.
- (e) Shafting for pulleys shall be of heat treated carbon steel. They shall be forged, ground and polished to obtain close diameter tolerances. The head shaft shall be provided with roller bearing pillow blocks.
- (f) The belt conveyor shall be driven by a squirrel cage, TEFC motor. A V-belt drive arrangement shall be provided between the motor and a helical speed reducer, the latter shall be mounted on the end of the head shaft. The driving pulley shaft shall have back stops to prevent backward movement of the belt.
- (g) The conveyor shall be supported on 150mm channel sections with 14 gauge steel deck plate between the two runs of the belt and the necessary supports to the floor. The floor supports shall be made out of steel plates having minimum 6 mm thickness. The conveyor shall be protected from weather by a 'dog box' type canopy.
- (h) An adjustable belt scraper shall be provided on the hopper end of the conveyor belt. The scraper and attachments shall be of fibre reinforced plastic.
- (i) Screenings discharge chutes shall be provided to transfer screenings from the screens to the troughed belt conveyor and from the conveyor discharge to skip. The latter chute shall extend beneath the belt scraper and shall allow access for maintenance of the belt scraper. Chutes shall be designed to minimize the accumulation of rags and stringy materials.
- (j) The conveyor shall be fitted with an emergency stop operated by wire rope at foot level. Two Nos. belts way switches shall be provided on conveyor.

3.22.3 Portable Screenings Container

Portable screenings containers made of galvanized steel shall be provided to store the screenings until time of pick up. Minimum two Screenings Containers shall be provided at the screening chamber. The container shall have capacity of approximate 2.0 cu.m and

shall be of a convenient height to permit the discharge of screenings directly into the container without having to transfer the screenings manually. The containers shall have hinged covers and their design shall permit their being lifted by an overhead hoist or packer truck. The container will have four wheels each of about 20 cm diameter and two of which shall be swivel castors. The maximum height of container including wheels shall be 66 cms. The sides shall be constructed of 12 gauge steel. The bottom of container shall be made of 5 mm plate steel. The containers shall be reinforced with 50 mm x 50 mm x 5 mm angle.

3.22.4 Motors

Motors shall be squirrel cage type conforming to IS 325. The Drive Motor shall be controlled by a Full Voltage Reversing Motor Contactor mounted on a Back Panel to be mounted in an Enclosure or MCC (Motor Control Center) in the main Panel. The power rating of motor shall be at least 125% of maximum power requirement. The other features of motors shall be as follows;

- | | | | |
|-------|----------------------|---|---|
| (i) | Type of duty | : | Intermittent (S4) |
| (ii) | Method of Starting | : | DOL |
| (iii) | Class of insulation | : | F (Temperature rise limited to class B) |
| (iii) | Type of enclosure | : | TEFC |
| (iv) | Degree of protection | : | IP 65 |

3.23 Manual Medium Bar Screen

- (a) The screen shall be installed in inlet bypass channel to grit chamber.
- (b) The aperture size of the screen shall be 10 mm and 50 angle of inclination.
- (c) The screen shall be fabricated out of SS316 flats and fixing bolts shall be of stainless steel.
- (d) The rectangular trash screens shall comprise galvanized M.S flats, 10 mm thick and 50 mm wide in section
- (e) The screen shall be rigidly fixed to the frame.
- (f) All the bypass screens shall be provided with 2 sets of SS 304 cleaning rakes with appropriate grip handle.

3.24 Manually Operated Travelling Crane

3.24.1 Crane

- (a) The crane shall be manually operated for return activated sludge pumping station.
- (b) The capacity of crane shall be as per the equipment list in particular mechanical requirement and of class II.
- (c) The crane bridge shall consist of a single bridge girder carrying two wheels at each end of the span. Steel used shall be tested quality steel conforming to IS 2062.
- (d) The long travel bridge wheels shall be rim toughened; heat treated galvanized carbon steel or low alloy steel or C.I. They shall be double flanged type. The wheels shall have antifriction ball/roller bearings. The wheels shall be machined on their treads to match the runway rail section. The bridge shall have a geared shaft and pulley connecting to opposite wheels of the span, to achieve the long travel motion of the bridge, by means of a chain. The runway rails of adequate strength and rigidity, rail clamps and other accessories for mounting the rails and suitable end stops for the bridge shall be supplied by the Contractor.

3.24.2 Trolley and Chain Pulley Block

- (a) The chain pulley block shall be operated on the lower flange of the bridge girder
- (b) The load chain shall be made of alloy steel as per IS:3109. It shall be heat treated to give ductility and toughness so that it will stretch before breaking. It shall be of welded construction with a factor of safety not less than 5.
- (c) The hand chains, SS 316, for the hoisting and traverse mechanism shall hang well clear of the hook and both the chains shall be on the same side. The hand chain wheel shall be made from pressed sheet steel and shall be provided with roller type guarding to prevent snagging and fouling of the chain.
- (d) All the gearing shall be totally encased. Proper lubricating arrangements shall be provided for bearings and pinions. Gears shall be cut from forged steel blanks. Pinions shall be of heat treated alloy steel. Gears shall be as per BS 436/IS:4460.
- (e) The trolley track wheels shall be rim toughened, heat treated carbon steel or alloy steel shall be single flanged and shall have antifriction ball bearings. The wheels shall be machined on their treads to match the flanges of the track joints.
- (f) The travelling trolley frame shall be made of rolled steel conforming to IS:2062. The side plates of trolley frame shall extend beyond wheel flanges, thus providing bumper protection for the wheels. The two side plates shall be connected by means of an

equalizing pin.

- (g) Axles and shafts shall be made of carbon steel and shall be accurately machined and properly supported.
- (h) The lifting hooks shall be forged, heat treated alloy or carbon steel of rugged construction. They shall be of single hook type provided with a standard depress type safety latch. They shall swivel and operate on antifriction bearings with hardened races. Locks to prevent hooks from swiveling shall be provided. Hook shall be as per BS:2903/IS:3815
- (i) The brake for the lifting gear shall be automatic and always in action. It shall be of screw and friction disc type self-actuating load pressure brake. Brakes shall offer no resistance during hoisting.

3.24.3 Electrically Operated Hoists

- (a) Electric hoists shall be complete with hoisting motor, wire rope drum, wire rope, hook, necessary gearing, sheaves, electromagnetic brake for hoisting motion, weather & dustproof push button station, contractor panel, all wiring, limit switches, etc.
- (b) Electric hoists shall conform to IS: 3938 and shall be suitable for outdoor application. All the parts of the hoist shall be designed to withstand surrounding atmospheric conditions without any deterioration.
- (c) Rope drums shall be either cast or welded to sustain concentrated loads resulting from rope pull. Drums shall be machine grooved right and left with grooves of a proper shape for the rope used.
- (d) Gears shall be cut from solid cast or forged steel blanks or shall be of stress-relieved welded steel construction or built-up from steel billets and welded together to form a one piece gear section. Hoist ropes shall be extra flexible, improved plough steel rope with a well lubricated hemp core and having six strands of 36 wires per strand with minimum ultimate tensile strength of 1.6×10^6 KN / Sq.m.
- (e) Hooks shall be solid, forged, heat treated alloy or carbon steel of rugged construction of the single hook type and provided with a standard depress type safety latch.
- (f) Hoisting motor shall be equipped with electrically released, spring set, friction shoe type brakes having torque capable of holding 125% of the full rated hook load. Brake shall apply when either the motor controller or the main power switch is in

„OFF“ position or in the event of power failure.

- (g) Drive motors shall be designed for frequent reversal, braking and acceleration and shall be as per IS:325. Pendant control switch, controllers and resistors, controls, electrical protective devices, cables and conductors, earthing guards etc. shall be as per IS:3938. Limit switches shall be provided for over-hoisting and over-lowering.
- (h) The electric hoists shall be of Class II duty.
- (i) 25% overload test, speed tests, limit switch tests and brake test shall be conducted for the hoist and trolley at manufacturer's works.

3.24.4 Hand Operated Hoists and Trolleys

- (a) Manual hoists shall be complete with hand-chain, trolley, pulley block, hook, hand and load chains, brake and other accessories. They shall comply with the latest applicable standards, regulations and safety code in the locality where equipment will be installed.
- (b) Each hoist shall be operated on a monorail (I-Beam). The factor of safety shall not be less than 5. The load chain may be heat-treated to give ductility, toughness and conforming to I.S. 3109/B.S.1663/B.S.3114. The load wheel is to be made from heavy duty malleable castings. The hand chain is to conform with B.S. 6405:1984 and hand chain wheel may be made from pressed sheet steel with roller type guarding. Gears shall be cut from solid cast or forged steel blanks or shall be stress - relieved welded steel construction.
- (c) Pinions shall be of forged carbon or heat treated alloy steel. Strength, Quality of Steel, heat treatment, face, pitch of teeth and design shall conform to BS-436, BS-545 and BS-721. Spur and helical gears must comply with B.S. 436 and worm with BS 721. Bearing must be ball and roller type conforming to I.S. 2513/B.S., 2525-32:1954.
- (d) Proper lubricating arrangements are to be provided for bearings and pinions. The brake for the lifting gear shall be automatic and always in

action

- (e) The proof testing of each chain pulley block is to be carried out as per latest applicable standards. The safe working load is to be marked in such way that is clearly visible from the operating level.

3.24.5 Electrically Operated Overhead Travelling Crane

- (a) The crane shall be electrically operated, bridge type complete with all accessories including down shop conductor, crane rails and fixtures, and shall conform to BS 2573,IS:3177 or relevant internationally approved standards.
- (b) The crane bridge shall consist of bridge girders on which a wheeled trolley is to run. The bridge trucks and trolley frames shall be fabricated from structural steel. Access walkway with safe hand railing as is required along the full span length of the bridge girder. Steel shall be tested quality conforming to ASTM A36 except that, plates more than 20 mm thick shall conform to IS:2062,BS:4360 or relevant internationally approved standards.
- (c) The bridge shall be designed to carry safely the loads specified in IS:807, BS:2573 or relevant internationally approved standards. All anti-friction bearings for bridge and trolley track wheels, gear boxes and bottom sheaves on hook shall be lubricated manually by hand operated grease pump through respective grease nipples.
- (d) Wheel base and structural frame of the wheel mounting of the end carriages shall be designed so as to ensure that the crane remains square and prevent skewness. Bridge and trolley track wheels shall be of forged steel and shall be double flanged type. The wheel diameter and rail sizes shall be suitable for the wheel loads
- (e) The crane rails shall be manufactured from wear resistant austenitic manganese steel. Mountings of the wheels shall be designed to facilitate easy removal for maintenance. Walkways shall be at least 500 mm clear inside width with a 6 mm thick non-skid steel plate surface. Steel rail stops to prevent rails from creeping and trolley from running off the bridge shall be abutted against ends of rails and welded to the girders. Bridge and trolley stops to match the wheel radius shall be provided before the buffer stops.
- (f) All exposed couplings, shafts, gear, wheels, pinions and chain drives etc. shall be safely encased and guarded completely to prevent any hazard to persons working

around. All bearings and gears shall have a design life of 100000 hours. Electro-magnetic and hydraulic thrust or brake shall be provided for the main hoist. One electro-magnetic brake shall be provided for each of the cross travel and long travel motions.

- (g) Hook shall be solid forged, heat treated alloy or carbon steel suitable for the duty service. They shall have swivels and operate on ball thrust bearings with hardened races. The lifting hooks shall comply with the requirements of IS 8610 or BS: 2903 / BS: 3017 or relevant internationally approved standards and shall have a safety latch to prevent rope coming off the hook.
- (h) Hoist rope shall be extra flexible, improved plough galvanized steel rope with well lubricated hemp core and having six strands of 36 wires per strand with minimum ultimate tensile strength of 1.6×10^6 kN/m² of Right Hand Ordinary (RHO) lay construction. The ropes shall have a 6:1 safety factor on the specified safe working load, and shall conform to IS:2266. Rope drums shall be grooved and shall be either cast iron or cast steel or welded steel conforming to IS:3177, BS:466 or relevant internationally approved standards
- (i) 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 BS:436, IS:4460 and BS: 721 or relevant internationally approved standards.
- (j) Name Plate showing the capacity, year of manufacture and rated capacity of hoist in figures not less than 150 mm height shall be placed on each side of the crane girder.
- (k) The maximum deflection under full load shall not exceed 1/900 of the span (as per IS: 3177).
- (l) All accessory and auxiliary electrical equipment including drive motors, electrically operated brakes, controllers, resistors, conductors, insulators, current collectors, pendant push button station, protective devices, operating devices, cables, conduits, etc. necessary for the safe and satisfactory operation of the crane shall be provided. (Power to the crane shall be provided by down shop conductors manufactured from high conductivity hard drawn copper. Conductors shall be completely shrouded such that they have no exposed current carrying surfaces. Pendant type push button station shall be sheet steel enclosed and shall comprise the following push

buttons and indicating lamps:

- a. `Start` and `Stop`.
 - b. Long travel - `Right` and `Left`.
 - c. Cross travel - `To` and `Fro`.
 - d. Hook - `Hoist` and `Lower`.
 - e. Red indicating lamp for supply `ON` indication.
- (m) Pendant type push button shall be supported independently of the electrical cable and shall be earthed separately, independent of the suspension. Automatic reset type of limit switches shall be provided to prevent over travel for each of the following:
- a. For `UP` and `Down` motions of the hook.
 - b. Long travel motion
 - c. Cross travel motion
- (n) Crane structures, motor frames and metal cases of all electrical equipment including metal conduit and cable guards shall be earthed. All motors, brakes, limit switches, panels, drum controllers, resistor unit sets shall be provided with two studs for earthing.
- (o) The crane, and all slings, ropes, shackles and other lifting equipment supplied shall be tested by the manufacturer at his works. The tests shall be carried out at 125% of Safe Working Load, and Test Certificates shall be supplied.
- (p) All motors shall be of the quick reversing type with electric mechanical brakes suitable for the duties specified. All movements shall be electrically powered suitable for operating with the hook loaded. Facilities shall be provided for the accurate location of the hook by means of `inching` the cross travel and down shop travel motions.
- (q) Sufficient slings, ropes, shackles, lifting beams, etc shall be supplied to handle all items of plant covered by the crane. They shall be labelled or marked with the Safe Working Load (SWL) and the purpose for which they are intended.
- (r) The Contractor shall include with the cranes all necessary contactors, control cubicles and protection equipment necessary to operate the crane and provide adequate electrical protection against overload, phase and earth fault and fail-safe protection in the event of an interruption in the power supplies. All access ladders

and platforms necessary to carry out maintenance and repairs shall be provided and installed by the Contractor.

- (s) All electrical equipment shall be fully tropicalised.
- (t) Site tests shall be carried out by the Contractor who shall supply the necessary materials for the test load. The test load shall be removed from site by the Contractor after successful tests have been carried out.

3.24.6 Jib cranes

- (a) Fixed Jib Cranes shall be provided for each clarifier in the lowering/removal of equipment's /parts to/from the clarifier floor and transferring the same outside the clarifier area. The Jib Crane capacity shall be 1.25 times the maximum weight to be handled in the clarifier or 1.5 Tonnes whichever is maximum.
- (b) The lift and reach of the cranes shall be suitable for the clarifier offered. The crane shall be capable of being swivelled by 360°. Adjacent halves of clarifiers may be provided with common jib crane if feasible.

All materials used in the construction shall be corrosion resistant. Mild steel used shall be galvanised. Ropes, chains and pulleys shall be of stainless steel construction. Hardware shall be of SS 316. Two number of Jib crane shall also be provided for handling submersible mixers in Pre- Anoxic and Anaerobic Tank area to lower the submersible mixers from platform level to ground level.

3.25 STP Process - Membrane based technology:-

3.25.1 INTRODUCTION

The purpose of setting up STP for the rejuvenation and beautification of rivers Various technologies were studied and a techno-economic study was done for life cycle cost to achieve at the desired outlet parameter so as to use treated sewage for non-domestic purpose. Based on this study cost of MBR technology is considered for estimation purpose. The cost will be differ as per the various technology combinations and vendors to achieve final standard outlet parameter.

The complete STP plant shall be setup on the platform over the river basin.

3.25.2 TECHNICAL SPECIFICATION

General Design Requirements

The following general design requirements shall be met by the bidders. These

requirements shall be fully met regardless of whether or not such requirements or any related components are shown in any drawings included in the contract documents.

- 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 contract documents.
- Where necessary, high noise equipment shall be provided with acoustic, sound-dampening enclosures to limit ambient noise during normal operation to the limits detailed in the General Requirements.
- All equipment shall be arranged and buildings and structures designed to permit safe and easy access to and for removal of all equipment.
- Fixed runways, lifting eyes, cranes, hoists, or other appropriate devices and means shall be provided to permit safe and easy removal of all equipment for maintenance or any other purpose
- All structures, whether liquid-holding or not, shall be designed such that they can be fully and completely drained and will not float or move when empty, because of groundwater buoyancy or any other reason. The structures shall be designed to counteract any possible floatation without the use of any type of groundwater pressure relief valves.
- The floors of all liquid-holding structures shall be appropriately sloped and trenches and drain sumps shall be provided at the bottoms of such slopes to facilitate complete drainage of liquid.
- Non-liquid-holding areas, structures, or buildings where leakage or other wet activities can occur, whether in normal use or during maintenance, shall be provided with covered drainage channels which shall direct the spillage to the plant gravity drain sump that takes the waste sludge and other waste flows to the Wet Well.
- Inlets into tanks, reactors, or other structures via pipes, channels, valves, or gates shall be designed such that the incoming flow does not cause any damage or excessive wear whatsoever to the structure or any equipment in the vicinity under any hydraulic condition, including but not limited to the condition when the structure is empty.
- For liquids and sludge, the minimum pipe flow velocity shall be no less than 0.5 m/s and the maximum pipe flow velocity shall be no more than 1.5 m/s for pumped suction and no more than 2.0 m/s for pumped discharge or

gravity flow. All mixed liquor and sludge lines shall be minimum 80 mm diameter and shall be provided with appropriate cleanouts and flushing arrangements for safe and easy flushing using high-pressure water.

- All liquid service pipes shall be provided with appropriate means for safe and easy drainage of the pipes when not in service.
- All pipes shall be colour banded and suitably labelled with the stream designation and direction of flow to enable individual lines to be identified throughout their run.
- Particular attention shall be paid to the layout of the chemical piping, which shall be arranged without clutter and shall be functional and neat in appearance.
- All piping routed under any type of structure or equipment shall be fully and completely encased in reinforced cement concrete, with the encasement thickness beyond the outer diameter of the pipe being at least 200 mm on all sides.
- Platforms, handrails/guardrails, ladders, and stairs shall be provided where necessary for proper, safe, and easy access to and/or operation of valves, gates, instruments, control panels, and other devices, equipment, or structures.
- Appropriate sampling ports and/or sampling valves shall be provided to allow easy, safe sampling of all process streams without spillage or contamination and without the need to interrupt normal operation.
- Foam, scum, fats, oil, grease, or any other floating material removed from any location in the STP shall be completely removed from the process flow path.

3.25.3 Process and Facilities Description

This Process and Facilities description is intended to provide a general indication of the processes and types of facilities that the Contractor shall be required to design, construct, commission and operate, and applies to STPs in this contract unless specifically indicated otherwise. The Contractor shall use this description together with other specific information for SPS, pumping Main, and STP provided elsewhere in these bid documents, including but not limited to “Design/Sizing Criteria and Other Requirements” of “Particular Mechanical

3.25.4 Wet Well Coarse Screen & Gate

The Wet well receives raw sewage directly from one or more sewer(s), which shall be conveyed from the inlet manhole and/or collection chamber to the Coarse Screen influent channel via an appropriately sized gravity pipe and screened using Coarse Screens placed in deep concrete channels immediately upstream of the Wet Well. One numbers of Mechanical Coarse screens shall be provided. The screenings

removed by the screens shall be discharged in to a container. One number of penstock gate shall be provided before the screens for isolation purpose.

3.25.5 Wet Well

The Wet Well included in this contract shall be provided with submersible pumps. Coarse-screened sewage from the Coarse Screens (located in inlet channel) shall be collected via appropriately sized channels which shall connect to the wet well described below. The wet well shall be a circular or rectangular concrete structure, and shall be designed to be fully self-cleaning and prevent any accumulation of solids or debris under any and all flow conditions. Wet well shall be provided with an adequate number of vents of adequate size to allow unrestricted changes in wet well liquid level. The vents shall be located in open areas exposed to the atmosphere, and shall be terminated in with screens to prevent entry of foreign objects into the vent piping.

3.25.6 Raw Sewage Pumps

The coarse-screened sewage from wet well shall be pumped by the Raw Sewage pumps to the Fine Screen Inlet Channel of STP as specified in the bid documents. Pump operation shall be automatically controlled based on wet well level.

3.25.7 Fine Screens

The Medium Screens shall receive coarse-screened sewage from the upstream Wet Well. An electronically controlled automatic jam removal system shall be provided in addition to the safety devices specified elsewhere in the document. One number of Mechanical fine screen shall be provided as working unit and one number of manual fine screen shall be provided as standby. The screenings removed by the screens shall be directly discharged in to a container at the appropriate elevation above finished ground level.

3.25.8 Vortex Grit Separator Basins

Gravity type grit basins shall be provided without mechanical grit collector. The sediment grit shall be discharged to grit pit by manual operation through pipes and valves. The grit slurry shall be taken to the nearest manhole of gravity sewer. The de-gritted sewage stream shall flow to the next process unit through a channel.

3.25.9 Rotary Drum Screens

Self-cleaning Fine Screens shall be provided in one duty and one standby

arrangement. The screenings removed by the Fine screens shall be directly discharged in to a container at the appropriate elevation above finished ground level. Performance requirements for Fine Screens shall be as specified by the MBR membrane manufacturer.

3.25.10 MBR Basins

The MBR Basins shall have complete mixed/plug flow. Minimum of two MBR basins shall be provided. The MBR design shall provide for easy isolation of each aeration tank and shall include all required facilities for cleaning the membranes. An electric monorail chain pulley block shall be provided for easy removal of the membrane cassettes. The block shall provide adequate vertical clearance to safely lift the membrane modules above all piping, equipment, or other items that may be located in the travel path from the module location in the tank to an adequately-sized adjacent membrane “lay-down” area designated for membrane maintenance or chemical tanks meant for recovery cleaning.

The scope of supply for the MBR system shall consist of, but not limited to the following:

- a) A complete microporous membrane system with relevant track record in sewage treatment application and associated pumps and process equipment as necessary to meet the performance requirements listed subsequently.
- b) All equipment associated with the backwash system including, pumps, chemical addition systems, air blowers, air compressors;
- c) Chemical storage, handling, injection and mixing systems, pumps, tanks, and instrumentation associated with the microporous membrane cleaning system;
- d) All interconnecting pipe works, fittings and valves,
- e) All interconnecting wiring (power and control)
- f) All required process control and monitoring instrumentation, and
- g) All on-line analysers for performance monitoring and verification.

3.25.11 Sludge Extraction

The sludge from aeration tanks shall be pumped to De-watering unit , and the sludge drying units.

3.25.12 MBR Unit

This building shall house all MBR-related equipment such as Scour Air Blowers, Permeate/ Backpulse Pumps, air compressors and WAS Pumps.

In addition, the MBR Equipment building shall house all equipment necessary for all types/modes of membrane cleaning.

The Process Air Blowers for Aeration may also be housed in the MBR building or in a separate building.

3.25.13 Return Activated Sludge (RAS) Pump Station

RAS pumps shall be provided to return settled sludge from the membrane-separated sludge from the MBR basins back to the Aeration Basins. A valve- controlled and metered tapping shall be provided from the RAS pump discharge header to withdraw Waste Activated Sludge (WAS) to solids processing. Return activated sludge pumps shall be used if required.

3.25.14 Chemical Building

A Chemical Building shall be provided to house all equipment for sodium hypochlorite and membrane cleaning chemicals such as citric acid storage tanks, storage area, dosing pumps and all associated equipments.

3.25.15 Service Water requirements

Service water shall be used for multiple applications including but not limited to Citric Acid and polymer solution preparation, screen washing, hose down and area washing, gardening and landscaping, MBR backpulse and chemical cleaning operations, human domestic non-potable needs, laboratory needs, and other general cleaning and flushing needs. The water system shall be designed to provide adequate water pressure for all of the above applications. The disinfected MBR permeate shall be used as service water for all the above applications.

3.25.16 Centrifuge Building

The sludge from new MBR plant shall be dewatered in the existing dewatering building housing the dewatering system.

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

Administration building, laboratory, storage facility, guard house shall be used as needed for a fully functional new plant.

The Process Air Blowers for Aeration may also be housed in the MBR building or in a

separate building.

3.25.18 Service Water requirements

Service water shall be used for multiple applications including but not limited to Citric Acid and polymer solution preparation, screen washing, hose down and area washing, gardening and landscaping, MBR backpulse and chemical cleaning operations, human domestic non-potable needs, laboratory needs, and other general cleaning and flushing needs. The water system shall be designed to provide adequate water pressure for all of the above applications. The disinfected MBR permeate shall be used as service water for all the above applications.

3.25.19 Gravity Sludge Thickener

Gravity sludge thickener shall be provided for thickening of Waste Activated Sludge (WAS) generated from MBR basins.

3.25.20 Thickened Sludge Pumps

Thickened sludge pumps shall be provided for pumping of thickened sludge to the sludge storage tank.

