

PRIVATE
RESIDENTIAL
VILLA .

MAHE, SEYCHELLE

SPECIFICATION
SEWAGE TREATMENT PLANT

PART 1 - EXECUTION

1.1 OBJECTIVES

- The objective of these specifications is to set-out the guidelines and performance criteria that shall be adopted for the implementation of package wastewater treatment facilities for the project. Wastewater collected from such development is considered to be pre-dominantly domestic wastewater. The treatment facility shall yield treated effluent with a quality suitable for unrestricted irrigation as defined in Section 2.2 of these Specifications. Due to variation of occupancy, it is proposed that the treatment plant be of 2 equal trains, each having a half capacity of the project.

1.2 SCOPE

- The scope of work of the Contractor comprises the design, manufacture and delivery, installation, commissioning, and testing of the wastewater treatment plant complete with all associated civil, architectural, mechanical, and electrical works and central control and monitoring system. The tender documents for the wastewater treatment plant are of the performance specification type. The Contractor shall submit a complete design to satisfy the performance criteria set out in these specifications for the approval of the Engineer.

1.3 DESCRIPTION

- The wastewater treatment plant shall be of the compact package type and shall be aesthetically acceptable and non-offensive with regard to odor and noise. The wastewater treatment plant shall include pretreatment including fine screen, grit removal, primary clarifiers; biological treatment including aeration, blowers, membrane, activated sludge handling facilities; and disinfection or whatever is deemed necessary to achieve the intended quality of the treated sewage. The design of the wastewater treatment plant shall comprise the following elements:
 1. Inlet Works comprising collection chamber, screening and grit removal, flow measurement and distribution chamber.
 2. Primary settling tanks
 3. Biological tanks
 4. Sludge circulation pumps
 5. Aeration system, including air blowers and air supply and distribution system
 6. Wastewater mixing or circulation pumps
 7. Membrane
 8. Disinfection system, such as chlorination system or any other system that will provide the effluent quality criteria. Chlorination systems shall include chlorine preparation dosing, residual concentration monitoring, as well as chlorine contact tank, as well as DE chlorination system to meet irrigation water Chlorine residual criteria. For UV Systems, the design shall provide Total Kill of Bacteria as well as post-chlorination equipment to maintain residuals in the transmission lines of irrigation water at rates compliant with the irrigation water quality standards.
 9. Sludge handling facilities.
 10. Control and Instrumentation Equipment and Devices, including locally mounted instruments and controls as well the connection to central control and monitoring system
 11. Utility services for all buildings and treatment units including power/electricity supply and water
 12. Protective painting and treatment of all structures and equipment
 13. Civil and architectural engineering work in connection with the plant.
 14. Pumping stations
 15. Tertiary treatment system with storage tanks and booster pumps as well as its connection to the service/ irrigation system.
 16. Area for laboratory equipment.

17. Fence walls.

1.4 OPERATING CONDITIONS

- The hydraulic design of the treatment facility shall take into consideration peak flow and organic load conditions in such a manner that shall not upset the hydraulic and performance reliability of the system.
- Equipment design shall take into account peak flow rates by applying appropriate peaking factors.
- The raw wastewater shall be delivered to the wastewater treatment plant by means of either gravity or force main from a pumping station; the influent line design shall be coordinated with the design of the wastewater collection system
- The treatment plant units shall be fully automated, with provision of auxiliary manual operation system to take over under conditions of failure of the automatic controls.

1.5 TENDER SUBMISSION REQUIREMENTS

- Technical Data to be Submitted with Tender
- Tender submission shall include all relevant technical data and manufacturers' literature sufficient to allow technical review of the process and equipment proposed including but not limited to the following:
 1. Name of the manufacturer and general description of the treatment units and equipment with material specifications, technical notes and design calculations.
 2. General arrangement drawing of the plant, overall dimensions, service connections, power ratings, etc.
 3. Process flow diagrams showing flows, capacities, power requirements.
 4. Piping and instrumentation diagrams for all treatment systems up to the Central Control and Monitoring System.
 5. Schedule of all items of equipment, listing the type, manufacture and country of origin and all data sufficient to allow technical review of the process and equipment proposed.
 6. General arrangement drawings and brief specifications of foundations and other architectural building and civil engineering work.
 7. Itemized manufacturer's spare parts list for 3 years normal operation for all items of the Wastewater Treatment Plant and equipment.
 - a. Work Plan and Time Schedule
 - b. A work plan and time schedule (memorandum of procedure) shall be provided by the Contractor/Tenderer in accordance with the Conditions for Tender, and shall include, a schedule of proposed dates for the design, manufacture, delivery and installation of the plant components and for commissioning and testing as well as proposed dates for the approval by the Engineer. In other words, the Contractor shall submit along with his tender the proposed time schedule for the construction of the treatment facility as well as for the installation of all equipment. A detailed work plan and time schedule shall also be prepared and submitted for approval for the commissioning, testing and operation and maintenance as well as for all activities during the defect liability period.