3.25.21 Plant Drain Pump Station

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

Design/Sizing Criteria and Other Requirements

Item/ Parameter/ Description	Units	Values
Treatment Process		MBR
Influent Wastewater Flow		
Peak Hour Hydraulic Peaking Factor (PF)		2 to 2.25
Influent Wastewater Characteristics		
pH		
BOD	mg/L	
COD	mg/L	
TSS	mg/L	
TKN	mg/L	
NH4-N	mg/L	

Item/ Parameter/ Description	Units	Values
Total Phosphorus	mg/L	
Treated Effluent Quality Requirements		
Bio chemical Oxygen Demand (BODs)	mg/l	< 3
Chemical Oxygen demand (COD)	mg/l	< 50
Total Suspended Solids (TSS)	mg/l	< 10
Colour		Courless
Total Nitrogen (TN)	mg/l	< 10
Total Phosphorus	mg/l	< 1.0
pH		6.5-8.5
Oil and Grease	mg/l	<10
Fecal Coliform	MPN/ 100 ml	Below Detectable Level
Odour		No noticeable offensive odour
Temperature	°C	Ambient
Treated Sludge Quality Requirements (Dewatered Sludge)		
Sludge Quality		Undigested dewatered sludge
Maximum Sludge VSS/TSS	%	75%
Minimum sludge TSS (dry solids)	% w/w	15%
STP Inlet and Outlet Hydraulic Conditions		
Receiving water body		
Receiving water high flood level	m	
TSPS at STP? (Y/N)		
Item/ Parameter/ Description	Units	Values
Nominal diameter(s) of incoming gravity sewer(s) at STP – Contractor to field-verify	mm	
MOC(s) of incoming gravity sewer(s) at TSPS – Contractor to field-verify		
Lowest incoming gravity sewer invert at STP terminal manhole/chamber - Contractor to field-verify	m	
Min drop from lowest sewer invert to downstream high water level	m	
Wetwell Coarse Screen Inlet Channel		

Item/ Parameter/ Description	Units	Values
Min No of Units		1
Type		Rectangular or tapered
MOC		RCC
Peak channel velocity at peak flow	m/s	0.75
Max SWD at peak flow	m	0.75
Wetwell Coarse Screen Channels		
Screen type		Climber type bar screen with mechanical cleaning
Min No of Units - Working		1
Min No of Units - Standby		1
MOC - Structure		RCC
MOC - Screens		SS 316L
Screen Drive Motor size - Min	kW	---
Angle of inclination of screen	deg.	75
Max SWD at peak flow	m	0.75
Velocity through openings at peak flow	m/sec	0.6 to 1.20
Clear spacing between bars	mm	20
Minimum bar thickness	mm	8
Minimum bar dimension in direction of flow	mm	15
Bar cross-section		Rectangular
Max width per channel	m	1
Min channel length	m	6
Wetwell Coarse Screen Effluent Channel		
Min No of Units		1
MOC - Channel		RCC
Peak channel velocity at peak flow	m/s	0.75
Max SWD at peak flow	m	0.75
TSPS		
No of structures		1
Type		Wet pit with submersible pumps
MOC - Structure		RCC
<u>TSPS Wet Well</u>		
No of wet pit compartments		2
Min HRT in operating volume at peak flow	min	5
Low - Low Low level difference	m	0.3
High High - High Level difference	m	0.3
Min freeboard above High High level	m	0.75
<u>Check for Detention Time</u>		

Item/ Parameter/ Description	Units	Values
Max HRT at design avg flow	min.	30
TSPS Pumps		
Pump type		Submersible non-clog solids handling wet pit
No of pumps - Working		2
No of pumps - Standby		1
Max rising main velocity	m/s	2.50
Hazen-William's C coefficient		110
Min pump efficiency within flow-head operating envelope		0.68
Min motor efficiency		0.90
Fine Screen Influent Channel		
Min No of Units		1
Type		Rectangular or tapered
MOC		RCC /SS 316
Peak channel velocity at peak flow	m/s	0.75
Max SWD at peak flow	m	1.0
Min Freeboard	m	0.50
Medium Screen Channels		
Screen type		Bar or Drum screen with mechanical cleaning
Min No of Units - Working		1
Min No of Units - Standby		1
Item/ Parameter/ Description	Units	Values
MOC - Channel		RCC / SS 316
MOC - Screens		SS 316L
Angle of inclination of screen	deg.	45
Max SWD at peak flow	m	1.0
Velocity through openings at peak flow	m/sec	0.6 to 1.20
Clear spacing between bars	mm	6
Minimum bar thickness	mm	8
Minimum bar dimension in direction of flow	mm	15
Bar cross-section		Teardrop
Max width per channel	m	1
Min freeboard	m	0.50
Min channel length	m	6
Vortex Grit Separators		
Type		Vortex Grit Separators
Min No of Units - Working		1

Item/ Parameter/ Description	Units	Values
Min No of Units - Standby		1
MOC - Structure		SS316
Design particle dia Grit Separators (sp gr - 2.65)	micron	particles with a specific gravity of minimum 2.65 and with a diameter of 200 micron
Max Design SOR at peak flow	m ³ /m ² /day	Bidder to provide
Min HRT at peak flow	sec	Bidder to provide
Min design SWD	m	Bidder to provide
Min freeboard	m	0.50
Ultra Fine Screen Influent Channel		
Min No of Units		1
Type		Rectangular or tapered
MOC		RCC
Peak channel velocity at peak flow	m/s	0.75
Max SWD at peak flow	m	1.5
Min Freeboard	m	0.50
Ultra Fine Screen Channels		
Screen type		Internally fed in-line or in-channel perforated plate drum screen with integral or separate screenings washer and compactor or Rotary drum screen
Item/ Parameter/ Description		
Units		
Values		
Min No of Units - Working		1
Min No of Units - Standby		1
MOC - Channel		RCC/ SS316
MOC - Screens		SS316
Screen Drive Motor size - Min	kW	1.5
Screenings Washer-Compactor Drive Motor Size - Min	kW	0.75
Max SWD at peak flow (in-channel)	m	1.2
Screen opening size	mm	2 to 3 as per MBR supplier
Min width per channel	m	0.80
Max width per channel	m	1.50
Min freeboard	m	0.50
Min channel length	m	6
Fine Screen Effluent Channel		

Item/ Parameter/ Description	Units	Values
Min No of Units		1
MOC		RCC
Peak channel velocity at peak flow	m/s	0.75
Max SWD at peak flow	m	0.80
Min freeboard	m	0.50
Aeration Basin Influent Channel		
Min No of Units		1
MOC		RCC
Max SWD	m	1.5
Min freeboard	m	0.50
Aeration Basins		
Min No of Units		2
MOC – Structure		RCC – fully covered with solid GRP non-skid cover plates
Max Height	m	6
Min Freeboard	m	0.5
Max height including freeboard	m	7-8
Minimum Total Volume	cum	Bidder to provide / As per Membrane Supplier's Design
Recycle Configuration		
RAS Ratio (R) - hydraulic design		4 Q to 6 Q
Anoxic Zones		
<u>Anoxic Zone Sizing</u>		
Min Anoxic Volume - Total	cum	Bidder should design based on CPHEEO or Metcalf eddy
Min no of anoxic zones per basin		2
Anoxic Mixers		
Direct pumping turnover frequency	per hr	Bidder to provide
Min no of mixers per zone - Working		Bidder to provide
Mixer type		Submersible
Required unit power input	W/cum	Bidder to provide
Aerobic Zones		
Aerobic zone DO	mg/L	2
<u>Aerobic Zone Sizing</u>		
Min Aerobic Volume - Total	cum	As per MBR supplier
Min no of aerobic zones per basin	Nos.	Bidder to provide
Aerobic Zone minimum L/W ratio		3.0

Item/ Parameter/ Description	Units	Values
Design aerobic (Nitrification SRT)	days	Bidder to provide
<u>Process Aeration</u>		
AOTR - average (minimum net oxygen requirement - field conditions)	kg/d	Bidder to provide
AOTR - peak (minimum net oxygen requirement - field conditions)	kg/h	Bidder to provide
Type of Aeration		Diffused air
Max Alpha Factor, α		0.50
Max Beta Factor, β		0.95
Max Fouling factor, F		0.80
Aeration system sizing basis liquid temperature		Max liquid temp
Aeration system sizing basis air temperature		Max air temp
Peak SOTR	kg/hr	Bidder to provide
SOTE per unit diffuser submergence at peak air flow (min to be provided and max to be used as design basis)	%/m	5.00%
Process Air Blowers		
Blower type		High speed turbo blower
No of blowers – Working	%	100
No of blowers - Standby	%	50
Design capacity per blower	inlet cum/hr	As per MBR supplier
Minimum Blower Efficiency in operating envelope,		0.60
Min motor efficiency		0.90
Min VFD efficiency		0.95
Process Air Diffusers		
Diffuser type		Fine bubble membrane, tubular or disc, retrievable
Membrane material		EPDM or silicone elastomer with UV protection
Max air flow per effective area (effective area for tubular diffusers is upper half only)	Nm ³ /hr/m ²	As per MBR supplier
Min no uninstalled spare diffusers - percent of installed	%	5
Diffuser Piping Grid, MOC		SS316L
Mixed Liquor Recycle Pumps		

Item/ Parameter/ Description	Units	Values
Number of Pumps per basin - Working	%	100
Number of Pumps per basin - Standby	%	100
Design capacity per pump	cum/hr	As per MBR supplier
Type of Pump		As per MBR supplier
Min. pump efficiency within flow-head operating envelope (η)	%	62.0
Min. motor Efficiency	%	95.0
Min VFD efficiency	%	90.0
Aeration Basin Effluent Channel		
Min No of Units		Bidder to provide
MOC		RCC
No of "passes"		1
Pass width	m	1
Min Freeboard	m	0.5
MBR Basins		
MBR volume considered part of minimum process volume requirement?		No
Min No of Units (n)		Bidder to provide
Basin MOC		RCC - fully covered with solid GRP non-skid cover plates
Clean-In-Place (CIP)		Provide CIP capability
Max height including freeboard	m	4-5
Membrane installation		Submerged in mixed liquor in dedicated MBR basins, separate from aerobic basins
Membrane chemistry		PVDF
Membrane support/reinforcement		Required
Membrane Skid		SS316
Max membrane pore size - Nominal	microns	≤ 0.04
Membrane format		Hollow fiber/ Flat Sheet
Module format		In-basin immersed
Permeate forward flow direction		Outside-In
Minimum Tensile strength of Membrane fibre	N (Hollow Fiber)	300
	kN/m (Flat sheet 1 m x 1 m)	19 Vertical 12 Horizontal
<u>MBR Operating Conditions</u>		

Item/ Parameter/ Description	Units	Values
TSS Range	mg/L	3,000 to 15,000
Maximum Total SRT		That required for near-complete nitrification (i.e. effluent NH ₃ -N ≤ 1 mg/L)
<u>Maximum net flux</u>	L/m ² /hr (lmh)	25-30 lmh
Avg flow with all (n) units		Bidder to provide
Avg flow with n-1 units		Bidder to provide
Maximum daily flow with all (n) units		Bidder to provide
Minimum spare capacity (blank spaces) per MBR Basin	% of min total effective membrane area	10-15%
Normal design average operating transmembrane pressure (TMP)	kPa	35
Maximum operating transmembrane pressure (TMP)	kPa	50
Minimum availability (i.e. percent of time filtering)	%	90
MBR Sludge pit		
Min No of Units		1
MOC		RCC
No of "passes"		1
Min Freeboard	m	1.0
MBR Scour Air Blowers		
Blower type		High speed turbo air blower
Min number of blowers - Working		To be same as the number of MBR basins proposed
Min number of blowers - Standby		Bidder to provide
Minimum Blower Efficiency in operating envelope, e		0.70
Min motor efficiency		0.90
Min VFD efficiency		0.95
MBR Permeate/Backpulse Pumps		
Min no of pumps - Working		To be same as the number of MBR basins proposed
Min no of pumps - standby		Bidder to provide

Item/ Parameter/ Description	Units	Values
Pump Type		Centrifugal
Minimum forward permeation capacity per pump	cum/hr	As per MBR supplier
Min pump efficiency within flow-head operating envelope		0.65
Min motor efficiency		0.90
Min VFD efficiency		0.95
Total average Permeate flow	cum/hr	Bidder to provide
Process Air Blower Building		
Structure		1
MOC - Roof, columns, beams		RCC
MOC - Side walls		200 mm solid concrete blocks
<u>Process Air Blower Room</u>		
Min Length	m	Bidder to provide
Min Width	m	Bidder to provide
Min Height	m	Bidder to provide
<u>Electric Panel Room</u>		
Min Length	m	Bidder to provide
Min Width	m	Bidder to provide
Min Height	m	Bidder to provide
<u>Overall dimensions</u>		
Min Length	m	Bidder to provide
Min Width	m	Bidder to provide
Min Height	m	5
Air Compressor		100 % W + 50% S
WAS Pump		100 % W + 100% S
MBR Equipment Building		
Structure		1
MOC - Roof, columns, beams		RCC
MOC - Side walls		200 mm solid concrete blocks
Minimum length	m	Bidder to provide
Minimum width	m	Bidder to provide
Minimum height - lower level	m	5
Minimum height - upper level	m	6
Chemical Building		
Min no of units		1
Min no of storeys		2
MOC - Roofs, Columns, and Beams		RCC

Item/ Parameter/ Description	Units	Values
MOC - Side walls		200 mm solid concrete blocks
Return Activated Sludge (RAS) Pumps		
Min no of pumps - Working		100 % W
Min no of pumps - Standby		100 % S
Pump Type		Non-clog centrifugal solids handling dry pit
Design capacity per pump	cum/hr	As per MBR supplier
Min. pump efficiency within flow-head operating envelope (η)	%	70.0
Min. motor Efficiency	%	95.0
Min VFD efficiency	%	90.0
Sodium Hypochlorite Dosing		
Sodium Hypochlorite Dosing or Gas Chlorination System		Bidder to provide
Gravity Sludge Thickener		
Min No of Units		1
Type		Circular, center column supported with central drive
MOC - Structure		RCC
Conical bottom minimum slope		1 to 12
MOC - Center Column		SS316
MOC - Bridge		SS316
MOC - Scraper		SS316
Max SLR	kg/m ² /day	25
Max center column velocity	m/sec	0.9
Center column wall thickness - minimum	m	0.025
Minimum SWD	m	4.5
Min Freeboard	m	0.5
<u>Check for Hydraulic Loading</u>		
Max hydraulic loading rate	cum/d/sqm	20.00
Thickened Sludge Pumps		
Min no of pumps - Working		100 %
Min no of Pumps - Standby		100 %
Type of Pump		Progressing Cavity
Min capacity per pump	cum/hr	Bidder to provide
Min. pump efficiency within flow-head operating envelope (η)	%	35.0
Min. motor Efficiency (Ve)	%	95.0

Item/ Parameter/ Description	Units	Values
Sludge Storage Tank		
Min No of Units		1
Type		Fixed cover - no gas storage or heating
Bottom shape		Conical
Minimum bottom slope		1 to 6
MOC - except cover		RCC with full internal epoxy coating
MOC - cover		Fixed RCC roof with full epoxy coating
Nominal HRT	days	3
Min total volume required	cum	Bidder to provide
Min SWD	m	4
Min freeboard	m	0.5
<u>Sludge Storage Tank Mixers</u>		
Min no of mixers per tank		1
MOC - Impeller and shaft		SS316
Type		Paddle
Centrifuge Feed (Dewatering Influent, DWI) Pumps		
Centrifuge operation schedule	hrs/day	8
Min no of pumps - Working		100 %
Min no of Pumps - Standby		100 %
Type of Pump		Progressing Cavity
Min capacity per pump	cum/hr	Bidder to provide
Min. pump efficiency within flow-head operating envelope (η)	%	35.0
Min. motor Efficiency	%	95.0
Min VFD efficiency	%	90.0
Dewatering Screw press		
Min hydraulic capacity - total	cum/hr	Bidder to provide
Min solids capacity - total	kg/hr	Bidder to provide
Min no of units - Working		1
Min no of units - Standby		0
Inclination	deg	0
Sludge feed pressure	mbar	0 – 300
Pressure sensor		transducer
Protection class		IP 68
Scraper thickness		Bidder to provide
Scraper self-adjusting capability		Bidder to provide
Filter diameter	mm	Bidder to provide
Filter basket segments	No	3

Item/ Parameter/ Description	Units	Values
Filter bar spacing		Variable spacing from 0.4mm to 0.25 mm shall be provided
Minimal filter thickness	mm	3
Movable parts		AISI 420
Weights		AISI 304
All components in contact with medium Screw, filter baskets, flushing system, housing, frame Covers		SS316L
Sealings, press cone		ABS/PMMA RAL 70,EPDM, NBR, PU, POM, PA
Noise level		66 dB(A)
Supercharge reactor		
Volume	l	Bidder to provide
Height adjustment range	mm	185 - 200
All components		SS316L
Max input TSS	% w/w	2.5%
Min input VSS/TSS	%	74%
Min dewatered sludge (DWSL) TSS required	% w/w	15%
Min solids capture required	%	90%
Polymer System		
Type		Dry polymer with batch tanks
Minimum polymer dose	kg/ton dry solids	5
<u>Dry Polymer Storage</u>		
Type		Covered bin

Item/ Parameter/ Description	Units	Values
MOC		ROTOMOULDED HDPE
Minimum storage period	days	10
Storage safety factor		1.50
<u>Polymer Batch Tanks</u>		
MOC		ROTO MOULDED HDPE
Poly solution strength	% w/w	0.2%
Solution storage volume safety factor		1.50
Min no of tanks - Working	tanks/batch	1

Min no of tanks - Standby	tanks/batch	1
Minimum capacity per tank	cum	Bidder to provide
<u>Polymer Batch Tank Mixers</u>		
Min no of mixers per tank		1
MOC - Impeller and shaft		Impeller : SS316L, Shaft: SS316
Type		Turbine
<u>Polymer Metering Pumps</u>		
Type of Pump		Hydraulic double diaphragm
Min no of pumps - Working		1
Min no of pumps - Standby		0
Min capacity per pump	cum/hr	Bidder to provide
Centrifuge Building		
Min no of units		Bidder to provide
No of levels		Bidder to provide
MOC - Roof, columns, beams		RCC
MOC - Side walls		200 mm solid concrete blocks
Minimum length	m	Bidder to provide
Minimum width	m	Bidder to provide
Minimum height - Basement	m	Bidder to provide
Minimum height - lower level	m	Bidder to provide
Minimum height - upper level	m	Bidder to provide
Plant Drain Pump Station		
<u>Plant Drain Pump Station Wet Well</u>		
MOC		RCC
Min HRT at peak flow	min	10
Min operating volume	cum	Bidder to provide
SWD at low level	m	2.0
Ground level to high water level	m	Bidder to provide
Item/ Parameter/ Description	Units	Values
<u>Plant Drain Pumps</u>		
Min no of pumps - Working		1
Min no of pumps - Standby		1
Type of Pump		Submersible
Min capacity per pump	cum/hr	Bidder to provide
Min pump efficiency within flow-head operating envelope		0.60
Min motor efficiency		0.90
Sub-Station for SPS and STP		

Min no of units		1
MOC - Roof, columns, beams		RCC
MOC - Side walls		200 mm solid concrete blocks
D G Room for SPS and STP		
Min no of units		1
MOC - Roof, columns, beams		RCC
MOC - Side walls		200 mm solid concrete blocks
<u>Overall dimensions</u>		
Min length	m	Bidder to provide
Min width	m	Bidder to provide
Min height	m	Bidder to provide
Administration, Laboratory, and SCADA Building		
Min no of units		1
Number of Storeys		2
MOC - Roof, columns, beams		RCC
MOC - Side walls		200 mm solid concrete blocks
<u>Overall dimensions</u>		
Min length	m	Bidder to provide
Min width	m	Bidder to provide
Min height per storey	m	Bidder to provide
Maintenance Workshop		
Min no of units		1
MOC - Roof, columns, beams		RCC
MOC - Side walls		200 mm solid concrete blocks
<u>Overall dimensions</u>		
Min length	m	Bidder to provide
Min width	m	Bidder to provide
Min height	m	Bidder to provide
Item/ Parameter/ Description	Units	Values
Guard Room (Security Room)		
Min no of units		1
MOC - Roof, columns, beams		RCC
MOC - Side walls		200 mm solid concrete blocks
<u>Overall dimensions</u>		
Min length	m	3.5
Min width	m	3.5
Min height	m	3.0

Plant Water Pump Station		
<u>Plant Water Pump Station</u>		
MOC		RCC
Min HRT at peak flow	min	10
Min operating volume	cum	2.1
SWD at low level	m	2.0
Ground level to high water level	m	2.0
<u>Plant Water Pumps</u>		
Min no of units - Working		1
Min no of units - Standby		1
Type of Pump		Submersible
Capacity of each pump - min	cum/hr	13
Min pump efficiency within flow-head operating envelope		0.60
Min motor efficiency		0.90

Membrane Specifications

1. The membranes shall be a proven design of a membrane manufacturer engaged in the production of membrane of this type.
2. Membranes shall allow product water (permeate) to be drawn through from the outside surface of the membrane to the inside.
3. The temperature-corrected permeability at 20°C will be monitored during the second year of the system operation, thus allowing the first year of operation for a break-in period. The permeability decline over this second year of operation will be used to predict the membrane permeability for the remaining 8 years of the manufacturer's stated membrane life. If the projected permeability demonstrates that the membranes will be unable to meet the project flow requirements at any point prior to stated end of life, the membrane supplier will be required to add or replace membrane modules to raise the permeability to a level suitable to reach the minimum flow requirements prior to the end of the initial warranty period.
4. The nominal pore size of the membrane shall be less than or equal to 0.04 micron.
5. Membranes shall be physically strong enough to withstand the operating conditions associated with continuous operation in an aerated tank of mixed liquor at concentrations of up to 12,000 mg/L.
6. The membranes, membrane modules, and membrane cassettes shall be by one manufacturer. For fiber breaks: The membrane manufacturer will guarantee that under correct screening and operation guideline the fiber breakage rate will be no

more than 0.5 percent of the fibers in a single membrane module over any twelve (12) consecutive months and no more than 1 percent over the total warranty period. Any modules exceeding this breakage rate will be replaced by the membrane manufacturer during the warranty period at their expense.

7. The membrane modules shall be constructed such that the membranes are held vertically and bonded firmly. The membrane modules shall also be attached to a common base to avoid lateral movement of the membrane modules during operation.
8. The material used for the manufacturing of the membrane fibers shall be Polyvinylidene Fluoride (PVDF).
9. The materials used to hold hollow membrane fibers in place shall be chemically resistant to high concentrations of chlorine (minimum 100 mg/L and maximum 5,000 mg/L) for up to 24 hours, and low pH (range 2 to 3) and high pH wash solutions (range 10 to 11) for up to 24 hours, respectively.
10. Membranes shall be capable of regular backwashing with and without cleaning chemicals to minimize pore fouling.
11. At least 30 l/mh flux @ 25^o C shall be considered to arrive at total membrane area required to treat specified wastewater quantity.
12. Clean-In-Place System: The membranes shall be cleaned “in-place” without removal from the membrane tank. The system shall consist of a chemical feed pump (if required) and storage tank (if required) and include all interior piping, valving, and in-tank piping and supports.
13. The minimum membrane warranty for life of membranes should be for 10 years where the membrane manufacturer should offer minimum 2 years full replacement warranty and additional 8 years on pro-rata basis.
14. The Bidder along with the bid must submit a Memorandum of Understanding (MOU) from the Technology Provider (Process Licensor) for MBR technology tie up for the proposed STP. Technology provider can sign multiple MOU’s with Bidders.
15. Technology Provider’ would mean the Technology Provider entity itself or their principal or their principal’s wholly owned subsidiary. The Technology Supplier should have registered office in India along with required support team who will provide required support.
16. It is mandatory for the Technology Provider to offer performance warrantee for the plant.

3.25.22 Scope

The MOU with the Technology Provider must contain the following Scope:

1. Fine Screens
2. DO Control
3. Anoxic Basin / Mixer
4. Bioreactor / Fine Bubble Diffusers and Blowers
5. Membranes, Membrane Modules and Cassettes
6. Membrane Support Frames
7. Permeate Pumps, RAS Pumps, Backpulse Pumps
8. Air Scour Blowers
9. Membrane System Valves and actuators
10. Piping & Valves within membrane filtration system tank limits
11. Membrane System Instrumentation, PLC & PLC Configuration
12. Complete Design Engineering Package of the plant along with technical support during installation & commissioning.

3.26 Grit Removing Equipment (Vortex Type for STP Plant)

GENERAL

The Grit Chamber shall operate on the vortex principle. Each Vortex Grit Chamber, complete with all accessories including, but not necessarily limited to: gear motor, gear head, air bell, propeller, drive tube, axial flow propeller, Grit Removal Turbo Pump and auxiliary equipment as specified herein shall be provided.

PERFORMANCE REQUIREMENTS

The proposed 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.

The grit separators shall be capable of removing at least 95% of particles with a specific gravity of minimum 2.65 and with a diameter of 200 micron and greater.

Organic removal: The final dewatered grit from the classifier / washer shall contain less than 5% putrescible organic matter on dry basis.

VORTEX TYPE GRIT CHAMBER

The flow from the screen channel shall be conveyed to the Vortex type Grit Chamber, through piping, for the removal of silt / panna sand / grit / inorganic matter by means of RCC tank designed as per relevant IS code of practice. There shall be W+S No. Vortex Type Grit Chamber. Grit chambers shall be designed for peak + other flow. Mechanical grit chamber shall be capable of removing grit of particle size and sp. gravity as defined under raw sewage characteristics. The Grit Chamber shall be of RCC M30 grade construction with suitable RCC foundation with necessary water tightness test. The inside surface of the Grit Chamber shall be provided with 20 mm thick water proof plaster in Cement mortar 1:3. The bottom of the Chamber shall be provided with 40 mm thick IPS screeding. The outside surface shall be provided with 20 mm thick double coat Sand faced plaster in cement mortar 1:3 with exterior emulsion as per Civil specification.

The grit + water mixture from vortex grit chamber shall be fed to grit washer for classification of organics and clean grit.

The clean grit shall be guided to trolleys providing GI (2mm) chute of adequate opening. Chute shall be extended up to 2m above ground level or directed by engineer-in-charge during execution.

The grit removal chamber shall have inlet and outlet separated by 360° or 270° of the tank periphery. There shall be a sloping floor connecting the upper and lower sections.

The screened wastewater enters the Vortex type grit chamber at the bottom where a tangential rotational movement is generated due to the curved vortex chamber. A constantly rotating stirrer helps support the wastewater circulation within the grit chamber ensuring a constant velocity of rotation within the complete grit trap system even under dry weather conditions.

The impeller blades shall create a slight upward flow in the central zone of the upper chamber.

Due to the constant radial rotation the solids are very quickly collected within the center of the grit chamber from where they then pass into the bottom of the grit collection tank. The grit-free wastewater then exits and flows onto the next treatment step. Centrifugal or airlift pumps can then deliver the collected solids from the grit collection tank into a grit washer where the solids can then be subsequently separated and dewatered and organic particles removed.

The circular tank grit trap shall be supplied complete with geared motor, gear box assembly, impeller drive tube, impeller, air blower and airlift pump assemblies.

However, the contractor shall have to supply all the necessary equipments to achieve the desired results as described in the tender elsewhere. However, the necessary datasheet pertaining to equipment offered by bidder shall have to be submitted along with the tender.

➤ **Vortex Grit Separator Mechanism:**

- Geared motor – Motor should be provided with IP 65 protection.
- Bull gear box: Enclose bull gear in a heavy cast iron casing, confirming DIN/ISO standards. Unit with at least 5.0 service factor at standard operating speed and power demand.
- Bearings: Drive unit and motor bearings have a minimum life of 1,00,000 hours. Turntable bearings supporting the paddles assembly have a minimum bearing life of 20 years
- Turning drive tube driven by the bull gear and specially designed propeller/impeller.
- The grit removal device shall be fitted with a rotating impeller. The impeller shall be manufactured in two halves and shall be clamped to the drive tube when fully assembled. The stub shaft should not have any supporting bearings under the water and should be hanging from the gear head assembly.
- The impeller shall be fitted with four fixed blades set at an angle of 30° and provide sufficient washing action to prevent lighter solids entering the classification gap between impeller and grit hopper whilst allowing settled grits through for collection.
- The impeller blades shall create a slight upward flow in the central zone of the upper chamber.
- Due to the constant radial rotation the solids are very quickly collected within the center of the grit chamber from where they then pass into the bottom of the grit collection tank. The grit-free wastewater then exits and flows onto the next treatment step. Centrifugal or airlift pumps can then deliver the collected solids from the grit collection tank into a grit washer where the solids can then be subsequently separated and dewatered and organic particles removed.
- The MOC of centrifugal pump shall be Ni-Hard/High chrome alloy and shaft shall be of duplex stainless steel.

➤ **Control Panel for Vortex Grit mechanism**

- With all components required for fully automatic operation of the plant, incl. control units, motor protection relay, overload protection, fuses, relays, mains isolator.

- Protection grade: IP 65, painted steel plate
- Control of the operation time of the grit discharge pump by means of a 24 hours timer in combination with an impulse/pause time relay (freely selectable)

➤ **Grit Classifying System**

Contractor should provide a COANDA Grit classifying system where the grit is classified and dewatered, and organic matter is reduced in a single and compact unit.

The grit/water/organics mixture is introduced into the grit washer through the inlet line and vortex chamber of the washer into the Coanda Tulip. While the rotating flow is diverted from the vertical into the horizontal, by making use of the Coanda effect, a defined flow pattern is produced in the tank which provides optimal conditions for separation of the mineral components.

Since sedimentation depends both on the particle size and particle density, not only mineral particles will settle but also the organics. The actual washing of grit, i.e. separation of organics from mineral components, happens in the lower turbulence-free part of the Grit Washing Plant

While the clean grit is automatically removed by the inclined grit removal screw it is statically dewatered prior to being discharged into a container. Also the organics which have remained in the plant are discharged. Organics discharge, however, happens discontinuously and in dependence of the whole process system.

- The stationary parts of the grit washer are:
 - Inlet tank with feet
 - Through for grit discharge
 - Support
 - Grit discharge
 - Gear motor
- The movable parts of the grit washer are:
 - Auger with central pipe and flights, upper and lower shaft pinion
 - Stirrer
- Intake tank: The central part of the grit washer is the conical inlet tank. A Coanda Tulip is installed inside the tank below the vortex chamber. Water outlet is via an overflow weir arranged circularly in the tank. A perforated plate in the bottom section of the tank is provided for grit washing.

- Grit removal trough: The grit is discharged via a chute directly into the container or conveyer
- Gear motor: The gear motor is flanged directly to the upper trough end. Torque transfer onto the screw shaft pinion is achieved by means of an adjusting spring connection. The gear motor also takes over the axial and upper radial bearing of the screw shaft.
- Screw: The shaft pinion has an adjusting spring connection on top. A silicon carbide sleeve combined with a chilled cast iron pinion ensures wear protection of the bottom shaft pinion. The screw flights have different designs and are arranged on the screw shaft up to the grit discharge unit. One oppositely directed flight at the end support grit discharge.
- Stirrer: A slowly running stirrer supports the separation of the lighter organic particles from the dense grit particles. The stirrer is driven by a gear motor that is connected to the stirrer axis. The stirrer consists of several arms. There is a casing around the stirrer axis.
- The MOC shall be 304L stainless steel or equal quality, acid-treated in a pickling bath (except fittings, chains, chain wheels, drives, bearings).

➤ **Control Panel for Grit Washer**

- Control panel with all components required for fully automatic operation of the plant, incl. control units, fault signal lamps, motor protection relay, overload protection, fuses, relays, operation hours counter, mains isolator and emergency cutoff switch etc.
 - Control panel to control the following units:
 - 1 drive motor of grit removal screw
 - 1 drive motor of stirrer
 - 1 x grit level control with limit switch
 - 1 x electro valve with timer function
 - Painted steel RAL 7035
 - Protection grade: IP65
- Wash Water Pump of suitable flow and pressure as required for grit washer
- Piping to and from existing STP units of DI K7 only
- Compressor for air lift pump of suitable flow and pressure with control panel
- Necessary Cables and cable tray
- Power supply to and from MCC

HEAD LOSS:

The grit trap shall have minimum head loss. The design shall be capable of removing grit of sp. Gr. 2.65 from raw screened sewage.

INSTALLATION AND OPERATING INSTRUCTIONS

Installation and operation shall be carried out in accordance with instructions provided by the manufacturer.

GUARANTEE

The manufacturer of the grit removal unit shall guarantee for one year operation or 18 months from the date of shipment that the equipment shall be free from defects in mechanical workmanship. The manufacturers shall replace any part of the equipment free of charge to the customer should the part prove to have manufacturing defect during the guarantee period

Datasheet: Vortex Grit trap and Washer

Vortex Grit Chamber			
Item	Description	Unit	Particulars
General			
1	Manufacturer		
2	Type		Vortex grit mechanism
3	Application		Removal of Grit
4	Duty		Continuous
5	Model No		
Process details			
1	Liquid to be handled		Raw Sewage
2	No. of units	Nos	1 working + 1 standby
3	Design flow for each Unit	MLD	
4	Grit design Load		60 lit/1000 m3 of sewage
5	Settled grit specific gravity		2.65
6	Removal rate for > 0.200 mm size	%	95
A	Grit chamber		

Vortex Grit Chamber

Item	Description	Unit	Particulars
1	Flow path	Degree	360
2	Upper chamber diameter	mm	3658
4	Lower chamber diameter	mm	1524
8	Total height of Vortex Grit Chamber	mm	4017
12	Material of Construction		
	Vortex Grit Chamber		RCC
	Vortex Agitator		SS316
	Wetted parts		SS316
	Hardware		SS316
13	Head loss across the grit mechanism	mm	< 6
B	Vortex Drive Motor		
1	Manufacturer		
2	No. of units	Nos.	
3	Type		
4	Voltage / frequency/phase		
5	Power	kW	
6	Rotary speed of output shaft	rpm	
7	Rotary speed of motor shaft	rpm	
8	Gear Ratio		
9	Efficiency	%	IE2
10	Degree of protection	IP	IP65
C	Grit Pump		
1	Manufacturer		
2	No. of units - Working	Nos.	1 Working + 1 standby
3	Type		Flooded Suction
4	Impeller blade type		Fully recessed
5	Suction end		DN 100
6	Discharge end		DN 80
7	Capacity of the pump	m ³ /h	

Vortex Grit Chamber			
Item	Description	Unit	Particulars
8	Delivery head	m	
9	Power	kW	
10	Motor RPM		
11	Efficiency of motor		IE2
12	Solids handling	mm	80
14	Voltage / frequency/phase		415 +/- 10% / 50 +/- 5%/ 3
15	Degree of protection	IP	IP55
Material			
1	Pump Casing		Ni Hard
2	Impeller		Ni Hard
3	Casing cover		Ni Hard
4	Shaft sealed		SS329
5	Shaft sleeve		SS316
6	Impeller type		Non-clogged Vortex recessed impeller
7	Motor housing		Cast Iron
C	Grit Washer		
1	Manufacturer		
2	No. of units	Nos.	1
3	Model no		
4	Type		Grit washing plant
5	Throughput capacity	m ³ /h	
6	Organic content at outlet of grit classifier	%	< 5 %
7	Dryness of the grit	%	≥ 80
12	Screw drive	kW	1.1
13	Stirrer drive	kW	0.55
14	Rotary speed of screw motor	rpm	1440
15	Rotary speed of stirrer motor	rpm	1420

Vortex Grit Chamber

Item	Description	Unit	Particulars
18	Voltage / frequency/phase		415 +/- 10% / 50 +/- 5%/ 3
19	Degree of protection	IP	IP 65
Materials			
1	Tank		SS 316
2	Screw		SS 316
3	Wetted Parts		SS 316

3.27 Fine Bubble tubular Membrane Diffusers

- (a) Provide a retrievable arrangement that provides complete mixing and aeration of basin contents.
- (b) Space diffusers evenly along each header.
- (c) Furnish all components necessary to provide a complete mixing and aeration system. Work shall include but not necessarily be limited to the following:
 - Flanged connections (SS 316) at the upstream side of each drop leg for connection to an isolation double flanged metal seated butterfly valve Gear operated
 - Stainless steel Drop legs (SS 316).
 - Slip joint connections to the air distribution header (SS 316).
 - Stainless steel Air distribution headers (SS 316).
 - Diffuser connectors (SS 316).
 - Tubular diffuser assemblies with silicone elastomer membranes with anti-microbial coating.
 - Anchored Supports (SS 316) as necessary
 - Gaskets.
 - Header joints (SS 316).
 - Bolts, nuts and washers (SS 316).
- (d) Provide two tubular diffusers at each header connection. Mount to a reinforced tee located on the bottom center line of the header. The reinforced Tee shall be adjustable to allow accurate alignment of the diffuser.

- (e) The Diffusers should be able to withstand high blower air and water temperature.

3.27.1 Diffuser Assembly

- Provide orifice flow control to ensure orifice head loss is at least 2.5 times the head loss in the air header at all air flow rates in the diffuser's design operating range.

3.27.2 Air Header and Droplegs

- a) Header and drop legs shall be constructed of 316 stainless steel
1. Bottom elevation of the air distribution header shall be same throughout the tank.
 2. Design connections between sections of the air distribution header to allow individual header sections to rotate independently of adjacent header sections.
 3. Header dimensions shall conform to dimensional tolerances specified in ASTM A554-89 and ASTM A530-87.
- (b) Furnish a drop leg from the air main connection at the top of the tank.
1. Provide a slip joint connection between the drop leg and distribution header.
 2. Support the drop leg from the connection at the air header.
- (c) Use factory welding only; field welding shall not be allowed.
1. Wire brush outside of each weld area.
 2. Remove all discoloration and deposits left by welding by pickling.
 3. Factory weld all diffuser connections. Stiffen both the diffuser connectors and the headers to withstand a moment of 56.5 N.m at the connector without permanent deformation.
- (d) Passivate all SS 316 assemblies and parts after fabrication by immersion in a pickling solution of 6 % nitric acid and 3% hydrofluoric acid at 60° C for minimum 15 minutes.
1. Neutralize by immersion in a tri-sodium phosphate rinse.
 2. Submit certificate that this has been done.

3.27.3 Supports and Anchors

- (a) Provide wall and floor mounting supports for all drop legs and air headers as necessary to anchor firmly on the wall and to the bottom of the tank and as specified herein shall be ss304.
- (b) Anchor supports to concrete walls and floors using stainless steel expansion bolts sized and spaced as required for the loads encountered.
- (c) Design supports to allow leveling the air header and diffuser assemblies to within specified tolerances.

- (d) Provide expansion couplings in the drop legs and air headers as necessary to accommodate anticipated thermal expansion and contraction.

1. Submit expansion coupling design as well as computations for sizing.

3.27.4 Spare Parts

Provide spare parts in the quantities indicated.

<u>Item</u>	<u>Quantity</u>		
Diffuser Assemblies	10%	Orifice	Inserts
10%			

3.27.5 Installation

(a) Install all components in accordance with the manufacturer's instructions and recommendations.

(b) Install all diffusers to within +/- 10 mm of a common horizontal plane.

3.27.6 Field testing

(a) All Fine bubble diffused aeration systems will be field tested.

(b) Testing will verify the installation as well as the diffuser's ability to deliver the specified air flow rates at the manufacturer's stated pressure loss. Testing will also verify the uniformity of mixing provided.

(c) Levelling tests:

1. Introduce clear water into each tank to the top of the diffuser elements.

2. Check the level of the diffusers to document that all element horizontal surfaces are within 10 mm of a common horizontal plane and at the specified elevation.

3.27.7 Leakage and distribution of flow tests:

(a) After successful completion of the leveling tests, raise the water level to 50mm above the manifold.

(b) Visually inspect the water surface to ensure that the airflow is uniformly distributed across the tank.

(c) Pressure test:

All of air supply pipe line shall be tested by pressure. Test pressure shall be at least 2 times higher than normal operation pressure.

- (d) If client is unsatisfied any test result, repeat the test until the installation is essentially void of air leaks.
- (e) Repair any leaks in the elements holders, elements, pipes or the like.

3.28 Disc Fine Bubble Aeration System

Design:

The Disc membrane diffuser shall be developed specifically for Releases 1~3mm fine bubble in the wastewater treatment plant. All materials have been selected for their ability to withstand the effects of the chemical, bio-chemical agents and 0~100°C used in wastewater tank. The diffuser can be placed in an evenly distributed grid system over the entire aeration tank bottom. Air can be easily through the air orifice and integrated non-return valve into the wastewater. The air orifice design to maintain the diffuser standard airflow input prevented the max. air enter to damage diffuser membrane. The membrane shall be secured onto the support dish with a constrict flex rim and retaining ring designed to increase the tension on the point of engagement as the diffuser air rate increases.

Construction:

The materials of construction for both support dish and membrane diaphragm are non-corrosive and UV resistant. The support dish shall be upward facing convex plastic (Glass filled reinforced Polypropylene) for working without any acid dosing requirements and integrated non-return valve designed for back-flow prevention while airflow is interrupted. The membrane diaphragm which covers the dish is made of high grade EPDM resistant to the usual sewage ingredients. The membrane shall be further fastened to the support dish with a U-type retaining ring without special tools for fastening or replacement the membrane.

Aeration system shall be retrievable grid, membrane disc fine bubble aeration system

The fine bubble aeration system will comprise: Stainless steel (SS316) droplegs and Headers.

- SS316 manifolds and air distributors.
- SS316 diffuser holders and retainer rings.
- Stainless steel supports and anchors
- Bolts, nuts and gaskets for aeration system flange connections.
- Air distributor purge systems.
- Membrane disc diffusers with integral O-ring gaskets and subplates.

The following design features will be incorporated in the fine bubble aeration system:

- Fabricated manifold with fixed threaded union joints for connection to the air

distributors.

- Manifold sections connected with fixed threaded union or flanged joints to prevent rotation or blow apart.
- Manifold, distributor connections and supports designed to resist thrust generated by expansion/contraction of the air distributors over a temperature range of 70°C
- Air distributors perpendicular to the air manifold.
- Fabricated distributors with single diffuser holders solvent welded to the crown of the air distributor for complete air seal and strength.
- Distributors and holders designed to resist a dead load of 90kg applied vertically to the outer edge of the diffuser holder.
- Air distributor sections joined with positive locking fixed threaded union or flange type joints for all submerged header joints to prevent blow apart and rotation. Bell and spigot, slip on or expansion type joints are not acceptable for submerged joints.
- Threaded union joints designed with spigot section connected to one end of the distribution header, a threaded socket section connected to the mating distribution header, an “O” ring gasket and a threaded screw on retainer ring. Solvent welding shall be done in the factory. · Air distributor support spacing at a maximum of 2400mm.
- All supports designed to allow for thermal expansion and contraction forces over a temperature range of 70°C and to minimize stress build up in the piping system
- Supports designed to be adjustable without removing the air distributor from the support.
- Diffuser assembly comprising: diffuser membrane with integral „O” ring, sub-plate, holder, retaining ring and air flow control orifice.
- Integral check valve incorporated into the membrane diffuser assembly
- PVC support plate incorporated to form an air plenum under the diffuser and support for the membrane when the air is off
- Retainer ring threads designed with minimum cross section of 3mm and to allow for one complete turn to engage threads.
- A liquid purge system to drain the entire submerged aeration piping system for each aeration grid including airlift purge eductor line and manual control valve.
- Circular membrane diffuser discs with integral O-ring will be manufactured of EPDM synthetic rubber compound with precision die formed slits.

Thermoplastic materials (i.e. plasticized PVC or polyurethane) are not acceptable.

- Carbon black will be added to the EPDM material for resistance to ultraviolet light.
- The maximum tensile stress on the diffuser will be limited to 10 psi (69 kPa) when operating at 2.4 SCFM/sq. ft. (43.9 Sm³ /h per m²) of material. Proportionately thicker material is to be furnished for larger diameter disc diffusers to limit the maximum tensile stress and to resist stretching.
- Supports and anchors, spare parts, installation method, field testing, leakage and flow distribution tests shall be same as per above clause nos. 8.18.3 to 8.18.7.

3.28.1 Rotary Air Blowers High Speed Turbo Blower

Turbo blowers are single-stage, high speed gearless air cooled radial turbo blowers designed to meet varying flow and pressure requirements in various processes. Blower is a modern frequency controlled, gearless driven machine along with lubricant-free aerodynamic bearings, guarantees an economical, reliable and maintenance-free operation.

Turbo Blowers employ the high precision machined cast impellers, hydrodynamic air foil bearings (air- lubricated), highly efficient Permanent Magnet motors and sensor-less Inverter drives, which eliminate the complicated gear trains or pulley & belt to provide considerable energy savings without much scheduled maintenance and with very low level of noise. Acoustically enclosed unit with noise not exceeding 80dB at distance of 1 meter from periphery of the Blower unit.

A. Permanent Magnet (PM) Motor

The Blower shall be driven with Permanent Magnet motor. The rotor of the motor has built-in permanent magnet, the power is required only to rotate the shaft. With the rotor being specifically designed to rotate at high speed, the size of the rotor is small. Rotor shall be of titanium & Inconel alloy is lighter in weight. Because of these two factors the twisting torque is comparatively very small. The high electric grade material & high rotating speed produce less heat & hence cooling energy required is comparatively lower. PM Motor shall be synchronous motor, which has no slip & hence power factor shall be high. The efficiency is consistently maintained more than 95% from full load to partial load conditions. The PM motor is entirely air cooled and capable of a wide range of operating speed. Integrated variable speed drive ensuring starting current of the PMS motor to be less than 10% of the full load current. Current (Ampere) based active control should be used to enable high rise-to- surge.

B. Frequency Inverter

The frequency inverter, DC choke and RFI filter are standard and integrated in the Turbo Blower package. Other types of harmonic filters shall be supplied as per site conditions.

C. Air Foil Bearings

Air bearings shall not come in any physical contacts when shaft is in motion, which doesn't require any lubricant. The Air Foil bearings are of aerodynamic bearings. At standstill (idle mode) the shaft sits on a foil tightened by springs. During operation, due to shaft rotation a cushion of air is generated between the foil and shaft which maintains the shaft in suspension without any need for an external source of compressed air. This increases energy efficiency. The bearings are not lubricated and the system is absolutely oil-free.

D. Impeller & Casing

The impeller is directly mounted on the shaft of the motor. The impeller is made up of machined cast stainless steel Gr. SUS630 having high structural strength /Aluminum alloy material. The profile is backward leaning to provide larger flow capacity, wide operating flow range & high efficiency. The impeller alone is first dynamically balanced & again dynamically balanced together after mounting on the shaft. The spiral casing and the blower bellmouth are made of cast aluminum, while the discharge connection is made from Stainless steel.

E. HMI Display

HMI display indicates the Discharge Pressure, Inlet Temperature, Discharge Temperature, Flow Rate, Power consumed, Speed and the across the inlet filters. It shall also displays the performance curve with the actual operating point in it. HMI Touch Screen Graphical Display with on-line performance curve showing Pressure v/s Flow, Operating Point.

HMI should provide on-line display of instantaneous values & trending of following parameters: Pressure Drop across Suction Filters, Suction Air Temperature, Discharge Air Temperature, Discharge Air Pressure, Input Power & Dissolved Oxygen; RPM, Run Hours with facility for MODBUS connectivity to SCADA to display these parameters. Facility for remote control of pressure, flow, power, D.O. parameters shall also be provided. Integrated Mass Flow Meter for instantaneous on- line flow measurement with +/- 1% accuracy.

The following operation mode can be selected from HMI.

- a. Constant Current
- b. Constant Pressure
- c. Constant Volumetric Flow
- d. Constant Oxygen (Dissolved Oxygen Control)

3.28.2 Acoustical Enclosure

- (a) Provide a factory assembled acoustical enclosure around the entire blower. Disassemble the enclosure as necessary for shipment. Provide either removable or hinged doors for access to all blower parts and components for servicing and maintenance. Size access panels to allow easy access by a single operator. Hinges, fasteners and appurtenances shall be stainless steel. Provide clear, transparent Lexan or plastic windows to visually observe gauges.
- (b) Mount an auxiliary exhaust fan and thermostat on the acoustical enclosure to provide air circulation after blower shutdown or when the temperature inside the enclosure exceeds 40⁰C.
- (c) The free field A-weighted sound pressure level measured in four quadrants at 1 metre distance from the enclosure shall average 80 dBA, or less. Measure with a Type 1 instrument suited for checking compliance with Environmental and Occupational Noise Rating Recommendations.

All the accessories shall be complied as per specification mentioned in Centrifugal single stage blower.

3.29 Blower

- a) The blower shall be of single-stage centrifugal, and shall be designed integral type. The flow rate should be adjustable by controlling the rotation speed with frequency converter or inlet vane or discharge guide vane according to the inlet temperature and differential pressure to ensure the optimal power consumption. Regulation should be possible in the range of 100-50% of the specified design flows at all project design temperatures and at design pressures.
- b) The regulation should be fully automated and contain a program for continuous optimization of blower efficiency with respect to changes in inlet temperature, differential pressure and required flow.

- c) The pressure grade of the blower casing shall be minimum PN10. The casing shall be cast and bolted together and allow the impeller to be removed with the casing in situ.
- d) The impeller shall be open radial flow type (with backward leaning) and made of aluminium alloy, all surface of the vanes should be finish machining.
- e) High frequency, variable rotation speed and air-cooling motor should be adopted. The impeller and cooling fan should be directly connected with the motor shaft.
- f) The motor shall be equipped with magnetic bearings (If required), which should have the characteristic of magnetic suspension and continuous variable rotation speed. The motor should be installed at a frame with flexible fastening devices.
- g) Two radial magnetic bearings and one axial magnetic bearing shall be orientated accurately via the active-bearing controller controlling the rotor. The active bearing controller shall be powered by one DC and one 3 phase AC input. The service life of all bearings should be more than 100000 hours.
- h) Appropriate cooling arrangement shall be provided at the blower discharge line so as to bring down the outlet air temperature within tolerable limits, so as to safeguard the life of fine bubble diffusers and satisfactory performance of the same. This cooling arrangement is mandatory with all types of Blowers.
- i) The local control cabinet should be equipped with display screen and keypad unit. The running state of the blower should be able to monitor at real time. The displayed data at least include the following:
- Actual flow (%)
 - Running time (hour)
 - Running time (day)
 - MWh counter
 - Differential pressure
 - Reference flow (%)
 - Model of the blower
 - Power frequency of the motor (Hz)
 - Current (A)
 - Transition temperature
 - Motor temperature
- j) When operating, if the control system finds fault, the blower will give an alarm

automatically or stop and the fault code will be displayed at the control cabinet. All signals can be transferred to the control centre of the plant.

k) The blower should have the following protection functions (but not limited to):

- Over voltage of the main power supply
- Under voltage of the main power supply
- I-phase fault
- Over voltage/Under voltage of the auxiliary power supply
- Inlet and outlet air pipe blocking
- Air temperature is higher than the specified limited temperature
- Cooling air temperature is high than the specified limited temperature

Accessories

a) Inlet filter and silencer :

Each blower shall be provided with an inlet filter/silencer mounted directly on the inlet of the Blower via a flexible connection. Such mounting is for the purpose of reducing pressure drop across the inlet appurtenances and of minimizing noise from pipes. Filter/silencer housing shall consist of stainless steel plate and acoustical sound-deadening material on the inside.

Filters shall be removable through easily accessible doors and have very high removal efficiency and shall be sized for maximum face of velocity of 2m/sec at peak air flow.

b) Discharge Flex Connector :

Each blower shall be provided with discharge expansion Bellows joint of SS316. The expansion joint shall alleviate stress caused by thermal expansion and contraction in the piping system. The expansion joints shall be capable of withstanding the pressure under all operating conditions and shall be rated for temperatures up to 160°C.

c) Discharge Cone Diffuser Silencer :

Each blower shall be supplied with a combined discharge cone diffuser-silencer to increase the discharge from the blower outlet to the discharge pipe, thus reducing the air velocity to max. 20 m/sec. The length of the discharge cone shall be aerodynamically designed in order to recover dynamic pressure head and minimize discharge turbulence. The discharge cone shall be constructed of stainless steel plate and acoustical sound-deadening material on the inside, with flanges, and be equipped with a stud for a possible measuring device.

d) Blow-off (Bypass) Valve :

Each blower shall be provided with a blow-off valve to allow unloaded start-up and unloaded stop. The valve operator shall be motorized, equipped with open/closed limit switches, and shall be suitable for air service at 200°C operating temperature. Controls for the valve shall be mounted in each local blower control cabinet with indicating light.

e) Blow-off silencer :

Blow-off silencer shall be provided for each blower and mounted on the discharge by-pass line. The blow-off valve silencer shall be constructed of stainless steel and contain sound absorption material encased in an outer shell. The silencer shall have one sleeve inlet connection for mounting onto the end of the bypass line.

f) Discharge check valve (Back-flow Barrier) :

Each blower shall be provided with one discharge check valve flange ends located in the discharge side pipe work, spring loaded butterfly design for mounting between flanges according BS EN 1092-1/BS: 4504. The pressure losses of the fully open valve must not exceed 1.0 kPa. The valves shall be rated for temperatures up to 160°C.

g) Noise Protection Cover:

The blower and motor should be covered with one Acoustic cover, which should be equipped with electric cooling ventilator.

h) Base plate and anchor bolts:

Each blower unit shall be furnished with a frame of adequate size to support the blower, motor, magnetic bearing controller frequency converter, control cabinet and other accessories. The base plate shall be constructed of fabricated steel, provided with lifting lugs and of sufficient rigidity to permit lifting by a fork-lift, with all equipment mounted, without distortion or other damage to the base plate or to components parts of the machinery.

Material of Construction

Sr.N	Description	Material of Construction
a	Blower Housing & Gear Box	CI IS 210 Gr. FG 250
b	Impeller	Aluminium alloy
c	Shaft	Carbon Steel (High Tensile) EN 19
d	Base plate	Profiled steel
e	Inlet filter, silencer casing	Galvanised Steel
f	Acoustic enclosure	Al-Zn coated steel, insulated with glass
g	Blow-off silencer and motor	Galavanised steel

i	Inlet cone extension	Galavanised steel
j	Coupling	Alloy Steel
k	All connecting accessories and	AISI 316

Control

The control system of the blower should be well connected with the control system of the whole plant. All the real time monitor and protection function shall connect with the control software; the remote control shall be carried out with 4-20 mA or network.

Local control panel and control cabinet shall be combined, that include display screen and keypad, main switch and lock stop push button. The blower operation shall be controlled by the main running switch and keypad.

Performance Guarantee:

The Performance of the compressor shall be guaranteed according to the requested project design values subject allowed tolerances on Flow & Pressure: +/- 0%, and Power: 2%.

Compressor or any portion thereof is liable for rejection, if it fails to give any of the guaranteed performance parameters.

3.30 Submersible Mixer

- (a) The submersible mixer shall be installed in the specified plant areas, and they shall be capable of providing a velocity gradient in the range of 500 to 1000 mm/sec.
- (b) The mixer shall have a self-cleaning propeller optimized for effective mixing and vibration-free running, and required power shall be at least 10Watt/m³ of tank volume.
- (c) The mixer shall be driven by a submersible high efficiency 3 phase motors IP68 Class H Motor shaft and rotor shall be dynamically balanced.
- (d) Bearings shall be lubricated-for-life with a calculated life of more than 100,000 operating hours.
- (e) The mixers shall have the flexibility to be located at different depths and thereby avoiding dead zones.
- (f) The mixer shall be provided with the following :
 1. Lifting frame with a winch which can be dismantled, free standing with adjustable boom length.
 2. Mounting socket for free standing hoist suitable for wall mounting.
 3. Guide for floor fixing components and support brackets for wall mounting.

4. Stainless steel (SS316) rope for raising and lowering the mixer.
5. Rope block for holding the stainless steel 316 rope where the lighting frame is used in different locations.
6. Support rope for reliable support and guidance of power supply cable.
7. Support clamps and hooks to support the power supply cable in such a manner that it is not under strain.
8. The propeller, and motor housing, guide pipe, support brackets and all fasteners shall all be of SS 316. The propeller shaft shall be of SS 431. The Lifting winch & Davit shall be of Stainless Steel 316 construction.

3.30.1 Acoustical Enclosure

- (a) Provide a factory assembled acoustical enclosure around the entire blower. Disassemble the enclosure as necessary for shipment. Provide either removable or hinged doors for access to all blower parts and components for servicing and maintenance. Size access panels to allow easy access by a single operator. Hinges, fasteners and appurtenances shall be stainless steel.
- (b) Provide clear, transparent Lexan or plastic windows to visually observe gauges and lever arms.
- (c) Mount an auxiliary exhaust fan and thermostat on the acoustical enclosure to provide air circulation after blower shutdown or when the temperature inside the enclosure exceeds 40⁰C
- (d) The free field A-weighted sound pressure level measured in four quadrants at 1 metre distance from the enclosure shall average 85 dBA, or less. Measure with a Type 1 instrument suited for checking compliance with Environmental and Occupational Noise Rating Recommendations.

3.31 Gravity Thickeners

Circular (radial), fixed bridge, central turn table type or peripheral drive type picket fence, collecting effectively with proper circumferential speed, a clarifier shall be provided. The Thickener shall be rugged and robust in design and shall be provided with high capacity drive head and induction motor having high torque rating, centrally or peripherally located, with positive sludge raking by means of one or more raking arms. Both the raking arms should have scraper blades fitted at the bottom, so that the sludge from scraper blades is pushed to the sump on every rotation.

- (a) The circular reinforced concrete thickeners tapering at bottom shall be provided for thickening process
- (b) Design shall be such that the sludge can become compacted and can be extracted from the bottom. Interstitial liquid flows through peripheral weir at top. Tanks shall be deep enough to allow the sludge to settle. At least 50 cm freeboard shall be provided. Provision shall be made to remove the sludge from top if there is a serious risk. Also temporary potable pumping arrangement from top of the sludge thickener, facility shall be considered.
- (c) Provision shall be made for collection of thickened sludge and pumping it to Centrifuge. A full diameter bridge with walkway with central drive shall be provided with: central platform for the installation of the scrapers and their drives and for the local control panel; a radial scraper system with bottom scraper blades, suspended on the bridge.
- (d) The thickeners shall have a full diameter fixed bridge complete with 1200mm walkway for personnel access to the centre, access stairs to ground level and hand railing, a motor driven sludge scraper complete with all necessary controls, delivery pipe work, a stilling well and overflow steel weir plates. Hand railing MS Chequered plate walkways of minimum 6mm thick, access steps etc shall be galvanized. Handrails shall be of tubular construction and made of 50NB pipes heavy duty class.
- (e) The scraping gear shall be supported from the tank base and from a fixed bridge carrying the central electrical drive for the rotating gear. The equipment including driving motor, gears, shafting and scrapers shall be designed for continuous operation and sized for the most arduous operating condition including starting from rest with an accumulation of sludge in the thickeners.
- (f) The electric motor, gearbox etc., shall be provided with a sunshade. (Canopy)
- (g) The fixed bridge, hand railing, access steps and the feed well shall be galvanized steel. The main drive shall be cast Iron construction and shall be enclosed in a dustproof enclosure with oil bath lubrication. All underwater hardware shall be of SS316.
- (h) Suitable overload protection for the drive shall be provided to ensure that the sludge shall not overload the equipment and emergency stop pushbutton shall be provided.
- (i) The scrapers shall be fitted with rotation monitors and over torque protection to alarm in the event of a failure.

1. Corrosion allowance of 2 mm shall be taken in the structural sections of

scraper arm, bridge etc.

2. Structural design calculations shall be submitted for all structures including scraper arm, bridge etc. and also the calculation for drive head selection including the Torque Rating.
- (j) V-notch weir in SS304 construction of size minimum 4mm thick and 200 mm wide shall be provided along the launders for uniform draw-off of the overflow. The weir plate shall be fixed to the launder by means SS316 grade clamping plates and fasteners.
- The hydraulic equipment will consists of the DI inlet pipe (runs along the bridge) to the central feed well of the thickener; sludge draw-off pipe with an manual & Motorized Knife Gate valve (in SS CF8M material of construction) for intermittent operation according to an adjustable timer; a drain pipe with manually operated gate valve for the complete emptying of the unit; a discharge pipe/channel from the peripheral collecting channel to the main channel leading to the Supernatant sump.
- (k) The sludge thickener mechanism shall be generally in MS galvanized construction, suitable for installation in a circular RCC tank and shall include the following
- a. Mechanism support beam spanning the diameter of the tank.
 - b. Walkway and handrail from the edge to the centre of the tank.
 - c. Drive mechanism with internal gear type.
 - d. Reduction gear box.
 - e. Chain and sprocket with guard.
 - f. Central shaft with scraper arm and picket fence.
 - g. Skimmer Scum Baffle and Scum trough.
 - h. Overflow weir:
 - i. Vertical pickets.
 - j. Torque Indicating Device.
 - k. Overload Alarm protection.
 - l. Auto lifting device. - With minimum 300 mm lift.

3.32 Ultra Violet Disinfection System

Objective To disinfect water by using Ultra violate light

General description

An In Line UV system comprise of a unit's controller and a UV chamber that contains UV lamps, lamp's intensity sensor/s and water transmission to UV sensor, suitable to deliver UV dose to the water

Manufacturer Experience

Minimum 5 years' experience in the manufacture of closed pipe ultraviolet disinfection systems of similar design to that proposed for this project.