1.6 QUALIFICATIONS OF MANUFACTURERS/SUPPLIERS

- The manufacturer of the wastewater treatment plant shall be one of the qualified manufacturers in the field of wastewater treatment facilities and to have extensive experience (more than 10 years) in designing, manufacturing and installation of wastewater treatment plants of similar capacities. Manufacturer is to have a certified regional representative. The manufacturer's representative is to have an established organization with technical engineering capabilities and skilled technicians for the operation and maintenance of similar capacity wastewater treatment plants. Spare parts availability and after sales service is a requirement for the approval of the Wastewater Treatment

Plant Manufacturer and manufacturer's representative. The Contractor shall submit with the tender, technical qualifications, experience, scope of actual installation of similar capacity wastewater treatment plants, for the approval of the Engineer.

1.7 SPECIAL CONDITIONS

- Design - General
 1. The Contractor shall prepare and submit for the approval of the Engineer the detailed design of all process units, and all associated works within the wastewater treatment plant. The detailed design shall include all design calculations for all process/treatment units including calculations of performance efficiency and hydraulic sizing of treatment units, sizing and design of all interconnecting pipes and channels, as well as the calculations of all structural, mechanical and electrical designs of the treatment units and auxiliary buildings. The design calculations shall clearly define the operational parameters adopted in the design to provide the specified quantity and quality of treated effluent, including the raw wastewater influent flow rate along with the corresponding required controls to ensure the proper performance of the treatment plant.
 2. The treatment plant shall be designed with provision for a sufficient holding capacity that is divided into an adequate number of equal and parallel trains to prevent operational upsets of the treatment process and to avoid a complete shut off in case of unexpected emergencies. The design shall also be based on the wastewater characteristics and the quality of the treated effluent.
 3. Equipment design shall take into account peak flow rates by applying appropriate peaking factors.
 4. The organic loading capacity of the treatment plant shall be based on the average waste load with a consideration for any variations of the peaking conditions.
 5. The design of the plant shall be complete with all necessary performance controls, treatment units' drainage, flushing and cleaning, filter cleaning and backwashing, as well as all necessary laboratory, workshop and control equipment etc.

- Design Parameters
 1. The design of the treatment facility shall be based on the design parameters that are given in Table 11.

Parameter	Value
Influent Characteristics:	
- Total Suspended Solids, TSS	220 mg/L
- BOD ₅	220 mg/L
- pH	7.2
- Total Nitrogen (N)	40 mg/L
- Total Phosphorous (P)	8 mg/L
Effluent Characteristics:	
- Total Suspended Solids, TSS	10 mg/L
- BOD ₅	10 mg/L
- pH	6-9
- Total Coliform (MPN)	0
- Total Nitrogen (N)	< 30 mg/L
- Ammonia Nitrogen (N)	5 mg/L
- Total Phosphorous (P)	10 mg/L
- Chlorine Residual	0.5 - 1 mg/L

- Design Calculations
 1. The Contractor shall prepare and submit for approval detailed design calculations of all unit processes, structural, mechanical and electrical designs. The Design calculations for treatment processes shall indicate clearly all appropriate design parameters, which are given herein as an example for the extended aeration activated sludge plant:
 - a. Flow - Design. (m³/day)
 - b. BOD₅ (mg/L); BOD₅ at Design Flow (kg/day)
 - c. Total Suspended Solids (TSS) (mg/L); Total Suspended Solids (TSS) at Design Flow (kg/day)

- d. Total Dissolved Solids (TDS) (mg/L)
- e. TKN (mg/L); Total Kjeldahl Nitrogen (TKN) at Design Flow (kg/day)

Additional Design Calculations shall clearly indicate the following:

- f. Screen Bar Width (cm)
 - g. Food To Micro Organism Ratio (F/M)
 - h. Aerator Tank Capacity (m³)
 - i. Recycle Flow (m³/d)
- Oxygen Requirements
 - a. Actual Oxygen Requirements at Design. Flow (kg/day)
 - b. Standard Oxygen Requirements at