Necessary information to provide in proposal

The manufacturer will provide the following information as part of its proposal:

- Calculations of UV Dose used for system sizing and guarantees. System sizing to be solely based on EPA UVDGM validation protocol Nov 2006 and validated RED values.
- The UV system shall provide the minimum dose needed for 3 log inactivation of Cryptosporidium (or UVDGM table 1.4 of specific microorganism log removal required for inactivation) according to LT2ESWTR, under peak flow conditions with one reactor out of service and with allowance for reduced lamp output at end of lamp life and under fouled conditions.
- Sleeve manufacturer certification approving that the absorption of the protecting quartz sleeve at 253.7 nanometers shall not exceed 2% per 1 mm. thickness.

Guarantee

Manufacturer to provide a performance guarantee for the lifetime of the system of the bacteriological performance requirements with an effluent quality entering the UV unit that is equal to or better than the specification requirements.

Ultraviolet Disinfection Chamber and UV Lamps

1. The disinfection chamber will be made from S S 316, with not more than 2 lamps per bank of lamps, in case of multiple banks of lamps – the banks of lamps need to be position one after the other in 90deg to each other.

2. Medium Pressure lamps, enclosed within a quartz sleeve that is no less than 5 mm thick, and that is situated perpendicular to the flow path. If multiple lamps are used, each subsequent lamp shall be placed perpendicular to the previous lamp.
3. Lamps shall have the capability to be removed from either side of the chamber without having to stop the UV system and drain the water from the disinfection chamber.
4. Only Medium pressure High intensity UV arc tubes shall be provided for disinfection.
5. Each lamp shall operate between 40%-100% power.
6. Germicidal UV output from the lamps shall not be affected by temperature.
7. Each UV system shall have a UV intensity sensor per lamp within the UV system. UV intensity sensor that views and monitors the lamp power directly through the air with no other medium in between. Each UV intensity sensor will be connected to the system's controller reporting real time intensity of each lamp for assuring the delivery of the contacted dose.
8. Each UV system shall include at least one UVT sensor per system that is integrated within the system chamber. The UVT sensor will be connected to the system controller inline and provide the UVT for the validated dose pacing algorithm.
9. The sensors shall be non-immersed within the disinfection chamber and will have no contact with water or other medium other than air, enabling disassembly of the sensor without stopping or draining the reactor.

Power/ Control Module/Monitoring

1. Each power supply (ballast) shall independently operate one lamp that is capable of 40-100 percent adjustability.
2. All power supply, UV intensity, UVT analyzer and flow meters will be controlled by a single controller with a touch screen which will capable of display and control of the following parameters:
 - a. Flow rate
 - b. UV Dose (in mJ/cm²)
 - c. Lamp life and efficiency for each individual lamp

- d. Power output of the Power Supply (ballast)
 - e. Specific screens for calibrating UVT and UV intensity sensors.
 - f. History and Event log-in capabilities and display screens
3. Each Controller shall contain Alarm capabilities, both display and remote. Alarms will report on low dose, lamp efficiency, temperature, UVT and flow conditions.
 4. Each Control Module shall have a built-in automated programmed capability to operate in Dose mode.
 5. Each controller will be capable of controlling external outputs, including dry outputs up to four flow valves.
 6. Each Controller will be capable of connecting to remote PC operation software provided by the manufacturer.
 7. Each Controller shall be able to self-adjust within the operation envelope as defined in the validation protocol according to USEPA UVDGM protocols.
 8. The software shall have built in EPA reporting capabilities for standard operation and off spec events.
 9. Controller shall have built in capabilities to tie into existing SCADA via MODBUS communication protocols via RS485.

Dosage

1. The UV system shall provide the minimum Validated dose needed for 3 log inactivation of Cryptosporidium (or UVDGM table 1.4 of specific microorganism log removal required for inactivation) according to LT2ESWTR under peak flow conditions. The basis for evaluating the UV dose and system design criteria for the UV system shall be in accordance to the manufacturer's certification based on bio-dosimetric tests.
2. The UV Dose will be sized according to using an end of lamp life factor of a maximum of 0.8.
3. The UV dose shall be capable of adjustment by a medium pressure lamp and ballast integrated system that is capable of adjusting the lamp intensity from 40-100 percent.

Spare Parts

1. Spare Parts shall be supplied with the equipment as follows.

a. 1 MP UV lamp per 1 lamp in installed

b. 1 set of gaskets per lamp

3.33 Dewatering Screw Press

Principle of Operation : Flocculated sludge is pumped into a cylindrical screen basket wherein an auger slowly rotates. The diameter of the auger's shaft increases towards the end of the basket and the gap between its flights decreases.

The volume between basket, shaft and flights continuously decreases, and the pressure thus increases, as the sludge is moved through the basket. Sludge water is pressed through the basket's screen. The auger pushes the increasingly thicker sludge towards the annular clearance, defined by a circular opening and an adjustable discharge cone therein.

The cone is pressed against the opening by pneumatic cylinders, thus maintaining a defined sludge pressure at the discharge end. Scrapers on the screw shaft permanently clean the filter basket from the inside. A static/dynamic spray bar shall be backwashing the basket periodically.

Constructional details, MOC, Flow: Screw press must be provided with a conical auger slowly rotating in a cylindrical 3-piece filter basket. The flocculated sludge should be fed into the inlet housing where a pressure transmitter measures the sludge feed pressure. In the first filter section a large open filtration area must ensure the rapid removal of free water.

While the sludge is conveyed to the second filter section the flocs shall get compressed against the filter basket as cake thickness narrows down continuously. In the third filter section the cake thickness shall be reduced to its minimum while an individual dehydration force will be applied on the sludge cake by an adjustable pneumatic cone.

The outside of the filter basket shall be periodically cleaned with water by a spray bar while the filters inner surface is continuously cleaned by a wiper element fixed to the auger helix.

The casing and filter unit of the screw press shall be designed at an angle. Pre-dewatering of the sludge, shall be supported by gravity. A stable sludge cake quickly develops between the flight segments so that the start-up procedure requires less time and reduces demands on

controls compared to horizontally installed machines. The inclined installation combined with integrated, height-adjustable machine feet shall provide enough space below the sludge discharge to connect a screw conveyor without the need to place the machine on an additional elevation. All components in contact with the medium shall be stainless steel 304L or 316L (except fittings, drives and bearings), and acid-treated in a pickling bath with maximum permissible hydrogen sulphide content in the air: 6 ppm

Components and Accessories: The entire machine should include below minimum components but not less than: **Polymer injection device - For continuous mixing of coagulants and sludge, comprising:**

Polymer injection ring with integrated distribution channel and 4 injection nozzles. Double sealed cover to provide easy access to distribution channel and nozzles. Weight loaded mixing valve with inspection opening. One-piece blockage-free design, adjustable mixing energy via lever and weight.

- **Self-adjusting scrapers:**

Self-adjusting scrapers on the screw shaft shall permanently and reliably clean the inner filter surface with every rotation of the screw. Free water can thus run off unhindered.

As a result, dewatering efficiency increases and flocculant consumption is reduced. Scraper shall be minimum 2.5mm thick.

- **Filter basket:**

Filter shall be in the form of Wedge wire basket as it does not require any support frames on the outside which would reduce the open filter surface and impair filter cleaning.

Spacing in filter shall be variable from 0.4mm to 0.25mm

Filtration area shall be axially divided into 3 cylindrical zones;

Only the upper half of the basket needs to be lifted off for maintenance with this option. The screw shaft and the lower half of the screen basket remain in their original position, or can be removed from the screw shaft by means of a special mechanism but remain inside the filtrate chamber of the screw press during maintenance.

This saves time, reduces space requirements and the need for using lifting devices for maintenance.

The outside of the filter shall be cleaned at intervals by rotating the filter basket along a stationary/dynamic spray nozzle bar. Spray bar shall be mounted in horizontal position to minimize the clogging of the nozzles caused by filtrate water.

Light and large inspection openings shall be provided for quick and easy access to the complete outside screen surface as well as to the sludge discharge and the inside of the screen in the inlet area.

- **Ventilation sockets** for connection to a customer supplied ventilation system. Two sockets allow for ventilation or exhaustion of the machine interior to prevent explosive atmospheres or odours. **(Optional for smaller flows)**
- **Supercharge reactor shall be provided** for optimal flocs formation downstream the polymer injection and mixing unit. Horizontal reactor shaped to provide defined turbulence and pressurized feeding of the screw press. Reactor shall be provided with height adjustable support legs.
- **Compressor** : Piston type, Air-cooled, oil-lubricated compressor shall be provided to supply pressurised air to the pressure cone system.
- **Performance criterion** : Inlet consistency – 3-5% Outlet consistency – 23-26%
- **Motor information** : IE4, IP 65, Squirrel cage induction motor, 0.09 kW max for cleaning system motor, 0.55 kW to 3 kW for screw drive motor.

Control panel specifications : parallel to auto start by level control.

Control unit to display: Operating hours, operating and fault signals, run times, etc.

Basic controls Screw press:

- Control of Screw Press drive
- Control of solenoid valve(s) for flushing system
- Control of thin sludge pump (only signals)
- Control of coagulant agent pump (only signals)
- Evaluation of pressure sensor press (incl. Primary pressure control)
- Screen basket position detection

Control panel make	Rittal or Equivalent
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Nominal voltage	415 V \pm 10%
Nominal frequency	50 Hz \pm 5%
Network configuration	TN-C-S/Ethernet
Neutral conductor	can be applied
Protection grade	IP 54
Automation	Schneider/ Equivalent
Operation	Schneider/ Equivalent
Material	MS/ CRCA
Paint	RAL 7035/Equivalent

Datasheet - Screw press	
Screw press	
Inclination	0
Cake discharge height clearance	
Sludge feed pressure	0 – 300 mbar
Pressure sensor	transducer
Voltage	24 V
Output signal	4 – 20 mA
Protection class	IP 68
Explosion class	none
Scraper thickness	
Scraper self-adjusting capability	
Filter diameter	mm
Filter basket segments	3
Filter bar spacing	Variable spacing from 0.4mm to 0.25mm shall be provided
Minimal filter thickness	3mm
Filtration area in feed zone	
Open filtration area	
Polymer injection and mixing device	

Nominal width	
Fitting length	
Total length	
Polymer connection	
Housing	
Movable parts	AISI 420
Weights	AISI 304
Motor data screw	
Direct gear drive with 3-PTC thermocouples, permanent-magnet motor, start type: VFD/DOL The screw drive shall exceeds the current energy efficiency standards of electric motors. The maximized electrical efficiency allows for a wider speed range so that the screen can be operated with higher solids throughputs or a maximized dewatering degree.	
Efficiency class	IE4
Performance	kW
Nominal current	A
Voltage	U = 400 - 460 V
Frequency	f = 10 - 70 Hz
Rotary speed of output shaft	n = 0,16 - 1,12 min-1
Protection class	66
Isolation class	F
Ex protection class	without Ex-protection
Motor data cleaning system	
Direct gear drive Asynchronous motor	
Performance	kW
Nominal current	A
Voltage	V
Frequency	50 Hz
Rotary speed output shaft	min-1
Protection class	IP66
Explosion class	without Ex-protection
Material of Construction	
All components in contact with medium	316L

Screw, filter baskets, flushing system, housing, frame Covers	
Sealings, press cone	ABS/PMMA RAL 70,EPDM, NBR, PU, POM, PA
Noise level	66 dB(A)
Supercharge reactor	
Volume	1
Height adjustment range	185 - 200 mm
Material	304L/316L
Inlet flange	DN
Outlet flange	DN
Diameter	mm
Reactor length	mm
Weight empty	kg

The centrifuge shall comprise a conical cylindrical bowl and scroll feed horizontally mounted in bearings on a frame. The centrifuge bowl and scroll support frame shall be mounted on a fabricated steel sub-frame.

The bowl and scroll shall be made from stainless steel AISI 316 material. The leading faces of the scroll shall be protected against abrasive wear by the application of a suitable hard-coated material. (Tungsten carbide).

The whole rotating assembly shall be enclosed by a Stainless steel (AISI316) fabricated casing incorporating a Centrate discharge hopper and outlet pipe, and a rectangular solids hopper which shall discharge the dewatered sludge into the disposal system.

The rotor shall consist of a solid bowl which is conical-cylindrical in shape and which rotates about a central shaft. An inner scroll shall be provided to convey separated sludge from the periphery of the cylindrical bowl to the beach at the conical end of the rotor.

The main scroll bearings shall be arranged for lubrication by an external lubrication system. Wherever practicable greasing nipples shall be arranged together as a battery. The complete rotating assembly shall be dynamically balanced and test certificates provided.

Sludge shall be fed into one end of the rotor through a centrally positioned feed tube and dispersed to the bowl through an inlet chamber.

The bowl shall be provided with an adjustable 360⁰ peripheral weir at its cylindrical end to control the depth of the Centrate in the rotor.

The fixed outlet castings of the rotor shall be designed to collect the centrate and dewatered sludge from the rotor. Baffles within the casing shall direct the separate phases to the relevant discharge points and prevent cross-contamination.

The centrifuge shall be mounted on heavy-duty vibration isolators, located between the machine and the supporting steelwork or foundations, to damp vibrations and prevent vibration transmission. Two axis vibration monitors shall be provided to stop the centrifuge automatically when excessive vibration is detected.

Flexible connections shall be provided on the sludge fed system and the Centrate system at the centrifuge. The dewatered sludge discharge system shall incorporate flexible chutes.

(i) Variable Speed Drive

A variable speed drive shall be provided to accelerate the rotor to operational speed and maintain that speed during the centrifuge's duty period. The bowl drive shall be electric or hydraulic and shall be coupled to the drive shaft by a multiple „V“ notch belt drive.

(ii) Differential Scroll Drive

The scroll drive shall be provided with a separate drive mechanism to control its rotation in the same direction but at a different speed to the outer bowl. The differential speed shall be adjustable.

The drive shall be linked to the main bowl drive by an epicyclic gearbox. The differential speed of the scroll shall be automatically and manually adjustable so that the moisture content of the dewatered sludge can be controlled as required.

For safe operation, contractor shall provide control panel showing proper Sequence of operation with interlocking.

Chutes and interconnecting piping shall be provided with flexible joint (minimum 10 mm flexible in all direction) to avoid vibration.

3.34.1 Conveyor System

(a) For the disposal of sludge a common motor driven endless belt conveyor shall be provided. The conveyor shall be designed in accordance with IS 11592 or equivalent. The conveyor and chutes shall be suitable for handling occasional heavy objects which will cause shock loads

- (b) The construction of the frame and support shall be robust and torque resistant. Belt conveyor shall be of 20 deg. Trough type complete with drive assembly structures, idlers, pulleys and belt cleaners. Idlers and pulley shall be provided with anti-friction bearings.
- (c) The belt material shall be two ply nylon or equivalent with minimum 3 mm neoprene covering on carrying side. Splicing shall be employed to make the belt endless. The belt shall operate over three roll twenty degree, troughing idlers. The idlers shall rotate on precision type, deep groove, single row ball bearing with built-in close fitting triple labyrinth grease seal. The ends of the outer shell shall be counter bored and a full length centre tube journalled concentricity. The outer shell, centre tube and precision die formed steel ends shall be brazed into an integral unit to provide concentricity. The ends of the centre tube shall be bored concentrically with each other after roll assembly to provide correct bearing alignment and to provide prestressing of boring. The centre tube shall be grease fit after assembly. Troughing idlers shall have means of adjustment or ensuring belt tracking. On the return run the belt shall operate over flat roll idlers having bearing, shaft and lubrication arrangements as above for carrying idlers. Spacing of idlers shall be of 1200 mm on carrying run and 2400 mm on return run.
- (d) The head and tail pulleys shall be manufactured from welded steel/any alloy steel and shall be provided with rubber lagging. Lagging for drive pulleys shall have herringbone grooving. Pulleys shall be equipped with taper lock bushings. The tail pulley shall incorporate a screw rake for adjusting belt tension. Head and tail pulleys shall be adequately guarded.
- (e) Shafting for pulleys shall be of heat treated carbon steel. They shall be forged, ground and polished to obtain close diameter tolerances. The head shaft shall be provided with roller bearing pillow blocks.
- (f) The belt conveyor shall be driven by a squirrel cage, TEFC motor. A V-belt drive arrangement shall be provided between the motor and a helical speed reducer, the latter shall be mounted on the end of the head shaft. The driving pulley shaft shall have back stops to prevent backward movement of the belt.
- (g) The conveyor shall be supported on appropriate channel sections with 14 gauge steel deck plate between the two runs of the belt and the necessary supports to the floor. The floor supports shall be made out of steel plates having minimum 6

mm thickness. The conveyor shall be protected from weather by a „dog box“ type canopy.

- (h) An adjustable belt scraper shall be provided on the hopper end of the conveyor belt. The scraper and attachments shall be of fibre reinforced plastic.
- (i) Sludge cake discharge Hoppers shall be provided to transfer the sludge cake from the Centrifuge to the troughed belt conveyor and from the conveyor discharge to skip. The latter chute shall extend beneath the belt scraper and shall allow access for maintenance of the belt scraper. Chutes shall be designed to minimize the accumulation of rags and stringy materials.

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

3.35 Progressing -Cavity Pumps

- (a) Pumps shall be of the type in which a pumping action is generated by a helical rotating eccentrically within a resilient stator in the form of a double internal helix. The eccentric motion of the rotor shall maintain a constant seal across the stator as it travels through the pump to give a uniform positive displacement.
- (b) Pumps shall be arranged generally with a single shaft seal at the suction end. Mechanical seals shall be used. If a flexible shaft is used to accommodate the eccentric motion, a corrosion resistant shroud shall be fitted to prevent fiber build-up on the shaft. Enlarged inspection access holes shall be fitted to the suction chambers of all pumps for periodic removal of accumulated debris. The shaft bearing shall be positively isolated from the fluid being pumped.
- (c) The rotor material shall be selected for corrosion and abrasion resistance for the fluid being pumped, and for prolonged service life. Hard chrome or other approved coatings shall be not less than 250 micron thickness and shall be diffused in to the base material. The rotor shall Generally be single-stage and shall incorporate not less than 3600 of twist, but for high-head applications, it may be necessary to use more than a single-stage. The stator shall be of a resilient material selected for chemical and abrasion resistance for the fluid being pumped. Pump speed shall suit the application, where variable delivery output is needed; the pump shall be provided with a variable-speed drive. The size and speed range of the pump shall ensure that the highest expected duty point shall lie within the available speed range.
- (d) Pumps shall normally be driven by a fixed-speed electric motor through reduction

gearing and the combined drive shall be continuously rated. Pump and motor shall preferably be mounted in-line on a common base plate. Alternatively, the drive motor may be top-mounted above the pump to minimize floor area, and shall be connected by external V-belts and pulleys. V-belt drives shall have full guards of the type that allow the belts observed without removal of the guard. Facilities shall be provided for ready adjustment of belt tension.

- (e) Coupling guards shall be provided, which shall be rigid, securely fixed, and designed so that removal is not necessary during normal operation, routine maintenance and routine inspections.
- (f) All motor enclosures shall be provided with ingress protection to IP55. Motor anti- condensation heaters shall be provided and shall be suitable for use on a 220V single-phase, 50Hz supply. All bearing shall have a B10 design life of not less than 40,000 running hours and shall be designed for loading 20% in excess of calculated maximum loading.
- (g) Pumps shall be fitted with individual dry-running protection to initiate pump trip. Dry-running protection by „under-current“ monitoring or „pipeline-intrusive“ device shall not be used.

Material of Construction

S. No.	Component	Material
1	Pump Housing	CI IS210 Grade 260
2	Rotor & Coupling & Connecting Rod	SS AISI 316(HCP) 250 Microns
3	Shaft	SS AISI 410(HCP) 250 Microns
4	Stator	Nitrite black
5	Type of drive	V belt & Pulleys
6	Base plate	MS fabricated
7	Mechanical seals	oil-lubricated with tungsten carbide or silicon-carbide faces

Pumps models (handling water) shall be selected such that when handling sludge it meets the required duties of the viscous liquid. Pumps shall be selected which gives the required duties close to best efficiency point.

3.36 Chlorination System

Chlorine solution diffusers shall be supplied and installed at the dosing point.

Treated sewage shall be dosed with chlorine gas at concentrations not more than 10 mg/l. Effluent from the chlorine contact tank shall not have more than 1 mg/l of residual chlorine. (to minimize the effect on receiving water body eco system).

3.37 Chlorinators

- (a) Vacuum type chlorinators shall be supplied with one duty and one standby unit.
- (b) Chlorinators shall be free-standing, floor-mounted, and shall have a turn down ratio of 10: 1 over the full range of works operation.
- (c) Each chlorinator shall be equipped with a motorized plug positioned to be actuated by a sewage flow at the works outlet.
- (d) The dosing rate shall be manually set and each chlorinator shall be equipped with a 0 to 10mg/l scale and a manual dose setter over the complete range.
- (e) Mal-operation of the duty chlorination system shall be indicated in the chlorination room and the central MMI. The change to the standby system shall be carried out automatically in the event of a duty chlorinator failure.

3.37.1 A: Motive water pumps and Injector

- (a) Motive water pumps (1 working + 1 standby) shall be installed.
- (b) The pumps shall draw their supply from bore well/plant water supply.
- (c) The pumps shall be installed outside the chlorination room and shall be made from material resistant to corrosion by chlorine.
- (d) Two injectors shall be provided, each serving a duty / standby pair of chlorinators. The injectors shall be located near point of dosing i.e. upstream of Chlorine contact tank.

3.37.2 B: Inline vacuum induction type chlorine injectors

- (a) Inline vacuum induction type injector shall be designed for chemical induction and mixing for closed conduits and consist of induction unit, motor, lift rail, chemical hose assembly, stainless steel packing gland assembly and ball check valve.
- (b) All wetted materials shall be constructed of Grade 2 Titanium (unalloyed). The motor shall be chemical duty type.

3.37.3 Chlorine

Chlorine shall be supplied as liquid from nominal 1 tonne chlorine tonner.

3.37.4 The Tonner Room

- (a) Storage shall be provided for chlorine tonners sufficient for at least one month's usage at normal rates of application. (min. storage period shall be based on average flow rate).
- (b) The system shall be designed to prevent freezing of the liquid chlorine at the maximum rate of withdrawal.
- (c) Tonners on line, tonners on standby and full and empty tonners, shall be stored separately in the tonner room.
- (d) Four sets of tonner rollers shall be provided. Tonners not in use shall be stored on concrete cradles
- (e) A 3-tonne overhead single girder electric travelling crane shall be provided in the chlorine tonner room for the following functions:
 - (1) Offloading (and reloading) of tonner from trucks;
 - (2) Handling of tonners within the storage area
- (f) The system shall serve the tonner store width over the entire length including the loading/ unloading area.
- (g) The hoist and traverse speeds shall be as follows ;
 - (1) Long traverse speed 5m/min
 - (2) Cross traverse speed not more than
 - (3) Slow lifting speed 1m/min
 - (4) High lifting speed 5m/min
- (h) The container lifting beam shall be specifically designed for handling chlorine containers and equipped with necessary shackles and hooks.
- (i) Operation of crane system shall be from the floor level using independent push button pendant controls operating at a 230 volt 50 Hz AC supply
- (j) Two lifting beams shall be provided (a duty and a spare) and a one tonner weigher to be suspended from the crane hoist.
- (k) When the pressure in the duty chlorine tonner falls to less than 1 kg/cm^2 the automatic changeover device shall operate to isolate the empty tonner and to bring the full standby tonner on line
- (l) A pit and alkali absorption system shall be provided to contain and neutralise

chlorine in the event of a leak. The system shall comprise a pit located in the tonner storage room, suitable pump in SS CF8M material and accessible by the overhead crane system. The pit shall be surrounded with removable guard railing. The pit shall be kept full with a neutralising solution of lime. The pit shall be capable of holding side by side two chlorine tonners. A provision shall be made to drain the pit.

- (m) In addition to the above Automatic chlorine leak absorption system (Gas Scrubber with NaOH dosing) shall be provided adjacent to the Tonner room. The process shall be designed to contain and neutralize chlorine gas vapours in response to gas leak or catastrophic cylinder failure. The system should be able to absorb 99.99% of the chlorine gas entering the scrubber.

When a leak occurs, the pump and fan shall start automatically. The fan shall provide sufficient vacuum to contain the chlorine gas and deliver it to the scrubber. The pump shall circulate the concentrated caustic solution over the scrubber packing to absorb all the chlorine gas.

- (n) Special consideration shall be given to any floor drainage system in the tonner building; adequate traps shall be provided to ensure that chlorine gas cannot escape. All leader tubes carrying cables or pipes out of the building shall be sealed at either end to prevent any chlorine gas leaking out.

3.38 Chlorination Room

- (a) The chlorination room shall be constructed adjacent to the tonner room but with no interconnecting door or other form of access.
- (b) Gas lines from the tonner room into the chlorination room shall run in ducts to be sealed after installation and prior to commissioning.

3.38.1 Chlorine Leak Detectors

Not less than three chlorine gas leak detectors shall be provided each, with a single detector cell. At least two sensors shall be located in the chlorine tonner storage room and at least one sensor in the chlorination room. The chlorine leak detectors in the tonner room shall be mounted at each end of the tonner room.

- a) The chlorine leak detectors shall have two adjustable alarm levels sensitive to chlorine concentrations above 1 mg/m³. The range of adjustment of alarm levels shall facilitate selection of the following alarms:

- b) The low level alarm shall:
- (1) Initiate a local audible and visual alarm;
 - (2) Start the ventilation fans in the tonner and chlorination rooms; (3) Raise an alarm at the local control panel and at the central MMI.
- c) The high level alarm shall:
- (1) Initiate local audible and visual alarm;
 - (2) Initiate audible and visual alarms outside the buildings (the alarm shall be sufficiently loud to be heard in all buildings at the STP);
 - (3) Raise an alarm at the local control panel and at the central MMI;
 - (4) Shut down the chlorination systems;
 - (5) Stop the tonner room and chlorination room exhaust fans.
- d) The chlorine detectors shall have self-checking circuitry and detector failure alarms shall be provided at the local control panel and central MMI.
- e) Detector failure alarms shall not be combined with the leak alarms.
- f) Statutory warning notices relating to the storage and handling of chlorine shall be provided. The signs shall be pictorial and provided in Kannada and English.

3.38.2 Ventilation System

- (a) Each area where chlorine is stored or used as gas or liquid shall be provided with a forced ventilation system.
- (b) Air intakes shall be sized to allow uniform ventilation and positioned to prevent possible recirculation.
- (c) Exhaust air shall be ducted from low level and discharged at high level.
- (d) An air change rate of four per hour under normal condition and a minimum of twenty changes of air per hour under shall be used in the event that a chlorine leak is detected
- (e) Exhaust fans shall be heavy duty industrial pattern manufactured from chlorine resistant materials.
- (f) Ductwork (Minimum 400mm ID) shall be manufactured from Aluminum sheets/PP(3mm) ±FRP(5mm) in circular or rectangular sections.
- (g) Ducts shall be designed in accordance with relevant Indian standard specifications.
- (h) Fan controls shall be linked to the gas leak detection system.
- (i) Hardwired fan controls shall be provided and shall be manually controlled. An

override shall be provided to operate the fans in the event of a chlorine leak alarm.

- (j) Fan controls shall be grouped in an enclosure outside the ventilated area and shall include the following:
 - (1) fan off/on;
 - (2) fan running/failed indication lights;
 - (3) low and high gas leakage indication alarm light.

3.38.3 Chlorine Residual Monitors

- (a) Chlorine residual monitors shall be provided at the plant outlet.
- (b) The monitor installation shall be located in a covered location easily accessible for viewing and maintenance and shall be provided complete with sample pumps as necessary to ensure the continuity of the sample.
- (c) The sampling pipe work complete with isolation valves etc. shall be designed to ensure the sample reaches the monitor in a time not greater than 1 minute. The monitor drainage pipe work shall permit the visual checking of the presence of flow and shall discharge to the foul drain. Sample sewage not passed through the monitor shall be returned to the process.
- (d) The residual signals shall be displayed at the local control panel.
- (e) High and low chlorine residual levels shall raise alarms at the local control panel.

3.38.4 Safety Equipment

- (a) Materials and equipment necessary to ensure the safety of personnel operating the chlorination plant and others shall be provided.
- (b) The equipment shall include:
 - (1) Two sets of approved self-contained breathing apparatus, each comprising an air set, carrying harness, face mask and valves and ancillary equipment. Each set shall be provided with three 1200 litre capacity, 140 mm diameter, air tonners;
 - (2) Two sets of approved positive airline breathing apparatus, each comprising body harness, face masks and valves and 30 m of airline. One air trolley, comprising wheeled frame with two air tonners, control manifold, airline hose and hose winding drum. Two spare tonners suitable for changeover shall be provided ;
 - (3) One portable electric motor driven air compressor for recharging air tonners, complete with quick-release air hose couplings;

- (4) Two 'instant action' resuscitators.;
- (5) Four sets of safety clothing in various sizes, each comprising PVC overalls, wellington boots with steel toe caps, goggles, gloves and safety helmets.
- (c) Each set of safety equipment shall be mounted in a glass-fronted, non-locking PVC coated steel cabinet in approved locations on the outside of the building.
- (d) Two emergency showers shall be provided and shall be installed outside on either side of the tonner room.
- (e) Each shower shall be operated automatically by a quick acting hand or foot valve.
- (f) Four eyebaths shall be supplied. Two eyebaths shall be adjacent to each of the showers
- (g) Water for the showers, etc, shall be drawn from the service water supply
- (h) A telephone will be provided close by outside the building for emergencies.

3.38.5 Chlorination Power and Control

- (a) A combined MCC and control panel shall be provided and located in a suitable location protected from the weather and the effects of the process. The control panel shall provide facilities for :
 - (1) Display status and values associated with the chlorination systems;
 - (2) Duty pump selection;
 - (3) Annunciate alarms associated with the chlorination systems;
 - (4) Operator adjustment of process set points.
- (b) The chlorination systems shall operate using a fixed manually set dose rate. The quantity of chlorine dosed will therefore be adjusted in direct proportion to the process flow at the dosing point.
- (c) The chlorine residual monitors to be provided shall be used for monitoring and alarm purposes only.

3.39 Plant Drainage Pump set

- (a) The total head capacity curve shall be continuously rising towards the shutoff with the highest at shut off.
- (b) The pump shall run without undue noise and vibration
- (c) The power rating of the pump motor shall not be less than the power required from zero discharge to zero head.
- (d) Pump shall be submersible type with double mechanical seals. Motor shall be of IP

68 protection.

- (e) It shall be suitable for handling turbid water. Pump and motor shall have common shaft.
- (f) Delivery pipe of drainage pump sets shall be of size 40 NB and as per IS 1239, heavy class. Required length of pipes and fittings shall be provided. Pumping main shall be common for two pumps
- (g) Level switch to start and stop the pump automatically shall be supplied with the pump. A level indicator shall also be provided.
- (h) The capacity, total head and range of operating head of drainage pump set shall be as specified in particular mechanical requirements.
- (i) The material of construction of pumps shall be as follows :

S.	Component	Material
(i)	Impeller	Stainless Steel :ASTM743CF8M
(ii)	Casing	Cast Iron : IS 210 Gr. FG 200
(iii)	Shaft	Stainless Steel: BS:970 GR 410

3.40 Fire Extinguishers

- (a) Portable fire extinguishers are to be provided for all units as per the requirement of Tariff Advisory Committee (TAC) or meeting the requirement of local regulations whichever is more stringent.
- (b) All the extinguishers shall be of TAC approved.

3.41 Propeller Exhaust Fan

- (a) The fan should comply with IS 2312
- (b) The blades shall be of mild steel and properly balanced so as to avoid noise and vibration.
- (c) The blade and blade carriers shall be securely fixed so that they do not loosen in operation. The means provided for securing the fan mounting or fan casing to the wall partition or window shall be such as to provide a secure fixing without damage to the fan or wall.
- (d) Suitably designed guards shall be fitted to the inlet and the outlet side to prevent accidental contact. No flammable material shall be used in the construction of fan. Moulded parts, if used, shall be of such materials as to withstand the maximum

temperature attained in the adjacent component parts.

- (e) The fan shall have protective insulation or be capable of being earthed. A fan with protective insulation may be of all insulated construction or have either double insulation or reinforced insulation. Each fan should be provided with a 10 sq.mm mesh bird screen. The sheet used for the cowl should be 14 G.

3.42 Forced Fresh Air Circulation System

Fresh air circulation system is to be provided for the Raw sewage pump house and Blower room for circulation of fresh air to limit increase in temperature and also avoid stale air presence. The complete system along with all associated required air supply fans, exhaust fans, ducts, grills, galvanized bird screens, hoods and all necessary accessories shall be provided. Suitable arrangements to prevent ingress of rain water into building shall also be provided. The system shall be designed with required air changes and the contractor shall provide detailed calculations to determine the air capacity, static pressure etc. and relevant technical details for the approval of Engineer.

All duct work shall be of high quality approved galvanized sheet steel guaranteed not to crack or peel on bending of fabrication of ducts.

The ducts shall be fabricated from galvanized plain steel sheets conforming to IS: 277-2003. All duct work, sheet metal thickness and fabrication, unless otherwise directed, shall strictly meet requirements as described in IS: 655.

All joints shall be tight and shall be made in the direction of air flow. The ducts shall be reinforced where necessary and must be secured in place so as to avoid vibrations of the duct and its supports.

Volume control dampers shall be of an approved type, lever operated and complete with locking devices which will permit the dampers to be adjusted and locked in any position.

Exhaust fans of appropriate rating shall be provided for pumping stations. The contractor shall submit the fan selection details for approval.

For axial flow fans / propeller fans, speed limitation shall be as follows:

For impeller diameter of up-to 450 mm - maximum speed shall be 1500 rpm. For impeller diameter above 450 mm - maximum speed shall be 1000 rpm.

Suitable designed guards shall be fitted to the inlet and the outlet sides to prevent accidental

contacts. No inflammable material shall be used in the construction of fans.

Drive motors shall be rated at least 15% higher than the power requirement at duty point or 10% higher than the maximum power requirements at the selected speed, whichever is higher. Motor shall be conforming to TEFC, IP 54 protection.

3.43 Air-conditioning Equipment

The air conditioning units shall be of split type, with the outdoor condensing unit mounted on the terrace of the room or grouted on external side of the wall with suitable brackets.

3.44 Valves

- (a) Valves shall be as per internationally recognized standards. Flanges shall be machined on faces and edges. Flanges shall conform to ISO 7005, IS 6392, BS EN 1092-1/ BS 4504.
- (b) Valves shall be double flanged type and the faces shall be parallel to each other. The flange face should be at right angles to the valve centre line. Back side of valve flanges shall be machined or spot faced for proper seating of the head and nut.
- (c) Valves buried or installed in underground chamber, where access to a hand wheel would be impractical, shall be operated by means of extension spindle and/or keys. Wherever extension spindle is provided, the valve shall also be provided with suitable headstock.
- (d) Valve of diameter 450 mm and above shall be provided with lifting eyes and shall have detachable bolted covers for inspection, cleaning and servicing.
- (e) Valve shall be suitable for frequent operation as well as operation after long periods of idleness in either open or closed position.
- (f) The valve stem, thrust washers, screws, nuts and all other components exposed to the water shall be of a corrosion resistant grade of stainless steel.
- (g) Valves shall be free from sharp projections which are likely to catch and hold stringy material.
- (h) All the valve shall be of 10 bar rating.
- (i) All the valves on the suction and delivery side of the pumping station shall be of Motorised Knife gate type.
- (j) All valves in the plant shall be provided with dismantling joint/Flexible joint/SS

bellows for ease dismantling.

- (k) All the valves on the suction and delivery side of the Primary Sludge, RAS, Thickened Sludge, Centrifuge feed, Digester sludge and all sewage & sludge handling pumping system and for all sludge application in the plant shall be of Motorised Knife gate type.
- (l) All the valves shall be provided with Bypass valve arrangement 10% of main valve size.(Inbuilt arrangement for swing check valves and for knife gate valve and butterfly valves it shall be provided externally pipe to pipe). Valves 450 mm and above shall be provided with bypass.
- (m) 2 sets of ladders shall be provided in the raw sewage pumping station to facilitate access of valves.
- (n) Telescopic valves shall be provided in sludge storage tanks for sludge withdrawal purpose.
- (o) For all gas service and process air application the valve shall be Butterfly valves in Resilient seated (gas service) and Metal-Metal seated (for process Air service).

3.44.1 Electric Actuator

- (a) All local controls shall be protected by a lockable cover.
- (b) Each actuator shall be adequately sized to suit the application and be continuously rated to suit the modulating control required. The gearbox shall be oil or grease filled, and capable of installation in any position. All operating spindles, gears and headstocks shall be provided with adequate points for lubrication
- (c) The valve actuator shall be capable of producing not less than 1½ times the required valve torque and shall be suitable for at least 15 minutes continuous operation.
- (d) The actuator starters shall be integrally housed with the actuator in robustly constructed and totally enclosed weatherproof housing. The motor starter shall be capable of starting the motor under the most severe conditions.
- (e) The starter housing shall be fitted with contacts and terminals for power supply, remote control and remote positional indication.
- (f) Each starter shall be equipped as follows :
 - (1) 2 No. Three phase magnetically operated line contactors with no-volt release and electrical and mechanical interlock.
 - (2) 1 No. Three phase thermal cut-out device.
 - 1 No. Control circuit transformer fully protected by fuses on primary and secondary circuits.

- (3) 1 No. Set of “Open”, “Close” and “Stop” buttons.
- (4) 1 No. Local- Off-Remote switches with padlocking facilities.
- (5) 1 No. Set of torque and limit switches for “Open” and “Close” positions.
- (6) 3 No. Sets of auxiliary limit switches in each direction.
- (7) Valve position Analog Transmitter (i.e Actuator accept To Read Analog signal from Actuator to PLC and also To Write Analog Signal from PLC to Actuator) & mechanical indicator and handwheel for manual operation.
- (9) Reduction gear unit
- (10) Trip signals of Thermo switch, Torque Switch and Thermal Overload Relay shall be provided for Indication and also integrated to PLC.

3.44.2 Butterfly Valve

Butterfly valves shall be of double eccentric and resilient seated type generally as per BS EN 593 and IS 13095.

Butterfly valves shall be suitable for bi-directional pressure testing. The valves shall be of double flanged long type.

The valves shall be electrically/pneumatically/manual operated to suit the process requirement mentioned elsewhere in this tender document. The valve shall be free from induced vibrations. Valve shall be suitable for mounting in any position.

The valve seat shall be of metal to metal seated design for Process Air and Backwash Air application. All fasteners shall be set flush so as to offer the least resistance possible to the flow through the valve.

The shaft shall be stainless steel with Bronze or equivalent seal with self-lubricating bearings. Disc pins shall be stainless steel. Rings shall be bi-directional self-adjusting suitable for pressure or vacuum service. Valve shafts shall be a one-piece unit extending completely through the valve disc, or of the "stub shaft" type, which comprises two separate shafts inserted into the valve disc hubs.

All valve spindles and hand wheels shall be positioned to give good access for operational personnel. Valve of diameter 450 mm and above shall be provided with enclosed gear arrangement for ease of operation. The gear box shall be of worm and worm wheel design type, totally enclosed, grease filled and weather proof. The operation gear shall be such that they can be opened and closed by one man against an

unbalanced head of 1.15 times the specified rating. Valve and gearing shall be such as to permit manual operation in a reasonable time and not exceed a required rim pull of 200 N. All hand wheels shall be arranged to turn in a clockwise direction to close the valve, the direction of rotation for opening and closing being indicated on the hand wheels.

Material of construction of valves shall comply with following requirement:

Item	PN 10Valves
Body	Process and Backwash Air: Ductile (SG) Iron IS 1865 Gr.500/7 Biogas application: SS ASTM A 743 Gr.CF8M
Disc	Process and Backwash Air: Ductile (SG) Iron IS 1865 Gr.500/7 Biogas application: SS ASTM A 743 Gr.CF8M
Shaft	Stainless Steel BS 970 Grade 431 S 29
Body Seat	Stainless Steel ASTM A 276 Gr.316/CF8M
Disc seat	Stainless Steel ASTM A 276 Gr. Gr.316/ CF8M
Shaft Bearing	Bronze backed with PTFE
Internal Fasteners	Stainless steel AISI 316
Nuts, bolts & washers for pipe flanges	High tensile steel hot dip galvanized

The disc shall be designed to withstand the maximum pressure differential across the valve in either direction of flow. The disc shall be contoured to ensure the lowest possible resistance to flow and shall be suitable for throttling operation.

Valves shall be capable of closing against the maximum flow that can occur in system. The shaft shall be designed to withstand the maximum torque that will be imposed by the operator. It shall be secured to the discs by tapered stainless steel cotter pins.

Valves shall be provided with position indicator to show the position of the disc, mounted on the driven shaft end.

Rigid adjustable stop mechanism shall be provided within the gear box or elsewhere on the valve to prevent movement of the disc beyond the fully open or closed position (i.e. set points).

3.44.3 Sluice Valves

- (a) Sluice valve shall generally conform to IS 14846.
- (b) Sluice valves shall be of non-rising spindle type. The valve shall be furnished with a

bushing arrangement for replacement of packing without leakage.

- (c) Valves of 400mm and above shall be provided with thrust bearing arrangement for ease of operation.
- (d) Valves of diameter 400 mm and above shall be provided with enclosed gear arrangement for ease of operation. The operation gear of all valves shall be such that they can be opened and closed by one man against an unbalanced head 15% in excess of the maximum specified rating. Valve and any gearing shall be such as to permit manual operation in a reasonable time and not exceed a required rim pull of 400 N.
- (e) All valves, spindles and hand wheels shall be positioned to give good access for operational personnel.
- (f) All the hand wheels shall be arranged to turn in a clockwise direction to close the valve. The direction of rotation for opening and closing of the valve shall be indicated on the hand wheels.
- (g) The material of construction of valve shall be as follows :

S. No.	Component	Material
(i)	Body	Ductile (SG) Iron IS 1865 Gr.500/7
(ii)	Doors	Ductile (SG) Iron IS 1865 Gr.500/7 with EPDM rubber encapsulated
(iii)	Spindle	Stainless Steel: BS:970 Gr 431
(iv)	Bush	Bronze : IS:318 Gr LTB2
(v)	Internal Fasteners	SS 316

3.44.4 Knife Gate Valves

Design & Construction Details:

The Knife gate valves shall be manufactured generally as per the latest AWWA C520 -10 standards.

Other constructional features and details of components of the required valves are to be as under:

The valve body should be of ductile iron construction as specified. The valve should be provided with gate made of stainless steel of grade as specified and the gate should have beveled knife edge at the bottom to cut through and easily enter in the solids settled in the bottom and ensure positive shut-off / closure in sewage environment.

The Valve should be designed for sealing in uni-directional flow application.

The valve should be provided with replaceable type flexible sealing arrangement to offer drop tight shut off. The seals should be made of EPDM rubber and should be held in place by an easily removable type seal retainer ring. The seals should be mechanically retained in place in a machined groove on the face of seal retainer ring. The sealing system should be field replaceable at site.

The valve housing should have integral as cast tapered lugs provided for pushing the gate towards the flexible rubber seal only at the verge of closure with a view to avoid seal wear and achieve drop tight shut off. The surface of the gate coming in contact with the seal should be polished & buffed.

The bonneted valves shall have glandless design to avoid repeated tightening / replacement of gland packing. The stuffing “O” ring seal should be pressurized by thrust washer from both the sides and should be pressurized / tighten by thrust retainer nut.

The packings should be of graphited synthetic yarn to reduce the friction and offer higher life. Provision shall be made to enable tighten the gland packing by means of a pusher arrangement to minimize the leakage through the back of the valve. Replacement of gland packings should be possible in installed condition of the valve without there being line pressure.

The spindle should be double start / single threaded and non-rising type for compact & safe operation. Gate opening indicating arrangement should be provided to find out the extent of gate opening/closing. The operation of the valves shall be manual / motorized as specified elsewhere in the tender specification.

In case the valve is to be operated from a far then it shall be provided with joining couplings, extension spindle, spindle guides and mounting pedestal with suitable anchor bolts / anchor fasteners on the platform.

Materials of construction:

Component	Material
Body	: Ductile iron to BS 2789 Grade 420/12
Seal Retainer ring	: Stainless steel to ASTM A-351 Grade CF8M
Inlet Seal / Rubber Seals / O rings	: EPDM Rubber
Knife	
Spindle	: Stainless Steel ASTM A 240 type 316
Assembly bolts, nuts and fastener	: Stainless Steel ASTM A 276 type 316
Spindle nut	: Stainless Steel ASTM A 276 type 316

Bracket / Adapter plate	: Gunmetal / Phosphor Bronze / Brass
Packing	: Mild Steel to IS : 2062 grade A, Epoxy

3.44.5 Slide Gate Valve

- (a) Valve shall be of wafer type with elastomer body sealing arrangement for bi-directional shut-off. The valves shall be designed to allow gland repacking without relieving line pressure.
- (b) Body shall be two-piece cast construction bolted together with a mid-flange.
- (c) The elastomer body seal shall be held in body such that it is kept away from direct impingement of any particles in the flow medium.
- (d) The gate shall be provided with a bevelled edge to facilitate positive closure of valve even with contaminated area.
- (e) The body internals shall be countered such that settlement of particles in the media.
- (f) Purge connection shall be provided optionally for these valves for cleaning the seating area.
- (g) The material of construction of valve shall be as follows

S. No.	Component	Material
(i)	Body	Ductile (SG) Iron IS 1865 Gr.500/7
(ii)	Gate	Stainless Steel: BS:970 Gr 316
(iii)	Stem	Stainless Steel: BS:970 Gr 316
(iv)	Body seal	Stainless Steel : BS:970 Gr 316
(v)	Hand wheel	Cast Iron : IS:210 FGGr 260

3.44.6 Non Return Valve

- (a) Type of Valve:
 - For Raw Sewage, Clear water & Sludge Application: Only Swing type non return valve complying to IS 5312 is accepted for the individual delivery line & Common header of the pump. Swing door valves of size 600mm and above shall be of Multidoor type.
 - For Process Air Application: Only Flap type non return valve is accepted for the individual delivery line & Common header of the Air Blower.
- (b) The valves shall be suitable for mounting on a horizontal pipeline and flow direction shall be clearly embossed on the valve body. Hydraulic passages and doors shall be designed to avoid cavitation.
- (c) Valves shall possess high speed closing characteristics and to be designed for

minimum slam condition when closing.

- (d) Valve of diameter greater than 450 mm shall be provided, in addition to others, supporting feet and jacking screws. Hinge pins / shaft shall preferably be square in section to ensure positive location of flaps and provide for secure fixing.
- (e) Maximum pressure drop across the valve shall be 0.4 mwc. Maximum allowable leakage rate shall be 7cc/hr/mm diameter.

The material of construction of valve shall be as follows:

S. No	Component	Material
1	Body and Door	Ductile (SG) Iron:IS 1865 Gr.500/7
2	Body and Door Ring	Stainless Steel : ASTM A743, CF8M
3	Hinge Pin	Stainless Steel : BS970 431 S29
4	Bearings Bush	Stainless Steel backed Teflon
5	Internal Fasteners	SS 316
6	External Fasteners	High Tensile steel hot dipped galvanised

3.44.7 Telescopic Valves

The telescopic valve shall be a proprietary item of proven design manufactured in cast iron and adjustable to cater for variation in level.

The bell mouth height shall be controlled by a hand wheel operated from top of the chamber.

The bell mouth, pipe work, spindle and headstock shall be robustly constructed with adequate brackets of cast iron.

The bell mouth shall be connected by swept tees to a cast iron sludge outlet pipe of suitable diameter

Component	Material
Bell Mouth	Cast Iron : IS:210 Gr. FG
Piping	Cast Iron : IS:210 Gr. FG
Spindle	Stainless Steel Gr. 304
Hand wheel	Cast Iron : IS:210 Gr. FG

3.44.8 Diaphragm Valves

Diaphragm valves shall be of the full-bore type to suit the maximum working pressure ratings required. Body ends shall be flanged and drilled to BS EN 1092-1.

Indicators shall be supplied where specified showing both OPEN and CLOSED positions shall be supplied and provisions made for initiating the operation of remote indicator lights in the fully OPEN and CLOSED positions.

Valves used for toxic or hazardous fluids shall be provided with an additional 'O' ring seal of nitrile rubber or other approved material

Diaphragms shall be composed of moulded reinforced, flexible material attached by studs to the compressor. Diaphragm materials shall, where required, be composed of corrosion resistant material.

3.44.9 Isolating Cocks

For isolation of small bore pipe work tapings for instrumentation equipment etc., and for individual component isolation, the cocks shall be stainless steel, 0.25 turn ball or plug valve with the operating handle arranged to indicate the open and closed positions. Where specified, means shall be provided for securing the valve body to a front panel or near surface.

3.44.10 Pressure / Vacuum relief valves

Pressure relief valves shall be capable of relieving pressure in the system to prevent the system being pressurized in excess of a preset maximum allowable pressure. The valves shall be drops tight under no flow conditions. Minimum of 3 nos of these valves of 150mm diameter shall be installed in the plant at digester and downstream piping.

Vacuum relief valves shall be capable of preventing the vacuum pressure to be developed in the system by allowing air entry. The valves shall be drops tight under no flow conditions . The valve operation shall be achieved by the interaction of the inlet pressure and an intermediate pressure produced by a pilot valve or relay system acting on the upper side of the main valve.

The pilot valve or relay system shall be actuated by a diaphragm connected to the inlet pressure on its underside and a constant pressure on its upper side derived either from weights or from a spring.

Body ends shall be flanged and drilled to BS EN 1092-1.

3.44.11 Adjustable Weir Plates

The adjustable weir plates shall be manufactured from 3mm thick SS 304 Plates and to the approval of the Employers Representative.

Weir plates shall be complete with fixing nuts, bolts and washers and suitable for a total vertical adjustment of 100 mm through SS304 clamping plates. Fixings shall be designed for ease of accurately leveling the plates, securing the plates, and shall enable the plates to be adjusted during the life of the Works to accommodate differential settlement of the structure

3.44.12 Eccentric Structure Valve

- (a) Valve shall be eccentric structure or horseshoe type disc and body. The valve shall be used for sludge line and flow control.
- (b) The valves shall be for a smooth flux of fluid and suitable for fluid contained sludge and impurities at the treatment plant.
- (c) The material of construction of valve shall be as follows:

S. No.	Component	Material
(i)	Body	Ductile (SG) Iron:IS 1865 Gr.500/7
(ii)	Disc	Ductile (SG) Iron:IS 1865 Gr.500/7with
(iii)	Stem	Stainless Steel: BS:970 Gr 304
(iv)	Hand wheel	Cast Iron : IS:210 Gr FG 260

3.44.13 Air Valves

- (a) The air valve must be of the type that incorporates a kinetic and an automatic air release valve in one unit. It should be able to release air (gases) and to admit air into the sewage line, when the line is emptied.
- (b) The air valve must guarantee complete separation of liquid sewage from the sealing system of the air valve under all working conditions.
- (c) The air valve must have arrangement for draining and flushing by external water.
- (d) All sealing mechanism system parts of the air valve should be made of stainless steel-316.
- (e) The body of the valve should be such as to minimise the accumulation of sewage deposit at the bottom of the coating or of cast iron. The valve mechanism must be such as to prevent opening of the air valve upon every slight pressure change in line. Air Valve shall be Epoxy powder coating shall be provided inside and outside.
- (f) Each air valve must be supplied with a resilient seated sluice valve for isolation for maintenance purpose.

S. No.	Component	Material
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(i)	Body & Top Cover	Ductile (SG) Iron:IS 1865 Gr.500/7
(ii)	Float/Balls	SS 316
(iii)	Cover Bolts	Austenitic alloy steel
(iv)	Gaskets & Seals	EPDM

3.45 Domestic Water Pump sets

The Pump shall be of Centrifugal type, self priming and monoblock type. All the necessary piping with union, bends and tees shall be provided. Suction and discharge isolation valves and non-return valves on the discharge side shall be forged steel. Piping shall be as per IS: 1239 heavy class.

3.46 Approved Vendor/Manufacturer/Make List-Mechanical Equipment

S.No.	Item Description	Approved Vendor/ Manufacturer/ Make
1	Air Compressor	M/s Ingersoll Rand
		M/s Kaeser
		M/s Kirloskar Pneumatic
		M/s Atlas Copco
		Equivalent makes can be proposed which meets the qualification criteria mentioned below.
3	Chlorination System	M/s Industrial Device
		M/s Pennwalt
		M/s Capital Controls
		M/s Siemens
		M/s Milton Roy
		Equivalent makes can be proposed which
4	Cranes (EOT, Hoists ,Jib cranes)	M/s W.H. Brady
		M/s Transpade Engineers
		M/s Eddy Cranes
		M/s SafexElectromech
5	Centrifuge Decanter	M/s Pennwalt
		M/s Humboldt Wedag
		M/s GEA Westfalia
		M/s Andritz
		M/s Alpha Laval
6	Exhaust Fans	M/s Alstom

S.No.	Item Description	Approved Vendor/ Manufacturer/ Make
		M/s Howden
		M/s Bajaj
		M/s Crompton
		M/s Almonard
7	Flash Mixer/ Agitator	M/s Fibre & Fibre
		M/s Ceecons
		M/s Remi
		M/s Milton Roy
		M/s Grundfos
8	Horizontal Centrifugal Pumps	M/s KSB
		M/s Grundfos
		M/s Wilo/Mather & Platt
		M/s Pentair
9	Submersible Pumps	M/s KSB
		M/s Wilo
		M/s ABS Sulzer
		M/s Grundfos
	Submersible Pumps-Tube installed	M/s ABS Sulzer
		M/s Wilo
		M/s Grundfos
		M/s KSB
	Progressive Cavity Screw Pumps	M/s Rotomac Pumps
		M/s Netzch technology
		M/s PD Pumps
		M/s Tushaco Pumps
		M/s Roto Pumps
10	Chemical Dosing Pumps	M/s Milton Roy
		M/s Prominent
		M/s Heidelberg
		M/s Positive Metering Pumps
		M/s Swelore
		M/s SR Metering Pumps
11	Submersible Mixer	M/s ABS- Suzler
		M/s Grundfos
		M/s KSB
		M/s. Eurotek
12	Clarifiers and Thickener Mechanism	M/s Voltas
		M/s Triveni

S.No.	Item Description	Approved Vendor/ Manufacturer/ Make
		M/s Shivpad
		M/s Emco KCP
13	Vortex type Grit Removal	M/s Westech
		M/s Huber
		M/s Spirac
		M/s Smith & Loveless Inc.
	Grit Transfer Pump	M/s Egger,
		M/s KSB,
		M/s Gorman Rupp
14	Butterfly Valve	M/s Pentair M/s Fouress
		M/s VAG Valves
		M/s AVK Valves
		M/s KBL
15	Sluice Gate Valve	M/s VAG
		M/s KBL
		M/s AVK
16	PP Valve	M/s Shenco
		M/s. DVPL -Durga
		M/s. Jupiter
		M/s U N Polyvalves
17	Penstock Gates	M/s Jash
		M/s KBL
		M/s VAG
18	M.S- Cement Lined Pipes	M/s Jindal
		M/s PSL
		M/s Welspun
19	SS Pipes	M/s SAIL *
		M/s Jindal *
		M/s. Remi Pipes
		M/s Rupam Steel
20	DI/GI pipes	M/s Electrosteel
		M/s Lanco steel
		M/s Jindal

S.No.	Item Description	Approved Vendor/ Manufacturer/ Make
		M/s Kejriwal Castings
		M/s Surya Pipes
21	DI Pipe Fittings	M/s Kiswok
		M/s Kejriwal Castings
		Equivalent makes can be proposed which meets the qualification criteria mentioned below.
22	Motorised Weir Gates	M/s Jash
		M/s. DVPL-Durga
23	Chlorine Tonners	M/s ISGEC
		M/s Meenakshi Associates
24	Fine Bubble Diffusers	M/s Environmental Dynamics
		M/s OTT GMBH
		M/s Rehau
		M/s Southern scogen M/s. Eutotek
25	Centrifugal Turbo Air Blowers	M/s Howden
		M/s Siemens
		M/s Neuros
		M/s Godrej
		M/s Aerzen
26	Mechanical Screens (Bar/Drum Type)	M/s Jash Engineering
		M/s Bilfinger screens
		M/s Headworks
		M/s Huber
		M/s Eva Screens Ltd.
		M/s. United Technologies
		M/s. Auric
27	Electric Actuators	M/s Auma
		M/s Limitork
		M/s Rotork
28	Pneumatic Actuators	M/s Rotex
		M/s D Torque
		M/s Elomatic
29	UPVC & HDPE Pipes	M/s Jain Irrigation
		M/s Finloex
		M/s Duraline
		M/s ManikyaPlasticchem

S.No.	Item Description	Approved Vendor/ Manufacturer/ Make
		M/s Pennwalt Agro
		M/s. Prince Pipes & Fittings Pvt. Ltd.
		M/s Supreme
30	Motors	M/s Crompton Greaves Ltd
		M/s Marathon Electric (Alstom)
		M/s Kirloskar Electric company
		M/s Bharat Bijlee Ltd
		M/s ABB
31	Ball Valves	M/s BDK Engineers
		M/s Flowchem
		M/s Virgo
		M/s KBL
		M/s Microfinish
32	Knife Gate valves	M/s Jash Engineering (Scheute)
		M/s Bray
		M/s Fouress
		M/s VAG
		M/s AVK
33	Diaphragm valves	Crane Process
		Microfinish
		BDK Engineers
		Leader
34	Eccentric Plug valves	M/s Dezurik
		M/s VAAS
		M/s. Arflu
36	Alum Rapid Induction Mixer	M/s Rite water solution
37	Biogas Scrubber	M/s Innovative Environmental
		M/s Combustion research associates
38	Air conditioner	M/s Bluestar
		M/s Hitachi
		M/s Mistubishi
		M/s O General
41	Screw Impeller Submersible Pumps	M/s Hydrostal
		M/s Kubota Pumps
42	Screw Turbine Hydro Power	M/s JASH Engineering
		M/s REHART

S.No.	Item Description	Approved Vendor/ Manufacturer/ Make
		M/s KAUS-Gmbh
		M/s SPAANS
43	Direct Drive Turbo Biogas Mixing	M/s. Godrej Swam
	Geared Centrifugal Blower	M/s. Godrej
44	Disc Filter	M/s. Aqua Aerobic System Inc.
		M/s. Jash Nordic
		M/s. Huber
		M/s. Jonhson
		M/s. Yucheon
		M/s. Siemens
45	Belt Filter Press	M/s Auric
		M/s Techno-fungi
		M/s. Andritz

Note: Bidder shall select the equipment's from makes listed above or approved equivalent. Before placing the purchase order, approval shall be obtained from the MCGM/Competent Authority, For the Makes which are not listed above.

All the equipment, to be supplied under this contract has to be from experienced manufacturer. The equipment of only those manufacturers, who have sufficient proven experience of manufacturing the respective equipment of similar capacity, shall be considered. The experience of manufacturer shall be based on at least five installations of similar offering. The naming of a manufacturer in this specification is not intended to eliminate competition or prohibit qualified manufacturers from offering equipment. Rather, the intent is to establish a standard of excellence for the material used, and to indicate a principle of operation desired.

In order to achieve standardization for appearance, operation, maintenance, spare parts and manufacturer's service, like items of equipment provided hereunder shall be the end products of one

(1) manufacturer.

In the event that the contractor wishes to propose alternate makes for the equipment mentioned above, he shall submit the following:

1. Demonstrate that the proposed makes are "Superior / Equivalent" to the approved makes.

2. Manufacturer involved in manufacture of specified equipment for at least ten years before bid date

3. At least five successful installations (both in India / abroad) commissioned in last five years before bid date and satisfactorily operating for at least one year before bid date. End user certificate shall be provided for the same.

Manufacturer to provide full contact information for each reference as part of technical bid And the above qualities and requirements shall be demonstrated and evidenced by inspection of manufacturing units and successfully installed plants (at the End users plant/premises) for the equipment's desired and successful operation and certification by the Employer/Engineer (MCGM)/Representative.

The Employer shall reserve the right to accept or reject the Bidder proposed makes of Equipment.

Warranty

- A. Comply with the requirements of each type of Equipment and specification mentioned elsewhere in this document.
- B. Warrant all components to be free of defects in materials or workmanship for twelve months from date of satisfactory completion of performance test.
- C. Individual warranties by component manufacturer in lieu of single source responsibility by the main Equipment manufacturer shall not be acceptable.
- D. Items which fail during the warranty period, excluding expendable items, shall be replaced without cost to the Owner.
- E. Provide manufacturer's guarantee and warranty certificates prior to equipment start-up.

3.47 Pipelines, Pipe work and Fittings

3.47.1 Applicable codes

The following codes and standards unless specified herein shall be referred to, or equivalent to the approval of Engineer.

3.47.2 Materials

IS :	210	Specification for grey iron casting
IS :	290	Specification for coal tar black paint
IS :	456	Code of practice for plain and reinforced concrete

IS :	458	Specification for pre cast concrete pipes (with and without reinforcement)
IS :	516	Method of test for strength of concrete
IS :	638	Specification for sheet rubber jointing and rubber insertion jointing
IS :	783	Code of practice for laying of concrete pipes
IS :	816	Code of practice for use of metal arc welding for general construction in mild steel
IS :	1367	Technical supply conditions for threaded steel fasteners
IS :	1387	General requirements for the supply of metallurgical materials
IS :	1500	Method for Brinell hardness test for metallic materials
IS :	1536	Specification for centrifugally cast (spun) iron pressure pipes for water, gas
IS :	1537	Specification for vertically cast iron pressure pipes for water, gas and sewage
IS :	1538	Specification for cast iron fittings for pressure pipes for water, gas and sewage
IS :	1916	Specification for steel cylinder pipes with concrete lining and coating
IS :	2078	Method for tensile testing of grey cast iron
IS :	3597	Method of tests for concrete pipes
IS :	3658	Code of practice for liquid penetrant flow detection
IS :	5382	Specification for rubber sealing rings for gas mains, water mains and sewers
IS :	5504	Specification for spiral welded pipes
IS :	6587	Specification for spun hemp yarn
IS :	7322	Specification for specials for steel cylinder reinforced concrete pipes

3.47.3 Code of Practice

IS :	783	Code of practice for laying of concrete pipes
IS :	3114	Code of practice for laying of cast iron pipes
IS :	3764	Excavation work - Code of Safety
IS :	4127	Code of practice for laying of glazed stoneware pipes
IS :	5822	Code of practice for laying of electrically welded steel pipes for water
IS :	6530	Code of practice for laying of asbestos cement pressure pipes.

3.47.4 Materials for Pipelines

Each pipeline shall be constructed in a material compatible with the fluid conveyed

through that pipeline, i.e. the materials used in the pipes which are or can be in contact with the untreated or treated sewage, shall not contain any matter which could impart taste or odor or toxicity or otherwise be harmful to health or adversely affect the sewage conveyed. Nor shall any pipe be adversely affected by the fluid being conveyed through that pipe.

Pipe work and valve materials for the following duties shall be as follows or equivalent to the approval of the Engineer:

PIPE WORK AND VALVE MATERIALS

Application / Location	Material
Chlorine:Drum connections Chlorine gas or liquid	Cadmium plated 70/30 copper nickel CN 107, BS 2871 Part 1 flanged or welded carbon steel, CAF flanged joints
Chlorine gas lines below atmospheric pressure	Polyvinylidene fluoride (PVDF) with solvent welded or flanged joints/ Class E UPVC in concrete covered ducts outside building.
Chlorine solution Polyelectrolyte dosing line	Inside building and in exposed areas, rubber lined carbon steel Valves shall be globe type with forged steel bodies monel spindles, stainless steel seats and PTFE gland packing or carbon steel, monel plug, PTFE sleeved plug UPVC/HDPE
Alum	HDPE(High density polyethylene)

Water:

Raw Sewage, Process sewage, dirty waste water, supernatant and treated Sewage/Effluent, Process sludge

Digester Gas

Service water

Process Air & Backwash Air

3.48 Ductile Iron Pipes and Fittings

3.48.1 Pipes and Fittings

(a) General

Mild steel with mortar lining/Guniting (Beyond 1100mm diameter of pipe) or ductile iron (Up to 1100mm).

(SS316 Schedule 40 for Header and distribution pipe at top of digester, interconnection pipes in the plant shall be to SS316)

GI (below 80mm), ductile iron (80mm and above).

Stainless steel SS316 (Schedule 40) for exposed or buried service and for submerged service.

Pipes of size DN800 (32") and above, the wall Thickness shall be designed as per Internal Pressure Calculations or 9.53 mm thick whichever is higher. (Confirming to ASME B36.19M)

Ductile iron pressure pipes and fittings (Class K9) shall comply with IS 8329 and IS 9523. All fittings shall be socketed unless specified otherwise.

(b) Materials

The materials used in the manufacture pipes and fittings shall comply with IS 8329 and IS 9523.

(c) Tests

Tests on pipes and fittings shall be carried out in accordance with IS 8329 and IS 9523.

The test method shall be submitted for approval of Engineer.

The Engineer shall be permitted free access to the place of manufacture for the purpose of examining, inspection and witnessing the testing of pipes and fittings.

3.48.2 Joints

(a) Spigot and Socket Joints

These shall have sockets which are integral with the pipe and incorporate an elastomeric rubber ring gasket conforming to IS:5382-1969 (Latest edition/revision with amendments, if any)).

(b) Flanged Joints

These shall comply with dimensions and drilling details shall be to BS EN 1092-1/BS: 4504 Table 10/11 and 16/11. All flanged joints between steel and ductile iron pipe work shall be electrically isolated joints. These shall have isolation gaskets between the flanges, isolation sleeves around all bolts and isolation washers under all bolt heads and

nuts. All materials shall be supplied by a specialist manufacturer and be to the approval of the Engineer.

3.48.3 Linings

Ductile iron pipes and fittings shall have a cement mortar lining, in accordance with IS 11906 or ISO 4179.

Pipe linings shall be inspected on site and any damage or defective areas made good to the satisfaction of the Engineer. The Contractor may use specialist mortars, mortar additives or curing agents only with the approval of the Engineer.

Certain sections are amplified as follows:

No additives shall be used without the written approval of the Engineer, and shall be used strictly in accordance with the manufacturer's recommendations.

The minimum thickness of the lining at one point shall not be less than 4 mm.

3.48.4 Coating

(a) General

Ductile iron pipes and fittings shall be zinc coated with bitumen over coating, all in accordance with the following Specifications. Buried pipes and fittings shall also have a site or factory applied polythene sleeving. Pipe coatings shall be inspected on site and any damage or defective areas made good to the satisfaction of the Engineer.

(b) Zinc Coating

Zinc coating shall comply with ISO 8179 and shall be applied as a spray coating. The mass of sprayed metal shall not be less than 130 g/m² as described in Clause 5.2 of ISO 8179. (c)

Bitumen Coating Bitumen coating shall be of normal thickness 0.07 mm unless otherwise specified. It shall be a cold applied compound complying with the requirements of BS 341 6 Type II, suitable for tropical climates, factory applied in accordance with the manufacturer's instructions.

Damaged areas of coating shall be repainted on site after removing any remaining loose coating and wire brushing any rusted areas of pipe.

(d) Polythene Sleeving

Where polythene sleeving is specified (generally for all buried DI pipes need sleeve covering) to be applied in addition to bitumen coating it shall comply with ISO 8180. Site applied sleeving shall be stored under cover, out of direct sunlight, and its exposure to sunlight shall be kept to a minimum. Pipes having a factory applied sleeving must be stored

in the same conditions.

3.49 Reinforced Cement Concrete Pipes

3.49.1 Design

Design of RCC pipes including reinforcement details and the ends of pipes shall be in accordance with the relevant clauses of IS: 458.

3.49.2 Manufacturing

3.49.2.1 General

The method of manufacture shall be such that the form and the dimensions of the finished pipes are accurate within the limits specified in relevant clause of IS: 458. The surfaces and edges of the pipes shall be well defined and true, and their ends shall be square with the longitudinal axis. The ends of the pipes shall be further reinforced by an extra ring of reinforcement to avoid breakage during transportation.

The RCC pipes and collars/rubber rings shall be systematically checked for any manufacturing defects by experienced supervisors so as to maintain a high standard of quality. The Engineer shall at all reasonable times have free access to the place where the pipes and collars/rubber rings are manufactured for the purpose of examining and testing the pipes and collars/rubber rings and of witnessing the test and manufacturing.

All tests specified either in this Employer's Requirements or in the relevant Indian standards shall be performed by the supplier/contractor at his own cost and in presence of the Engineer if desired. For this, sufficient notice before testing of the pipes and fittings shall be given to the Engineer.

If the test is found unsatisfactory, the Engineer may reject any or all pipes of that lot. The decision of the Engineer in this matter shall be final and binding on Contractor and not subject to any arbitration or appeal.

3.49.2.2 Materials

For all materials Factory's test result, and written guarantee document with necessary analysis data shall be submitted to obtain the approval of the Engineer before carrying to sites.

3.49.2.3 Cement

Cement used for the manufacture of RCC pipes and collars shall conform to relevant IS

codes. The use of pozzolana as an admixture to Portland cement shall not be permitted.

3.49.2.4 Aggregates

Aggregates used for the manufacture of RCC pipes and collars shall conform to IS: 383. The maximum size of aggregate should not exceed one third the thickness of the pipe or 20mm, whichever is smaller.

3.49.2.5 Mixing and Curing Water

Water shall be clean, colour less and free from objectionable quantities of organic matter, alkali, acid, salts, or other impurities that might reduce the strength, durability or other desirable qualities of concrete and mortar. Contractor shall submit water quality report before using it.

3.49.2.6 Reinforcement

Reinforcement used for the manufacture of the RCC pipes and collars shall be mild steel Grade I or medium tensile steel bars conforming to IS:432 (Part-1) or hard-drawn steel wire conforming to IS:432 (part-2). Reinforcement cages for pipes and collars shall be as per relevant requirement of IS:458.

3.49.2.7 Concrete

Concrete used for the manufacture of RCC pipes and collars shall conform to IS: 456. The minimum cement content and minimum compressive strength of concrete shall be as per relevant requirements of IS: 458. Compressive strength tests shall be conducted on 15 cm cubes in accordance with the relevant requirements of IS: 456 and IS: 516.

3.49.2.8 Curing

Pipes manufactured in compliance with IS: 458 shall be either water cured or steam cured in accordance with the relevant requirements of IS: 458.

3.49.2.9 Dimensions

The internal diameter, wall thickness and length of barrel and collar of pipes, reinforcement (longitudinal and spiral), type of ends and minimum clear cover to reinforcement and strength test requirements shall be as per the relevant clauses / tables of IS:458 for different classes of pipes.

The tolerances regarding overall length, internal diameter of pipes or sockets and barrel wall

thickness shall be as per relevant clause of IS: 458.

3.49.2.10 Workmanship and Finish

Pipes shall be straight and free from cracks. The ends of the pipes shall be square with their longitudinal axis so that when placed in a straight line in the trench no opening between ends in contact shall exceed 3 mm in pipes upto 600mm diameter (inclusive), and 6 mm in pipes larger than 600 mm diameter.

The outside and inside surfaces of the pipes shall be smooth, dense and hard, and shall not be coated with cement wash or other preparation unless otherwise agreed to between the Engineer and the manufacturer or supplier.

The pipes shall be free from defects resulting from imperfect grading of the aggregate, mixing or moulding.

The pipes shall be free from local dents or bulges greater than 3 mm in depth and extending over a length in any direction greater than twice the thickness of barrel.

The deviation from straight in any pipe throughout its effective length, tested by means of rigid straight edge parallel to the longitudinal axis of the pipe shall not exceed, for all diameters 3 mm for every meter run.

3.49.2.11 Testing

All pipes for testing purposes shall be selected at random from the stock of the manufacturer and shall be such as would not otherwise be rejected under the criteria of tolerances as mentioned in IS: 458. Engineer reserve the right to attend all testing.

During manufacture, tests on concrete shall be carried out as per IS: 456. The manufacturer shall supply, when required to do so by the Engineer the results of compressive tests of concrete cubes and split tensile tests of concrete cylinders made from the concrete used for the pipes. The manufacturer shall supply cylinders or cubes for test purposes required by the Engineer and such cylinders or cubes shall withstand the tests prescribed as per IS: 458. Every pressure pipe shall be tested by the manufacturer for the hydrostatic test pressure. For non-pressure pipes, 2 percent of the pipes shall be tested for hydrostatic test pressure.

The specimen of pipes for the following tests shall be selected in accordance with relevant clause of IS: 458 and tests in accordance with the methods described in IS: 3597.

- i) Hydrostatic test
- ii) Three edge bearing test

- iii) Absorption test
- iv) Visual Examination

3.49.2.12 Sampling and Inspection

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

The number of pipes to be selected from the lot for testing shall be in accordance with Table 15 of IS: 458.

Pipes shall be selected at random. In order to ensure randomness, all the pipes in the lot may be arranged in a serial order and starting from any pipe, every pipe be selected till the requisite number is obtained, or being the integral part of N/n where N is the lot size and n is the sample size.

All pipes selected shall be inspected by Engineer for dimensional requirements, finish and deviation from straight. A pipe failing to satisfy one or more of these requirements shall be considered as defective.

The number of pipes to be tested shall be in accordance with column 4 of Table 15 of IS:458. These pipes shall be selected from pipes that have satisfied the requirements mentioned in the above clause.

A lot shall be considered as conforming to the requirements of IS:458 if the following conditions are satisfied.

The number of defective pipes shall not be more than the permissible number given in column 3 of Table 15 of IS: 458.

All the pipes tested for various tests shall satisfy corresponding requirements of the tests.

In case the number of pipes not satisfying requirements of any one or more tests, one or two further samples of same size shall be selected and tested for the test or tests in which the failure has occurred. All these pipes shall satisfy the corresponding requirements of the test.

All result of tested data must be prepared by contractor at site so that the Engineer shall make decision of "fail or pass" at once. All cost for the test shall be borne by the Contractor.

3.49.2.13 Marking

The following information shall be clearly marked on each pipe:

- a) Internal and External diameter and length of pipe
- b) Class of pipe
- c) Date of manufacture and
- d) Name of manufacturer or his registered trade-mark or both.

3.49.3 Jointing

3.49.3.1 General

Jointing of RCC pipes shall be done as per the requirements of following Employer's Requirements and as per the relevant IS standard. After jointing, extraneous material, if any, shall be removed from the inside of the pipe and the newly made joints shall be thoroughly cured. In case, rubber sealing rings are used for jointing, these shall conform to IS: 5382. The pipe joint work must be done neatly and keep even slope and level for pipe laying works.

3.49.3.2 Spigot and Socket joint (Rigid)

The spigot of each pipe shall be slipped home well into the socket of the pipe previously laid and adjusted in the correct position. The opening of the joint shall be filled with stiff mixture of Cement mortar which shall be rammed with caulking tool. This joint is used for low pressure pipe line.

3.49.3.3 Collar Joint (Rigid)

After laying the RCC pipes at proper alignment and gradient their abutting faces shall be coated with hot bitumen in liquid condition by means of a brush. The wedge-shaped groove in the end of the pipe shall then be filled with a tarred gasket in one length for each joint. The collar shall then be slipped over the end of the pipe and the next pipe butted well against the tarred gasket by suitable appliances approved by the Engineer so as to thoroughly compress the tarred gasket into the grooves, care being taken that the concentricity of the pipes and levels are not disturbed during this operation.

The collar shall then be place symmetrically over the end of the two pipes and the space between the inside of the collar and the outside of the pipe filled with a mixture of cement and sand to withstand any stress and prevent any water leakage, tempered with just sufficient water to have a consistency of the semi-dry conditions, well packed and thoroughly rammed with caulking tools. The joints shall be finished off with a fillet

sloping at 45° to the side of the pipe. The finished joints shall be protected and cured thoroughly as directed by the Engineer. Any plastic solution or cement mortar that may have been squeezed into the inside of the pipe shall be removed so as to leave the inside of the pipe perfectly clean.

3.49.3.4 Flush Joint (Internal)

This joint shall be generally used for culvert pipes of 900 mm diameter and over. The ends of the pipes are specially shaped to form a self centering joint with an internal jointing space 13 mm wide. The finished joint is flush with both inside and outside with the pipe wall. The jointing space is filled with cement mortar mixed sufficiently dry to remain in position when forced with a trowel or rammer.

3.49.3.5 Flush Joint (External)

This joint is suitable for pipes which are too small for jointing from inside. This joint is composed of specially shaped pipe ends. Each end shall be butted against each other and adjusted in correct position. The jointing space shall then be filled with cement mortar sufficiently dry and finished off flush. Great care shall be taken to ensure that the projecting ends are not damaged as no repairs can be readily affected from inside the pipe.

3.49.3.6 Spigot and Socket (Semi-flexible)

This joint is composed of specially shaped spigot and socket ends on the RCC pipes. A rubber ring shall be lubricated and then placed on the spigot which is forced into the socket of the pipe previously laid. This compresses the rubber ring as it rolls into the annular space formed between the two surfaces of the spigot and socket, stiff mixture of cement and mortar shall then be filled into the remaining annular space with a caulking tool.

3.49.3.7 Collar Joint (Semi-Flexible)

This joint is made up of a loose collar which covers two specially shaped pipe ends. Each end shall be fitted with a rubber ring which when compressed between the spigot and collar, seals the joint. Stiff mixture of cement mortar shall then be filled to withstand stress and prevent any water leakage, into the remaining annular space and rammed with a caulking tool.

3.49.3.8 Spigot and Socket Joint (Flexible)

The RCC pipe with the rubber ring accurately positioned on the spigot shall be pushed well

home into the socket of the previously laid pipe by means of uniformly applied pressure with the aid of a jack or similar appliance. The RCC pipes shall be of spigot and socket type and rubber rings shall be used, and the manufacturer's instructions shall be deemed to form a part of these Employer's Requirements. The rubber rings shall be lubricated before making the joint and the lubricant shall be soft soap water or an approved lubricant supplied by the manufacturer.

3.49.3.9 Cleaning of Pipes

As soon as a stretch of RCC pipes has been laid complete from manhole to manhole or for a stretch as directed by the Engineer, Contractor shall run through the pipes both backwards and forwards a double disc or solid or closed cylinder 75 mm less in diameter than the internal diameter of pipes. The open end of an incomplete stretch of pipe line shall be securely closed as may be directed by the Engineer to prevent entry of mud or silt etc.

If as a result of the removal of any obstructions the Engineer considers that damages may have been caused to the pipe lines, he shall be entitled to order the stretch to be tested immediately. Should such test prove unsatisfactory, contractor shall amend the work and carry out such further tests as are required by the Engineer.

It shall also be ascertained by contractor that each stretch from manhole to manhole or the stretch as directed by Engineer is absolutely clear and without any obstruction by means of visual examination of the interior of the pipe line suitably enlightened by projected sunlight or otherwise.

3.49.3.10 Testing at work site

After laying and jointing of RCC pipes is completed the pipe line shall be tested at work site as per the following Employer's Requirements and as directed by the Engineer. All equipment for testing at work site shall be supplied and erected by contractor. Water for testing of pipes shall be arranged by him. Damage during testing shall be contractor's responsibility and shall be rectified by him to full satisfaction of the Engineer. Water used for the test shall be removed from pipes and not released to the excavated trenches.

After the joints have thoroughly set and have been checked by the Engineer and before

back filling the trenches, the entire section of the sewer or storm water drain shall be proved by the contractor to be water tight by filling in pipes with water to the level of 1.50m above the top of the highest pipe in the stretch and heading the water up for a period of one hour. The apparatus used for the purpose of testing shall be approved by the Engineer. Contractor if required by the Engineer shall dewater the excavated pit and keep it dry during the period of testing. The loss of water over a period of 30 minutes should be measured by adding water from a measuring vessel at regular 10 minutes intervals and noting the quantity required to maintain the original water level. For the approval of this test the average quantity added should not exceed 1 liter/ hour/100 linear metres / 10mm of nominal internal diameter. Any leakage including excessive sweating which causes a drop in the test water level will be visible and the defective part of the work should be removed and made good.

In case of pressure pipeline, the completed stretch of pipeline shall be tested for site test pressure. The site test pressure should not be less than the maximum operating pressure plus the calculated surge pressure, but in no case should it exceed the hydrostatic test pressure as specified in IS: 458.

All of results of test and inspection data must be prepared by contractor at site so that the Engineer shall make decision of “fail or pass” at once. All cost for the inspection shall be borne by the Contractor.

3.49.4 Steel Cylinder Pipes and Specials

3.49.4.1 Design

In general the design of steel cylinder pipes with concrete lining and coating shall conform to clause 8 of IS 1916. In addition to above, in case of buried pipe line, the pipe shall also be designed for the Earth load, and traffic load.

3.49.5 Manufacturing

3.49.5.1 General

Steel cylinder pipes and specials with concrete lining and coating shall be systematically checked for any manufacturing defects by experienced supervisors and a very high standard of quality shall be maintained. The pipes and specials shall be inspected by Engineer at site and factory, and defects noticed, if any, such as protrusions, grooves, dents, notches, etc. shall be rectified, if agreed to by the Engineer. Care shall be taken that the

resulting wall thickness does not become less than the minimum specified. If the wall thickness becomes less than the minimum specified, as per Table 1 of IS: 1916, the damaged portion should be cut out as cylinder and replaced by an undamaged piece of pipe at no extra cost to the Engineer.

The Engineer shall at all reasonable times have free access to the place where the pipes and specials are manufactured for the purpose of examining, inspection and testing the pipes and specials and for witnessing the test and manufacturing.

All tests specified either in this Employer's Requirement or in the relevant Indian Standards shall be performed by Supplier/Contractor at his own cost and in presence of the Engineer, if desired. For this sufficient notice before testing of the pipes and specials shall be given to the Engineer. If the test is found unsatisfactory, the Engineer may reject any or all pipes and specials of that lot. The decision of the Engineer in this matter shall be final and binding on the Contractor.

3.49.5.2 Materials

All material shall conform to Clause 7 of IS 1916.

3.49.5.3 Manufacturing Process

Steel cylinder pipes with concrete lining and coating shall be manufactured as per Clause No.9 of IS: 1916 and specials shall be manufactured as per Clause 7 of IS: 7322. In case of spiral welded pipes, they shall be manufactured as per Clause 3 of IS: 5504. Internal lining shall be up to the full length of the pipes and specials. However, external coating shall be done leaving about 100 mm length of the pipes and specials from their ends. The internal lining and external coating to pipes and specials shall be done at factory. Before lining/coating by concrete/mortar the surface of pipes and specials shall be thoroughly cleaned. In the event that loose mill scale, tuberculation, or an accumulation of dirt, debris, oil or grease is present, it shall be removed from the surface by hand, by machine or both and given a coating of neat cement slurry.

3.49.5.4 Dimensions

The clear cover to the reinforcement whether steel cylinder or cage shall be not less than 9 mm for lining of pipe/special and 12 mm for coating of the pipe/special.

The permissible tolerance for diameter and length of pipe shall be as per Clause 4 of IS: 1916, whereas for diameter, arm length and angular deviation of specials the tolerance limit shall be as per Clause 6 of IS: 7322.

3.49.5.5 Workmanship and Finish

Workmanship and finish of pipe shall conform to Clause 4 of IS: 1916.

3.49.5.6 Testing

Each steel cylinder shall be subjected before lining/coating to a hydrostatic test under a water pressure equivalent to the test pressure in accordance with Clause 10 of IS:1916 and relevant provisions of IS:3597, provided that the whole of the area of the calculated reinforcement is used in the steel cylinder. In the case of pipes where a part of the principal reinforcement is provided in the cage, the steel cylinder shall be subjected to proportionately less hydrostatic test pressure.

Manufacturer's standard specials shall be hydrostatically tested before lining/coating. Where feasible, other specials shall be hydrostatically tested (before lining/coating) at factory. However, when this is not practicable, at the discretion of the Engineer, the unlined specials shall be tested by penetration test as per IS: 3658 or other approved means.

All of results of test and inspection data must be prepared by contractor at site so that the Engineer shall make decision of "fail or pass" at once. All cost for the inspection shall be borne by the Contractor.

3.49.5.7 Penetration Test

A suitable liquid penetrant (kerosene oil/Dye) is applied to the surface of the portion under examination and is permitted to remain there for sufficient time to allow the liquid to penetrate into any defects open at the surface. After the penetrate time, the excess penetrant which remains on the surface, is removed. Then a light colored powder absorbent called a developer is applied to the surface. This developer acts as a blotter and draws out a portion of the penetrant which had previously seeped into the surface openings. As the penetrant is drawn out it diffuses into the coating of the developer, forming indication of the surface discontinuities or flaws.

3.49.5.8 Marking

The following information shall be clearly marked on each pipe and special:

- i) Internal diameter, external diameter and thickness
- ii) Class of pipe and special with its serial number
- iii) Date of manufacture and

iv) Name of manufacturer or his registered trade mark or both

3.49.6 Jointing

3.49.6.1 General

Jointing of steel cylinder pipes and specials with concrete lining and coating be done as per the relevant IS. After jointing, extraneous material if any, shall be removed from the inside of the pipe and special. The welding of joints for pipes and specials at work sites shall comply with 816. Electrodes used for welding shall comply with IS: 814.

3.49.6.2 Butt Welded Joint

After pipes and specials are laid in the trench, the faces of pipes/specials shall first be tack -welded alternately at one or more diametrically opposite pairs of points. After completing tack welding, full welding shall be carried out in suitable runs following a sequence of welding portions of segments diametrically opposite. After jointing the exposed surface of the steel cylinder of pipes and specials shall be coated with M20 cement concrete of sufficient thickness so as to make it flush with the adjoining both inner and outer faces of pipes and specials. The gap in the internal lining at the joints shall be filled with cement mortar (1:2) for pipes and specials larger than 600 mm diameter. The lining/coating shall be done after the field test in the section has been successfully completed.

3.49.6.3 Lap Welded Joint with Slip-in-ends

In the case of pipes with plain or slip-in-ends, swaged end of the steel cylinder may be formed by heating one of its ends and expanding it or rolling it out to the required shape. The minimum depth and maximum clearance between the swaged end and the plain end of pipes for field welding shall be provided as directed by the Engineer. Lap welding shall be done from the external face at the junction of pipe and socket. After jointing the exposed surface of the steel cylinder of pipes and specials shall be coated with M20 cement concrete of sufficient thickness so as to make it flush with the adjoining both inner and outer faces of pipes and specials. The gap in the internal lining at the joints shall be filled with cement mortar (1:2) for pipes and specials larger than 600 mm diameter. The lining/coating shall be done after the field test in the section has been successfully completed.

3.49.6.4 Flanged Joints

The flanges for steel cylinder pipes and specials shall be as per BS EN 1092-1/BS4504.

Flanges shall be provided at the end of pipes or specials where valves, blank flanges etc. have to be introduced or flanged joints for the pipes are specified. The flanges shall have necessary bolt holes drilled. It might

be necessary for contractor to follow the instructions and specifications given by the valve manufacturer. All bolts, nuts and packing material required for flanged joints shall be provided by the Contractor. Bolts and nuts shall conform to IS: 1367 whereas rubber gasket of required thickness shall conform to IS: 638.

The bolts shall be evenly tightened in comply with relevant BS standard. Random inspection shall be carried out by jointly the Engineer and the contractor.

3.49.6.5 Cleaning of pipes and specials

Contractor shall ascertain that each stretch of pipeline is absolutely clear and without any obstruction by means of visual examination of the interior of pipeline suitably lighted by projected sunlight or otherwise. The open end of an incomplete stretch of pipeline shall be securely closed as may be directed by the Engineer to prevent entry of mud or silt etc. If as a result of the removal of any obstructions the Engineer considers that damages may have been caused to the pipeline, he shall be entitled to order the stretch to be tested immediately. Should such test prove unsatisfactory, contractor shall amend the work and carry out such further tests as are required by the Engineer.

3.49.6.6 Testing at work site

After laying and jointing of steel cylinder pipes and specials with concrete lining and coating is completed the pipeline shall be tested at work site as per the following Employer's Requirements and as directed by the Engineer. All equipment for testing at work site shall be supplied and erected by Contractor. Water for testing of pipes shall be arranged by him. Damage during testing shall be Contractor's responsibility and shall be rectified by him to the full satisfaction of the Engineer. Water used for test shall be removed from pipes and not released to the excavated trenches.

Each section of the pipe line shall be slowly filled with clean water and all air shall be expelled from the pipeline. The pressure in the pipeline should then be raised and maintained by means of pump to the test pressure. The test pressure should not be less than 1 1/2 times the working pressure at the lowest point or the static head pressure, whichever is higher. Under the test pressure no leak or sweating shall be visible at the welded joints. The duration of test shall be not less than 24 hours. The exposed joints shall be carefully examined and all such joints showing visible leaks shall be rewelded. Any cracked

or defective pipes and specials in consequences of this pressure test shall be removed and replaced by sound material by Contractor and the test shall be repeated to the satisfaction of the Engineer.

Proper arrangement of thrust blocks shall be provided during pressure testing or pipe laying works.

3.49.7 Steel Pipe work

Pipe/fitting material and dimensional standard shall conform to following:

Size mm (NB)	Material Specification (Steel)	Dimensional Standard
Pipes upto 150 mm	1239 PT, ERW, Black PT-1 HVY	1239 ERW
200 to 2400	2062	3589 - ERW 3589 for dimensions and minimum thickness. Pipe thickness shall be as per 2825
Elbows upto 25	ASTM-A 105	ANSI B 16.11 3000 # S.W.
40 to 150	ASTM-A 234 GR WPB	ANSI B 16.9
200 & above (meters)	2062	LR. BE. Sch 40 ANSI B 31.1
Coupling upto 25	ASTM-A 105	ANSI B 16.11 3000 # S.W.
Tees 40 to 200	ASTM - A 234 GR WPB	ANSI B 16.9 BE, Sch 40
Above 200	IS 2062	IS 2825 (min. Pipe thickness)
Reducers upto 25	ASTM-A 105	ANSI B 16.11 3000 S.W.
40 to 200	ASTM-A 234 GR WPB	ANSI B 16.9 BE, Sch 40
Above 200	2062	IS 2825 (min. Thickness for larger pipes)
Flanges	2062	BS EN 1092-1
Bolts, Anchor Bolts and all nuts	SS316	1364
Gaskets All	638 (rubber) reinforced	3 mm thickness

Facilities shall be provided for draining the pipe system and releasing air.

The pipe work layout within pump stations shall have the approval of the pump manufacturer. Fluid velocities in suction pipe work leading to pumps shall not exceed 1.5 m/s. Fluid velocities in delivery pipe work leading from pumps shall not exceed 2.0 m/s.

The whole of the jointing work and materials necessary to fix and connect the pipes,

including adequate and efficient pipe support shall be included in the Contract. The Contractor shall be responsible for ensuring that the internal surface of all pipe work is thoroughly cleaned before and during erection and before commissioning.

Cleaning shall include removal of all dirt, rust, scale and welding slag due to Site welding. Before dispatch from the manufacturer's works, the ends of the pipes, branch pipes, etc., shall be suitably capped and covered to prevent any accumulation of dirt or damage. This protection shall not be removed until immediately prior to connecting adjacent pipes, valves or pumps. All small bore pipes shall be blown through with compressed air before connection is made to instruments and other equipment. No point of passage of pipes through floors or walls shall be used as a point of support, except with the approval of the Employer.

Hydrostatic shop test for pipes and fittings shall be as per code/standard requirement. After erection at site, complete pipes and fittings shall be hydrostatically tested for a pressure of 1.5 times operating pressure.

Flanges, if fabricated in segments shall be fully radiographed and stress relieved. If fabricated out of billets/bars by cold rolling, welded flanges shall be radiographed and normalized.

Protection for pipes laid underground shall be by coating and wrapping system giving a final coat thickness of 4.5 mm may be employed. Such protection shall comprise 1.5 mm of coal tar primer application on a thoroughly cleaned surface, to be followed with fiber glass wraps set in coal tar enamel coats conforming to American Water Works Association specification C/203/57 for a total thickness of 3 mm. Such lining shall meet a spark test to be approved with a holiday detector of 10000 Volts.

The Contractor shall indicate on his detailed drawings what thrust blocks are required to anchor pipe work supplied by him. Particular care shall be taken to ensure that pipe work thrusts are, as far as possible, not transmitted to machinery or other associated apparatus.

Puddle flanges shall be fitted to pipes where the structure through which they pass is required to take thrust resulting from the pipe. Puddle flanges shall also be fitted where a water barrier is required. All puddle flanges shall be clearly shown on the drawings and the resultant thrust clearly indicated. Puddle flanges shall only be fitted with the prior approval of the Employer.

Buried pipes shall in addition be designed to withstand external loading exerted by soil, water, and live loads as relevant. The external ground water shall be taken at ground level

for design purposes. Saddle type/bracket type support wherever required shall be designed and supplied for the above ground pipe lines.

All pipe joints shall be of the butt welded type. End preparations and fabrication requirements shall generally conform to I.S. 2825. Flanges, if fabricated in segments, shall be fully radiographed and stress relieved.

Laying of welded steel pipes shall meet the requirements of I.S. 5822.

3.49.8 Welded Joints for Steel Pipes

Welding of joints in steel pipes shall be carried out manually by the metal arc welding process complying with AWWA Standard C206.

Before starting the welding of pipe joints in the Works the Contractor shall submit for the Engineer's approval details of the plant, methods and materials he proposes to use, including make and size of electrodes, number of runs, current strength and arrangements for air testing of individual joints.

Welding shall only be carried out by welders approved by the Engineer and each welder shall identify his work by means of a stenciled mark.

Welded joints other than for closing lengths shall be of the spherical spigot and socket type. For pipes of 675 mm diameter and smaller the pipe joint shall be welded externally. For pipes larger than 675 mm the pipe shall be welded internally and a sealing weld made externally.

All parts to be welded shall have loose scale, slag, rust, paint and other foreign matter removed by means of a wire brush and shall be left clean and dry. All scale and slag shall be removed from each weld run when it is completed. Pipes manufactured with longitudinal or spiral welds shall be lined up before jointing so that these welds are at least 15° apart around the joint circumference.

For pipes larger than 900 mm diameter a triple run convex fillet weld shall be used. For pipes of 900 mm diameter or less a double run convex fillet weld shall be used. The minimum leg length of the fillet as deposited is to be equal to the full thickness of the pipe wall. The actual throat depth shall not be greater than 9/10th and not less than 7/10th of the minimum leg lengths as deposited. The depositing of the weld metal shall be carried out in such a manner as to ensure that all the welds have adequate root fusion and are of good clean metal free from cracks, gas holes, slag inclusions and all other impurities. The surface of the weld shall have an even contour with regular finish and shall indicate proper fusion with the parent metal. All slag shall be thoroughly removed after

depositing each run of welding by light hammering with a chipping hammer followed by wire brushing. Any welds showing cracks or other cavities or in which the weld metal tends to overlap on to the parent metal without proper fusion or containing any other defects whatsoever shall be cut out and rewelded to the satisfaction of the Engineer at the Contractor's expense.

At closing lengths where two plain ended pipes are to be joined by a welded joint the gap between the two ends shall not exceed 75 mm. An external steel sleeve collar, of a thickness not less than that of the pipe itself and approximately 300 mm in length shall be placed centrally over the two ends to be jointed and the end of each pipe shall then be fillet welded to the sleeve collar in accordance with the above procedure.

No weld or adjacent parts of the pipe shall be painted prior to inspection by the Engineer.

3.49.9 Welder Performance Test

The Contractor shall submit for the Engineer's approval the names of persons whom he proposes to employ as welders with evidence that, as a minimum preliminary qualification, they have passed the qualifying tests prescribed in Clause 11 of BS 2633 and possessed certificates from an independent testing authority. The Engineer may further require any such person to perform satisfactory test welds under Site conditions and on pipes similar to those for use in the Works, before approving his employment as a welder. The Contractor shall maintain an up-to-date list of welders approved by the Engineer and if ordered by the Engineer he shall remove from the approved list any welder whose workmanship, as demonstrated by the results of air pressure tests on individual welded joints, is below a reasonable standard of quality of consistency in the Engineer's opinion.

3.49.10 Testing of Welded Joints

Where directed by the Engineer welded joints on pipes larger than 675 mm diameter shall be subject to a nitrogen gas test after welding.

A tapped hole (approximately 6 mm diameter) shall be made in the socket end of each pipe by the Contractor and shall be fitted with a suitable non-return valve. Nitrogen, at 400 kPa pressure, shall then be pumped into the annular space between the spigot and socket and the pump disconnected.

If no drop in pressure occurs over the ensuing period of 30 minutes the test shall be deemed

to be successful. If the test pressure cannot be maintained for 30 minutes all defects in the weld shall be cut back and re-welded and the test reapplied until successful. The cost of initial and subsequent testing of defective welds shall be at the Contractor's own expense.

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

3.50 Hydraulic Losses

Hazen-Williams Roughness Coefficient “C” for Head Loss calculation for Different Types of sludges. The frictional losses due to liquid flow in sewage shall be as per the table furnished Hazen-William formula using C values as below:

Solids in Sludge	Roughness Coefficient C	
	Raw Sludge	Digested Sludge
0	100	100
1	83	100
2	71	91
3	60	83
4	53	78
5	47	73
6	42	69
7	37	65
8	33	60
9	29	55
10	25	48

Manning’s coefficient of roughness n for

(a) RCC channels shall be 0.018

(b) Cast Iron, Ductile Iron and Mild Steel with cement mortar lining shall be 0.011

a) K values for fittings

The losses in mwc shall be calculated as per empirical formulas. K values for fittings shall be as given in below table

Sr.No.	Type of Fittings	Factor
1	Sudden Contraction	0.5
2	Entrance shape well rounded	0.5
3	Elbow 90 degrees	1.0
4	Elbow 45 degrees	0.75
5	Elbow 22 degrees	0.5

6	Tee 90 degrees	1.5
7	Tee in straight pipe	0.3
8	Gate valve open	0.4
9	Valve with reducer and increaser	0.5
10	Globe valve	10.0
11	Angle	5.0
12	Swing check	2.5
13	Venturi meter	0.3
14	Orifice	1.0

3.51 Pipe work Protection

All underground steel piping shall have their external surfaces protected by application of one coal tar enamel coat, wrapping of fiberglass, one more coat of enamel and a final wrap of enamel impregnated fiberglass. Pipe surface shall be thoroughly cleaned by shot or sand blasting. Primer paint recommended by the enamel manufacturer for the grade of enamel used shall be applied over this cleaned surface within four hours of cleaning. The primer paint shall be thoroughly mixed and applied as recommended by the manufacturer and the coating shall be free of bubbles, globules, drips and runs. The primer shall be thoroughly dry before enamel is applied and the latter shall not be applied later than 3 days after application of primer. First flood coat of enamel shall be overlaid by a single spiral wrap of fiberglass overlapping at least 20 mm on pipe up to 250 mm diameter and 25 mm on larger diameter pipes. Enamel shall be heated slowly in clean kettles, equipped with indicating or recording thermometers (100°C to 350°C range), to the recommended temperature. The enamel shall be stirred continuously. It shall be seen that fiberglass impregnates in the flood coat. Second coat of enamel and second wrap of bitumen impregnated fiberglass shall be applied in the same way. The total thickness of the coating shall not be less than 2.5 mm. Each end of the pipe left bare for a distance of 150 mm for welding shall be hand coated and wrapped after field welding is completed and hydro tested. Testing of pipe protection shall be done as directed by the Engineer using elcometers, coating thickness gauges, and bond test and holiday detectors.

3.52 External protection

All underground pipework having a cover less than 1.5 m and more than 4.5 m shall be encased with M 15 concrete of minimum 200 mm thick all around.

All underground pipelines having a cover more than 1.5 m shall be externally protected by guiniting of minimum 40 mm thick as per specification.

All above ground and pipes in galleries shall be externally painted with two coats of epoxy with minimum thickness of 180 microns.

3.53 Flexibility in Pipe work

The Contractor shall provide flexibility in the pipe work at joints in the main structures and shall submit proposals for the approval of the Engineer. Flexible joints or collars and cut pipes shall be allowed on all pipe work where necessary to allow for some margin of error in the building work. Wherever possible flexible joints shall be provided (as per Engineer's directive) with tie bolts or other means to transfer longitudinal thrusts as a whole so that external anchorages may be kept to a minimum. Flexible joints (SS316 Bellows and Dismantling joints) shall also be provided for case of erection and future dismantling of all valves and Equipment. Particular care shall be taken to ensure that pipe work thrusts are not transmitted to machinery or associated apparatus.

The Contractor shall indicate on his detailed drawings what thrust blocks are required.

3.54 Puddle Flanges

Puddle flanges shall be fitted to pipes where the structure through which they pass is required to take thrust resulting from the pipe. Puddle flanges shall also be fitted where a water barrier is required. All puddle flanges shall be clearly shown on the drawing and the resultant thrust clearly indicated. Puddle flanges shall only be fitted with the Engineer prior approval.

3.55 Small Bore Pipes and Hoses

Small bore pipes and hoses shall be of non-flame propagating materials. They shall be arranged for easy dismantling for cleaning where appropriate, and if screwed joint or joints formed by solvent welding are proposed for any chemical line, a sufficient number of flanged or flexible joints shall be provided to enable the pipe work to be removed in sections without working from one end to the other of a particular run. Tees and cocks shall also be provided at convenient points for the connection of a pressure water supply to flush pipe work through as required.

All pipes and hoses shall be labelled to enable individual lines to be identified throughout their run. Racks or trays shall be fixed to the duct walls or walls of tanks and buildings and the chemical pipes shall be fixed to these racks or trays with clips

which can easily be removed without dismantling adjacent pipes. The Contract includes for the supply and fixing of all such racks or trays. Full details of the type of hoses, pipes and racks of trays proposed, shall be submitted at the time of tendering.

3.56 Support of Pipe work and Accessories

All necessary supports, saddles, slings, fixing bolts and foundation bolts shall be supplied to support the pipe work and its associated equipment in an approved manner. Valve, meters, strainers, and other devices mounted in the pipe work shall be supported independently of the pipes to which they connect.

All brackets or other forms of supports, which can conveniently be so designed, shall be rigidly built up of steel by riveting or welding in preference to the use of castings.

No point of passage of pipes through floors or walls shall be used as a point of support, except with the approval of the Engineer.

After the collars and boxes or other fitting have been fixed in position, the floors, walls and roof structure will be made good by the Contractor.

3.57 Cast Iron Pipes

3.57.1 Manufacturing

3.57.1.1 General

C.I. pipes and fittings shall be systematically checked for any manufacturing defects by experienced supervisors and a very high standard of quality shall be maintained.

Engineer shall at all reasonable times have free access to the place where the pipes and fittings are manufactured for the purpose of examining and testing the pipes and fittings and for witnessing the test and manufacturing.

All tests specified either in this Employer's Requirements or in the relevant Indian Standards shall be performed by the supplier/contractor at his own cost and in presence of the Engineer if desired. For this, sufficient notice before testing of the pipes and fittings shall be given to the Engineer.

If the test is found unsatisfactory, the Engineer may reject any or all pipes and fittings of that lot. The decision of the Engineer in this matter shall be final and binding of the Contractor and not subject to any arbitration or appeal.

3.57.1.2 Materials

The general requirements relating to the supply of material shall be as per IS: 1387.

The material for pipes and fittings shall be of good quality cast iron conforming to IS:

210 (Grade – FG150).

3.57.1.3 Dimensions

The internal diameter, thickness and length of barrel, dimensions of pipes and fittings shall be as per the relevant tables of IS: 1536/1537/1538 for different class of pipes and fittings.

The tolerances for pipes and fittings regarding dimensions and deviations from straight line in case of pipes shall be as per relevant IS codes.

The standard weight of uncoated pipes and fittings and the permissible tolerance shall be as per relevant IS codes.

3.57.1.4 Workmanship and Finish

The pipes and fittings shall be stripped, with all precautions necessary to avoid warping or shrinking defects. The pipes and fittings shall be free from defects, other than any unavoidable surface imperfections which result from the method of manufacture and which do not affect the use of the pipes in the opinion of Engineer.

The pipes and fittings shall be such that they could be cut, drilled or machined and may be accepted provided the hardness of the external unmachined surface does not exceed 230 HBS. In the case of spigot and socket pipes and fittings for lead joints, the socket shall be without the centering ring.

In the case of flanged pipes the flanges shall be at the right angles to the axis of the pipe and machined on face. The bolt holes shall be drilled and located symmetrically off the centre line. The bolt hole circle shall be concentric with the bore and bolt holes equally spaced. The flanges shall be integrally cast with the pipes and fittings and the two flanges of the pipe shall be correctly aligned.

3.57.1.5 Testing

a. Mechanical Tests

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

b. Brinell Hardness Test

For checking the Brinell hardness, the test shall be carried out on the test ring or bars cut from the pipes used for the ring test and tensile test in accordance with IS 1500.

c. Retests

If any test piece representing a lot fails in the first instance, two additional tests shall be made on test pieces selected from two other pipes from the same lot. If both the test results satisfy the specified requirements, the lot shall be accepted. Should either of these additional test pieces fail to pass the test, the lot shall be liable for rejection.

d. Hydrostatic test

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

3.57.1.6 Coating

Coating shall not be applied to any pipe and fitting unless its surface is clean, dry and free from rust. All pipes and fittings shall be coated externally and internally with the same material, by dipping in a tar or suitable base bath. The pipe and fitting may be either preheated before dipping or the bath may be uniformly heated. The coating material shall set rapidly with good adherence and shall not scale off. In all instances where the coating material has a tar or similar base, it shall be smooth and tenacious and hard enough not to flow when exposed to a temperature of 65⁰ C, but not so brittle at a temperature of 0⁰C as to chip off when scribed lightly with a penknife. In case of pipes and fittings which are imperfectly coated or where the coating does not set or conform to the required quality, the coating shall be removed and the pipes and fittings recoated.

In case the pipes are to be used for conveying potable water, the inside coating shall not contain any constituent soluble in such water or any ingredient which could impart any taste or odour whatsoever to the potable water after disinfection and suitable washing of the mains.

3.57.1.7 Marking

Each pipe and fitting shall have cast, stamped or indelibly painted on it the following appropriate marks:

- i) The nominal diameter.
- ii) Flow direction and line marks for installation
- iii) Class reference
- iv) Mass of pipe
- v) Date of manufacture and

vi)Manufacturer's name, initials or identification mark.

Marking shall be done as per relevant IS code.

3.58 Jointing

3.58.1 General

Jointing of CI pipes and fittings shall be done as per the requirements of following Employer's Requirements and as per the relevant IS. After jointing, extraneous material, if any, shall be removed from the inside of the pipe. In case, rubber sealing rings are used for jointing, these shall conform to IS: 5382.

3.58.2 Tyton joints

In jointing cast iron spigot and socket pipes and fittings with tyton flexible joints the contractor shall take into account the manufacture's recommendations as to the methods and equipment to be used in assembling the joints. In particular the contractor shall ensure that the spigot end of the pipe to be jointed is smooth and has been properly chamfered, that the rubber ring as per IS: 5382, is correctly positioned in line, before the joint is made. The rubber rings and any recommended lubricant shall be obtained only through the pipe supplier or as otherwise directed by Engineer.

3.58.3 Flanged Pipes

The gaskets used between flanges of pipes shall be compressed fibre board or natural/synthetic rubber conforming to IS: 638, of thickness between 1.5 to 3 mm. The fibre board shall be impregnated with chemically neutral mineral oil and shall have a smooth and hard surface. Its weight per square metre shall be not less than 112 g/mm thickness.

Each bolt should be tightened a little at a time taking care to tighten diametrically opposite bolts alternately. The practice of fully tightening the bolts one after another is highly undesirable. The bolts shall be of mild steel unless otherwise specified.

3.58.4 Cleaning of Pipes and Fittings

The Contractor shall ascertain that each stretch of pipeline is absolutely clear and without any obstruction by means of visual examination of the interior of pipeline suitably lighted by projected sunlight or otherwise. The open end of an incomplete stretch of pipeline shall be securely closed as may be directed by the Engineer to prevent entry of mud

or silt etc.

If as a result of the removal of any obstructions the Engineer considers that damages may have been caused to the pipeline, he shall be entitled to order the stretch to be tested immediately. Should such test prove unsatisfactory, contractor shall amend the work and carry out such further tests as are required by the Engineer.

3.58.5 Testing at work site

After the pipes and fittings are laid, jointed and the trench partially backfilled except at the joints the stretch of pipe line as directed by Engineer shall be subjected to pressure test and leakage test. Where any section of the pipeline is provided with concrete thrust blocks or anchorages, the pressure test shall not be made until at least five days have elapsed after the concrete was cast. If rapid hardening cement has been used in these blocks or anchorages, the tests shall not be made until atleast two days have elapsed.

Each section of the pipe line shall be slowly filled with water and all air shall be expelled from the pipe by tapping at points of highest elevation before the test is made and plugs inserted after the tests have been completed. The specified test pressure based on the elevation of the lowest point of the line or section under test and corrected to the elevation of the test gauge, shall be applied by means of a pump connected to the pipe as directed by the Engineer.

The duration of test shall not be less than 5 minutes. The exposed joints shall be carefully examined and all such joints showing visible leaks shall be recaulked until water tight. Any cracked or defective pipes and fittings in consequence of this pressure test shall be removed and replaced by sound material by Contractor at no extra cost to the Engineer and the test shall be repeated to the satisfaction of the Engineer.

After the satisfactory completion of pressure test, the section of pipe line shall be subjected to leakage test. The duration of test shall be 2 hours. No pipe installation shall be accepted until the leakage is less than the number of cm³/h as determined by the formula:

$$q L = \frac{ND\sqrt{P}}{3.3}$$

Where,

q = The allowable leakage in cm³/hr

N = Number of joints in the length of the pipeline

D = Diameter in mm, and

P = The average test pressure during the leakage test in Kg/cm²

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

Necessary equipment and water used for testing shall be arranged by Contractor at his own cost. Damage during testing shall be Contractor's responsibility and shall be rectified by him at no extra cost to the Engineer. Water used for testing shall be removed from the pipe and not released in the excavated trenches.

After the tests mentioned above are completed to the satisfaction of the Engineer, the backfilling of trenches shall be done as per the Employer's Requirements specified elsewhere.

3.59 Un plasticised PVC Pipes and Fittings

Unplasticised polyvinyl chloride pipes, fittings and specials shall be to BS 3505 for potable water and BS 4346: Part 1 for fittings.

The pipes shall be of the spigot and socket type with approved gasket type flexible joint. The rubber gaskets shall be to BS 2494, Class C.

Where PVC pipes, fittings and specials are to be connected to cast iron, stainless steel or steel pipes, all metallic pipes, „Viking Johnson“ type flange adaptors or stepped couplings shall be used.

3.59.1 Polyethylene Pipes

Polyethylene pipes shall comply with BS 6437. The welding method shall be adapted to international standard and contractor shall obtain the approval of the Engineer before proceeding with such works. HDPE Pipelines: Indian Standard Materials IS4984 PE100.

3.59.2 Rubber Hosing

Rubber hosing shall conform to BS 5119, Type 2. It shall be capable of handling chlorine and sulphur dioxide solutions at a working pressure of 12 bar.

3.59.3 Copper Tubes and Fittings

Copper tubing and fittings for work above ground level shall comply with BS 2871 and BS 864: Part 2 respectively and be jointed with capillary joints. For underground location the copper pipe shall be to

BS 2871: Part 1.

3.59.4 Flanged Joints

All flanges shall comply with BS EN 1092-1/BS 4504. The nominal pressure rating for particular flanges shall be at least equal to the highest pressure rating of the pipes or fittings to which they are attached, but with a minimum nominal pressure of PN 10. All flanges shall be provided with all necessary nuts, bolts, washers and gaskets. In general, valves shall have flanged body ends.

All flanged joints which are buried or in chambers shall be protected with Densomastic and Densotape wrapping, applied in accordance with the manufacturer's instructions.

Flanges shall be installed on the pipes in the factory and field welding of flanges shall only be allowed with the approval of the Engineer.

Where pipework outside pumping stations and surge vessel chambers is cathodically protected, an insulated flange shall be incorporated at the first flange inside the structure. These flanges shall be tested to ensure that electrical insulation is achieved.

3.59.5 Gaskets and Joint Rings

Joint rings shall be manufactured to conform with BS 2494 and shall be of chloroprene rubber or other approved synthetic material suitable for temperatures up to 80⁰C.

Gaskets may be inside the bolt circle type and shall comply with BS 4865: Part 1. Alternatively the gasket shall be to the full diameter of the flange, drilled to suit the appropriate bolt provisions.

Chloroprene rubber with a hardness of 71 to 80 IRHD shall be used.

Joints shall be made in accordance with manufacturer's instructions or as specified herein.

Until immediately required for incorporation in a joint, each rubber ring or gasket shall be stored in the dark, free from the deleterious effects of heat or cold, and kept flat so as to prevent any part of the rubber being in tension.

Only lubricants recommended by the manufacturer shall be used in connection with rubber rings and these lubricants shall not contain any soluble constituent, shall be suitable for the climatic conditions at the Site and shall contain an approved bactericide.

After cleaning the flanges the gaskets shall be fitted smoothly to the flange and the joint

shall be made by tightening the nuts to finger pressure first. Thereafter the final tightening of the nuts shall be made by gradually and evenly tightening bolts in diametrically opposite positions using standard spanners.

Graphite grease shall be applied to the threads of bolts before joints are made.

3.59.6 Flexible Couplings and Flange Adaptors

Flexible couplings and flange adaptors shall be of the Viking Johnson or similar approved pattern and be assembled in accordance with the manufacturer's instructions and protected, if buried or in chambers with Densomastic and Densotape wrapping applied in accordance with the manufacturers' instructions. Flexible joints shall be harnessed or tied where necessary.

3.60 Storage & Shipment

3.60.1 Protection of Pipes and Fittings for Shipment

Except where otherwise specified all items shall have received their complete protective coatings before dispatch from the manufacturer's works and shall be additionally protected by approved means for the period of transit, storage and erection, against corrosion and accidental damage.

For the protection of pipe linings and in particular for protecting cement mortar linings from drying out, protective metal or timber discs shall be fitted over the ends of pipes and fittings. Similar timber protective discs shall be attached to all flanges of pipes and fittings, by means of bolts specifically provided for the purpose and which shall be discarded when the item is incorporated in the Works. The sleeves and flanges of flexible joints shall be wired together in suitable bundles.

3.60.2 Storage of Pipeline Materials

Pipes and fittings shall be stored raised off the ground, and shall be carefully supported, cushioned and wedged. Pipes shall not rest directly on one another and shall not be stacked more than four pipes high or two pipes high in the case of pipes of 500 mm diameter or over. Special care shall be taken to ensure that flexible pipes are cradled and supported in a manner that prevents any distortion of the pipes.

Couplings and joints (and all components thereof) and other similar items shall be stored in dry conditions, raised from the ground in sheds or covered areas.

Storage areas shall be carefully set out to facilitate unloading, and checking of materials with different consignments stacked or stored separately with identification marks clearly visible.

Where items to be stored have a limited shelf life or require special storage arrangements, the method of storage shall be to the approval of the Engineer and in accordance with the manufacturer's instructions.

All pipes and fittings supplied as spares shall have end covers which are proof against the entry of sand and vermin. Mortar lined pipes and fittings shall have end covers which form a complete seal, provision being made to accommodate the effects of temperature changes. Pipes and fittings supplied as spares shall have a temporary white external finish and shall be stored sheltered from the direct rays of the sun.

End covers and protection shall not be removed until incorporation of the pipes and fittings into the Works.

3.60.3 Transportation of Pipes and Fittings

Any vehicle on which pipes are transported shall have a body of such length that the pipes do not overhang. Large pipes shall be placed on cradles and the loads properly secured during transit. The pipes shall be handled in accordance with the manufacturer's recommendations.

Approved slings shall be used and all hooks and dogs and other metal devices shall be well padded. Hooks engaged on the inner wall surface at pipe ends shall not be used. Steadying ropes shall be employed. The positions of lifting slings shall ensure that stresses and tendency towards deformation in the pipes are kept at a minimum.

Pipe handling equipment shall be maintained in good repair and any equipment which in the opinion of the Engineer may cause damage to the pipes shall be discarded.

Under no circumstances shall pipes be dropped, be allowed to strike one other, be rolled freely or dragged along the ground.

3.60.4 Inspection of Pipes and Fittings

Before incorporating into the Works each pipe shall be brushed out and carefully examined for soundness. Damaged pipes which in the opinion of the Engineer cannot be satisfactorily repaired shall be rejected and removed from Site.

Damage to pipe coatings or linings shall be repaired to the satisfaction of the Engineer.

3.60.5 Built-in Pipe work and other Plant

The pipes and other Plant in water retaining structures shall, wherever possible, be built in as the work on the structure proceeds. The Contractor shall ensure that delivery of the requisite pipe work and other Plant is in accordance with the requirements of the programme.

Where a pipe subject to thrust passes through a concrete structure or where an external seal is required, a puddle flange shall be used. The puddle flange dimensions shall be to BS EN 1092-1/BS 4504 but shall be undrilled. The exterior of the pipe shall be cement washed symmetrically about the puddle flange by the manufacturer for a length at least equivalent to the thickness of the wall through which it passes.

The Contractor shall be responsible through every stage of the Works for checking the correctness of the setting of built-in Plant and shall satisfy himself they are positioned in accordance with his approved drawings.

3.61 Pipe laying

3.61.1 Carting & Handling

Pipes and fittings /specials shall be transported from the factory to the work sites at places along the alignment of pipeline as directed by the Engineer. Contractor shall be responsible for the safety of pipes and fittings/specials in transit, loading/unloading. Every care shall be exercised in handling pipes and fittings/specials to avoid damage. While unloading, the pipes and fittings/specials shall not be thrown down from the truck on to hard surfaces. They should be unloaded on timber skids with steadying ropes or by any other approved means. Padding shall be provided between coated pipes, fittings/specials and timber skids to avoid damage to the coating. Suitable gaps between pipes should be left at intervals in order to permit access from one side to other. In case of spigot socket pipes, care should be taken regarding orientation of pipes while unloading. As far as possible pipes shall be unloaded on one side of the trench only. The pipes shall be checked for any visible damage (such as broken edges, cracking or spalling of pipe) while unloading and shall be sorted out for reclamation. Any pipe which shows sufficient damage to preclude it from being used shall be discarded. Dragging of pipes and fittings/specials along concrete and similar pavement with hard surfaces shall be prohibited.

3.61.2 Storage

Each stack of pipes shall contain only pipes of same class and size, with consignment or

batch number marked on it with particulars of suppliers wherever possible. Storage shall be done on firm level and clean ground and wedges shall be provided at the bottom layer to keep the stack stable. The stack shall be in pyramid shape or the pipes laid lengthwise and crosswise in alternate layers. The pyramid stack shall be made for smaller diameter pipes for conserving space in storing them. The height of the stock shall not exceed 1.5 m.

Fittings/Specials shall be stacked under cover and separated from pipes.

Rubber rings shall be stored in a clean, cool store away from windows, boiler, electrical equipment and petrol, oils or other chemicals. Particularly in the field where the rubber rings are being used it is desirable that they are not left out on the ground in the sun or overnight under heavy frost or snow conditions.

3.61.3 Disinfection of Water Mains

The mains intended for potable water supplies should be disinfected before commissioning them for use. Special care should be taken to ensure disinfection of new mains. Among possible sources of contamination are sewer drainage, contaminated soil in the trench, contamination from workmen or their equipment of both and unavoidable foreign material present in the trench during construction. Education of crew members as to the need for avoiding contamination of the main during construction

is fundamental. Contractors and workmen should be thoroughly familiar with all pertinent state and local requirements governing installation of mains. All sewers, water mains and other underground conduits should be located prior to construction relocated, if necessary, to prevent contamination during construction. Pipe should be strung on high ground. At all times when construction is not actually in progress, watertight plugs should be installed in all pipe openings. Gunny sack and rags are not adequate. Provision should be made to pump any other water that might collect in the trench. Special care should be taken to avoid contamination of valves, fittings, and pipe interiors, both before and during construction each of them should be inspected and, if necessary, cleaned before installation.

After pressure testing the main, it should be flushed with clean water at sufficient velocity to remove all dirt and other foreign materials in the constructed pipeline. When this process has been completed, disinfection (using liquid chlorine, sodium or calcium hypochlorite) should proceed by one of the recommended methods as described in the following

3.61.4 Continuous Feed

In this method, water from the distribution system or other approved source and the

chlorine is fed at constant rate into the new main at a concentration of atleast 20 mg/l. A property adjusted hypochlorite solution injected into the main with a hypochlorinator, or liquid chlorine injected into the main through a solution feed chlorinator and booster pump may be used. The chlorine residual should be checked at intervals to ensure that the proper level is maintained. Chlorine application should continue until the entire main is filled. All valves, hydrants, etc., along the main should be operated to ensure their proper disinfection. The water should remain in the main for a minimum of 24 hours. Following the 24 hours period no less than 10 mg/l chlorine residual should remain in the main.

The Contractor is requested to provide photo and take a record the value of chlorine residual at starting point and after 24 hours before completion of work.

The Engineer shall jointly check the test at sites. If the value is insufficient, the disinfections work shall be repeated until satisfactory results are achieved.

Waste chlorine residual water must be neutralized before it is discharged to any drainage.

3.61.5 Slug Method

In this method a continuous flow of water is fed with a constant dose of chlorine (as in the previous method) but with rates proportioned to give a chlorine concentration of at least 300 mg/l. The chlorine is applied continuously for a period of time to provide a column of chlorinated water that contacts all interior surfaces of the main for a period of at least 3 hours. As the slug passes tees, crosses, etc., proper valves shall be operated to ensure their disinfection. This method is used principally for large diameter mains where continuous feed is impractical.

Regardless of the method used, it is necessary to make certain that backflow of the strong chlorine solution into the supplying line does not occur. Following the prescribed contact period, the chlorinated water should be flushed to waste until the remaining water has a chlorine residual approximating that throughout the rest of the system. Bacteriological tests as prescribed by the authorities should be taken, and if the results fail to meet minimum standards, the disinfecting procedure should be repeated and the results again tested before placing the main in service.

If continuous feed method is difficult to apply, Retention Method shall be considered as alternative way.

The area or pipe line to be disinfected shall be fed with chlorine solution from up stream under flowing water condition, and then the area shall be blocked after make sure to reaching more than 20 mg/l. The chlorine solution fed in the pipeline needs to wait for 1

day before starting measurement of residual chlorine. After 3 days later, the chlorine residual value shall be tested at sampling points at up stream and at downstream near to end to check whether the value is in range or not.

The Contractor shall provide photo and take a record the value of chlorine residual at starting point and after 24 hours before completion of work.

The Engineer shall jointly check the test at sites. If the value is insufficient, the disinfections work shall be repeated until satisfactory results are achieved.

Waste chlorine residual water must be neutralized before it is discharged to any drainage, as approved by Engineer.

3.62 Disc Cloth filter:

Disc/Cloth Media Filter shall be fixed with the following required accessories: Centertubes, Disc, Backwash Shoes, Brushes, Interconnecting pipes, Valves, Backwash Pumps. etc., Disc Cloth Filter installed shall be able to produce TSS value as specified in the bid document
Nominal filtration rate 10 microns

Each filter basin fitted with 304 SS mounting brackets

3.63 Sludge Dryer Unit:

Sludge Dryer Unit installed shall be of Paddle Type and shall be capable to achieve high dry solids content of 80-90 %.

Sludge Dryer unit shall comprise of all the following required accessories: Paddle Heater, Jacketed Casing, Paddle With Shafts, Rotary Joints, Drive Units, Flexible Hoses, Air Heater, Air Supply Fan, Bag Filter, Exhaust Fan, ducting, Temperature & Pressure Measuring Instruments, Steam Generator etc.

4 Rain and Air Monitoring System

Specifications for Continuous Rains Measurement system embedded with-in and integrated with Micro-Ambient Air Monitoring system.

Continuous Rain Measurement system embedded within and integrated with Micro-Ambient Air Quality Monitoring (CAAQM) System for Continuous Automated Real Time Acquisition of Rain Data along-with Gaseous and Particulate Pollutants data in outdoor ambient air. Rain & Pollution monitoring station must be a Single Fully Integrated system and it must be Plug & Play device with virtually no maintenance. System must have web based dashboard to “View and Download Data” remotely using any devices like PC, Laptop, Tablet or smartphone.

Physical attribute and Installation Capabilities of system

Micro Continuous Rain & Pollution system must have following physical attributes & installation capabilities.

Size – System must be compact and must have maximum dimensions of 220mm x 330mm x 180mm (H x W X D).

Weight – Weight of fully installed system must not exceed 3 Kgs.

Operating environment – System must have operating environment temperature range of -25°C to +50°C so that it can be installed in any part of Indian terrain.

Enclosure – System enclosure must be made of Polycarbonate and must have IP55 grade enclosure to protect it from heavy rains, high temperature, sand, or snow.

Installation – System must be “Plug & Play” device and capable of getting installed on a Pole, or on roof or on a wall or in a vehicle to create mobile monitoring. Appropriate installation components must be supplied with the system.

Power – System must run on 230V / 50Hz single phase power and must also have capability to get operated using Solar Power.

System Capabilities

Parameters to be measured

System must continuously measure Rain or Precipitation

System must measure other weather parameters which includes Temperature & Humidity

System must continuously measure pollutant gases which includes NO, NO₂, SO₂, CO, O₃

System must continuously measure Particulate Matter of size PM₁₀ & PM_{2.5}

Measurement Technology

System must have advanced Rain sensor which measures the Rain on continuous basis using small Doppler Radar with 20GHz capacity or bigger.

System must measure the Rain by measuring Speed Rate & Size of Rain Droplets using Doppler radar

System must measure Gaseous Pollutants using “Electrochemical Sensors” which must be mounded on a single PCB with specific design for reproducible measurements.

System must measure Particulate Matter using Laser Particle Counting Technology.

Power consumption

Average Power consumption of CAAQM system must be 8W and must not exceed 10W

System must have capability to get operated using Solar Power

System Specifications

Rain Gauge Sensor Specifications –

Measures Rain, Snow & hail

Measures Rain using Doppler Radar Technology with Doppler Radar capacity of 20GHz or more

Rain Gauge must not have any movable parts & must not require any onsite maintenance

Rain Gauge Measurement Surface – 8cm²

Rain Gauge Measurement Range – 0 to 100mm/hour

Rain Gauge Accuracy – +/- 10%

Rain Gauge Measuring Drop Size Range – 0.5 to 5.0 mm

Rain Gauge Resolution – 0.1mm

Rain Gauge Sample Rate – 1 Hz

Rain Gauge Operating Temp – -40°C to +60°C

Rain Gauge Operating Humidity – 0 to 100%

Gas & Particulate Sensors Specifications -

Nitrogen Oxide (NO_x) Measurement Range – 0 to 1.5ppm or better

Carbon Monoxide (CO) Measurement Range – 0 to 100ppm

Ozone (O₃) Measurement Range – 0 to 5ppm

Sulphur Dioxide Measurement Range – 0 to 10ppm

Particulate Matter (PM_{2.5}) Measurement Range – 0 to 500ug/m³

Particulate Matter (PM₁₀) Measurement Range – 0 to 1000ug/m³

Calibration of the System

Continuous Rain & Pollution system must be factory calibrated for Rain as well as for Gas & PM Pollutants measurements.

System must be calibrated for Gaseous and PM pollutants using “Co-locating” procedure against

“Reference System” at the time of shipping

System must have “System Calibration” certificate issued by the manufacturers.

Sampling Capabilities of the System for Rain, Gases & Particulate Measurements

System must sample the rain droplets using Doppler Radar

System must sample Ambient Air using Optimum Capacity Internal Fans to measure Gas as well as Particulate Matter.

Integrated System

System offered must be completely integrated i.e. single system must carry-out Rain Measurement along-with Gaseous & PM Pollutants measurement.

Data Acquisition & Processing, System Software and Communication

System must have onboard Data Conversion capability where by Sensor Signals are converted to finished data within individual system to maintain upmost data integrity.

System must have Cloud based software to provide anywhere access to View & Download the Data.

Software must have accessibility using any devices like PC, Laptop, Tablet or Smartphone through web browsers like Chrome, Explorer etc.

System software must have access to individual devices through User Name & Password.

System software must continuously provide exact location of each device.

System must record the Data every 2 minutes or better

System must have onboard SD card or equivalent device to store the data if communication with cloud server is lost. SD must store data of at-least 3 months.

System software must have capability to synchronize the data with cloud server if communication is lost and get re-established again.

System must have various communication capability which must include WIFI, Ethernet LAN, and cellular IP GPRS modem (excluding SIM).

System software must have capabilities to email the data every day

System Software must allow download of the data on various time average

Downloaded data must be in tamperproof .csv format

System software must provide Gas concentration data both in ppm or mg/m³ units.

Software Licenses

System must be supplied with free system software which must get all available updates free of cost till 2 years after installation. System also must have ONE year of Cloud Subscription.

System Life & Accessories

The Rain Gauge must have life of 7 to 10 years

The Gaseous Sensors must have life of 1 year or more

PM sensor must have life of 2 to 3 years

System must be supplied with 1 additional Sensor Board having all Gaseous Pollutants

SUB-SECTION

SOLAR SYSTEM -TECHNICAL SPECIFICATIONS

4.1 Scope :

The installation of Solar Power Generation System as given in table 4.1.2, for the captive use of electricity with net metering concept for the utilization of administrative power demand, which will not be the part of process power.

Special note for STP Premises of the installation of SOLAR UNIT, for the utilization of power demand of STP apart from process load.

Table 4.1.2

POISAR RIVER			
Solar Power Requirement			
Label	Location	Capacity (MLD)	Min. required solar Power (Kw)
STP:1A	Kranti Nagar-1A	1.50	55
STP:1B	Kranti Nagar-1B	2.00	75
STP:2	Appapada Kurar Nagar, Gokul Nagar	4.00	115
STP:3	Muslim cemetery near kurar culvert, Durga Nagar	3.50	125
STP:4	Mahindra Green Gate	1.50	125
STP:5	Thakur parking plot	8	70
STP:6	Near poisar subway, Gaon devi, Bihari Tekdi	4.00	225
STP:7	Opp. Poisar Gymkhana, Tulaskar wadi	3.00	145
STP:8	Irani Wadi	4.00	90
STP:9	Laljipada kandiwali west, Sanjay Nagar	2.00	160

The respective government subsidy shall be availed from nodal agency.

4.2 Standards

	Applicable BIS /Equivalent IEC Standards / Applicable MNRE Specifications	
	Standard Description	Standard Number

BOS Item /System	I	Crystalline Silicon Terrestrial PV modules poly/ mono	IEC 61215/ IS14286
	ii	Solar PV module safety qualification requirements	IEC 61730 (P1 - P2)
	iii	PV modules to be used in a highly corrosive atmosphere (Coastal area etc,) must qualify Salt Mist corrosion Testing	IEC 61701/ IS 61701

4.3 SOLAR PV MODULES

Type	Crystalline silicon - Poly or Mono
Origin	Manufactured in India
Module Efficiency Fill factor	$\geq 15.2\%$ $\geq 70\%$
Power warranty	25 years limited warranty on power output & 5 years product warranty
Performance Warranty	Should not be less than 90% of designed nominal power at the end of 10 years and 80% of designed nominal power at the end of 25 years.
Module frame	Anodized aluminium. Non-corrosive and electrolytically compatible mounting structure
Mounting structure	Metallic mounting structure. Hot dip Galvanized with 70 microns thickness
Module minimum rated power	The nominal power of a single PV module shall be $\geq 240\text{Wp}$.
RF Identification tag for each solar module	Must be able to withstand environmental conditions and last the life of the solar module and shall be kept inside the module laminate.

RF Identification tag data	a) Name of the manufacturer of PV Module b) Name of the Manufacturer of Solar cells c) Month and year of the manufacture (separately for solar cells and module) d) Country of origin (separately for solar cells and module) e) I-V curve for the module f) W_p , I_m , V_m and FF for the module g) Unique Serial No and Model No of the module h) Date and year of obtaining IEC PV module qualification certificate i) Name of the test lab issuing IEC certificate k) Other relevant information on traceability of solar cells and module as per ISO 9000 standard To be given for standard test conditions (STC).
Power output rating	I-V curve of the sample module should be submitted.

4.4 SOLAR PV MODULE MOUNTING STRUCTURE

The PV modules shall be mounted on fixed metallic structures of adequate strength and appropriate design, which can withstand the load of the modules and high wind velocities up to 150 km per hour.

- a. The module mounting structure will be designed in such a way that it will occupy minimum space without forfeiting the output from SPV panels & shall be designed to allow easy replacement of any module.
- b. Bidder may design foundation (RCC and PCC) and structure considering the wind loads and structural load bearing capacity of the building. The System integrator must ensure proper water proofing in case of any modifications to the roof.
- c. Detailed specifications for the mounting structure are given below:

Wind velocity withstanding capacity	150 km / hour
Structure material	Structural materials shall be corrosion resistant and electrolytically compatible with the materials used in the module frame, its fasteners, nuts and bolts. Hot dip galvanised steel with galvanisation thickness of min 70 micron or aluminium alloy.
Bolts, nuts, fasteners panel mounting clamps	Stainless steel SS304
Mounting arrangement for flat roofs	With Removable concrete ballast made of Pre-fabricated PCC(1:2:4), M15
Installation	The structures shall be designed for simple mechanical on-site installation
Minimum distance between roof edge and mounting structure (Horizontal Clearance)	≥ 0.60 m
Minimum clearance between lowest part of panel and mounting structure (Vertical Clearance)	Shall not be less than 100mm
Access for panel cleaning and maintenance	All solar panels must be accessible from the top for cleaning and from the bottom for access to the junction box
Panel tilt angle	North - south orientation with a fixed tilt angle depending on location (south facing)
Spares	Required numbers of spare structures must be provided.
Warranty	The structure must have a free replacement warranty for 10 years.

The prospective Installer shall specify installation details of the solar PV modules and the support structures with lay-out drawings and array connection diagrams. The work shall be carried out as per the designs approved by concerned tender inviting authority .

4.5 ARRAY JUNCTION BOX

The array junction boxes are free of dust, vermin, and waterproof and made of Thermo

Plastic. The terminals will be connected to copper bus-bar arrangement of proper sizes. The array junction boxes will have suitable cable entry points fitted with cable glands of appropriate sizes for both incoming and outgoing cables.

Technical Specification - Junction Boxes	
Material Thermoplastic	Dust, Vermin & Water proof
Hardware SS 304	Cable Gland Thermoplastic
Protection	IP 65 enclosures with transparent covers with Surge Protection Device (SPD) class-I/II, DC Fuse with holder and string disconnecter.

4.6 Surge Protection Device (SPD):

Internal surge protection shall consist of three MOV/GDT (glass discharge tube) type arrestors connected from +ve and -ve terminals to earth (via Y arrangement) for higher withstand of the continuous PV-DC voltage during earth fault condition. SPD shall have safe disconnection and short circuit interruption arrangements through integrated DC inbuilt bypass fuse (parallel) which should get tripped during failure mode of MOV, extinguishing DC arc safely in order to protect the installation against fire hazards.

- a. A surge protection device in each sub-array line shall be provided to prevent the high current transients from entering into the DC bus. Busbar must be made from tinned plated copper.
- b. It must be with DC disconnect switch and DC fuses positive side shall have a voltage rating of 1000V DC, current rating as required.

1. DC Distribution Box

A DC distribution box shall be mounted close to the solar grid inverter. The DC distribution box shall be of the thermo plastic IP65 DIN rail mounting type and shall comprise the following components and cable terminations:

Incoming 2 core (Positive and negative DC) cables from the DC Combiner Box;

DC circuit breaker, 2 pole (the cable from the DC Combiner Box will be connected to this circuit breaker on the incoming side);

DC surge protection device (SPD), class 2 as per IEC 60364-5-53; Outgoing 2 core cable(Positive and negative DC) to the solar grid inverter.

As an alternative to the DC circuit breaker a DC isolator may be used inside the DC Distribution Box or in a separate external thermoplastic IP 65 enclosure adjacent to the DC Distribution Box. If a DC isolator is used instead of a DC circuit breaker, a DC fuse shall be installed inside the DC Distribution Box to protect the DC cable that runs from the DC Distribution Box to the Solar Grid Inverter.

2. DC and AC CABLES:

For the DC cabling, XLPE insulated and PVC sheathed, UV stabilized single core flexible copper cables shall be used. Multi-core cables shall not be used.

For the AC cabling, PVC or XLPE insulated and PVC sheathed single or multicore flexible copper cables shall be used. Outdoor AC cables shall have a UVstabilised outer sheath.

The total voltage drop on the cable segments from the solar PV modules to the solar grid inverter shall not exceed 2.0%.

The total voltage drop on the cable segments from the solar grid inverter to the building distribution board shall not exceed 2.0%

The DC cables from the SPV module array shall run through a UV stabilised

PVC conduit pipe of adequate diameter with a minimum wall thickness of 1.5mm.

Cables and wires used for the interconnection of solar PV modules shall be provided with solar PV connectors and couplers.

All cables and conduit pipes shall be clamped to the rooftop/ walls/parapet with thermoplastic clamps at intervals not exceeding 50 cm.

The minimum DC cable size shall be 4.0 mm² copper. The minimum AC cable size shall be 4.0 mm² copper. In three phase systems, the size of the neutral wire size shall be equal to the size of the phase wires.

Cables and conduits that have to pass through walls or ceilings shall be taken through a PVC pipe sleeve.

Cable conductors shall be terminated with tinned copper end-ferrules to prevent fraying and breaking of individual wire strands. The termination of the DC and AC cables at the Solar Grid Inverter shall be done as per instructions of the manufacturer, which in most cases will

include the use of special connectors. Only copper cables of appropriate size and of reputed-make shall have to be used. However aluminium cables can be used on A.C side.

- a) All connections should be properly terminated, soldered and/or sealed from outdoor and indoor elements. Relevant codes and operating manuals must be followed. Extensive wiring and terminations (connection points) for all PV components is needed along with electrical connection to lighting loads
- b) All the Cu/Al. PVC or XLPE insulated Armoured. Sheathed cables required for the plant will be provided by the manufacturer.
- c) Only terminal cable joints shall be accepted. No cable joint to join two cable ends shall be accepted. All cable/wires shall be marked with good quality letter and number ferrules of proper sizes so that the cables can be identified easily.

All Cables shall confirm relevant IS/ IEC standards

All cables shall be supplied in the single largest length to restricting the straight through joints to the minimum number.

AC Distribution Box

An AC distribution box shall be mounted close to the solar grid inverter. The AC distribution box shall be of wall / rail mounting type and shall comprise of following components :

- Incoming 3 core cable from the solar grid inverter – AC circuit breaker, 2 pole / 4 pole
- AC surge protection device (SPD), class 2 as per IEC 60364-5-53 – Outgoing cable to the building electrical distribution board.

A manual disconnect switch beside automatic disconnection to grid would have to be provided at utility end to isolate the grid connection by the utility personal to carry out any maintenance. This switch shall be locked by the utility personal.

3. GRID INVERTER AND BI-DIRECTIONAL METER – MSEDCL / Supply Authority empanelled shall be used Standards for other components

Cables	i	General Test and Measuring Method PVC insulated cables for working voltage upto and including 1100 V and UV resistant for outdoor installation for A.C. cables. (It is suggested to use D.C. rated, UV resistant Photovoltaic cable having plug and play capability cables)	IEC 60227 / IS 694 IEC 60502 / IS 1554 (part I & II)
Earthing	i	Grounding	IS 3043: 1986
Switches/ Circuit Breakers/ Connectors	i	General Requirements Connectors -safety A.C. /D.C.	IEC 60947 Part I,II, III / IS 60947 Part I,II, III / EN 50521
Junction Boxes/ Enclosures for Charge Controllers/ Luminaries		General Requirements	IP 65 (for outdoor)/ IP 3x (for indoor) As per IEC 529

Balance of system materials:

4. Data logger:

- The communication local to the Solar Energy Generator shall follow Industry Standard like RS232 or RS485 or RJ45 LAN
- Communication between the Solar Energy Generator and the Application running on the Server shall be based on GSM/GPRS.
- Battery backup for data logger system is mandatory
- The data to be logged and made available as follows:-
 - Instantaneous DC Voltage
 - Instantaneous DC Current
 - Instantaneous AC Voltage
 - Instantaneous AC Current
 - Conversion Efficiency
 - Voltage graph showing Volts in Y-axis and Time-of-Day on X-axis.
Similarly Current graph

- Total AC Power generated per day, per week and per month showing Power Generation Profile graphs
 - Peak Power generated
 - Monthly Power generation charts showing the total power generated in each month.
- a) PV array energy production: Digital Energy Meters to log the actual value of AC/DC Voltage, Current & Energy generated by the PV system shall have to be provided.
 - b) Solar Irradiance: An integrating Pyranometer (Class II or better) shall be provided, with the sensor mounted in the plane of the array. Readout shall be integrated with data logging, system.
 - c) Wind Speed: An integrated wind speed measurement unit shall be provided.
 - d) Temperature: Temperature probes for recording the Solar panel temperature and ambient temperature shall be provided.

A data logging system for plant control and monitoring shall be provided.

5. EARTHING PROTECTION

1. Earthing protection: A minimum of two separate dedicated and interconnected earth electrodes must be used for the earthing of the solar PV system support structure with a total earth resistance not exceeding 5 ohms.
 - (i) Equipment earth (DC) and
 - (ii) System earth (AC)

Both equipment earth (DC) and system earth (AC) shall be checked for proper earthing.

- Equipment earth (DC): All the non-current carrying metal parts such as PV modules, DCDB are bonded together and connected to earth to prevent shocks to the manpower and protection of the equipment.
- System earth (AC): All the non-current carrying metal parts such as ACDB, Lightning Arresters are bonded together and integrated to existing earth.
- Earthing shall be done in accordance IS 3043-1986, provided that earthing conductors shall have a minimum size of 6.0 mm² copper wire or 10 mm² aluminium wire or 3mm² X 70 mm² hot dip galvanized iron flat. Unprotect aluminium or copper-clad aluminium conductors shall not be used for final underground

connections to earth electrodes.

- The earth electrodes shall have a pre-cast concrete enclosure with a removal lid for inspection and maintenance. The entire earthing system shall comprise non-corrosive components.

6. Caution Signs

In addition to the standard caution and danger boards or labels as per Indian Electricity Rules, the AC distribution box near the solar grid inverter and the building distribution board to which the AC output of the solar PV system is connected shall be provided with a noncorrosive caution label with the following text:

WARNING - DUAL POWER SOURCE SECOND SOURCE IS SOLAR SYSTEM

The size of the caution label shall be 105mm (width) x 20mm (height) with white letters on a red background.

7. METERING SCHEME:

The bi-directional (import kWh and export kWh) meter shall be fixed at the point of grid connectivity (the “Solar Service Connection Meter”) for the purpose of net-metering as per below diagram

The existing meter shall be rewired to record total solar generation.

Both bi-directional and solar generation side meter shall be in same vicinity.

The bi-directional meter shall comply with the requirements of CEA Regulations on Installation and Operation of Meters.

Meter must also display on demand, instantaneous, AC system voltages and currents, frequency, reactive power with sign.

For	1-5kW	: Single phase Bi-directional whole current meter class I
	5-17kW	: Three phase Bi-directional whole current meter class I
	17to 50kW	: Three phase 3 X 5 A, CT operated, 0.5s class, Bi-directional meter

Above 50kW i.e. For all HT installations - 0.2S class meter, 0.2 class CT's of suitable ratio and 0.2 class PT's $11kV / \sqrt{3} / 110V / \sqrt{3}$

Note: For HT installations, if the existing meter cubicle is having 2 element system of 2 CTs, 2 PTs and metering with three wire system, it shall be replaced by 3 element system of

3 CTs, 3 PTs and metering with four wire system.

8. Connection to Building Electrical System

The AC output of the solar grid inverter shall be connected to the building's electrical system after the BESCOM service connection meter at the consumer bus bar by providing suitable capacity manual disconnector. The solar grid inverter output shall be connected to a dedicated module in the Main Distribution Board (MDB) of the building. It shall not be connected to a nearby load or socket point of the building. The connection to the electrical system of the building shall be done as shown in below diagram.

Note: Any system up gradation in the infrastructure required to connect to grid shall be carried out by the consumer.

Single Line Diagram of Rooftop Facility

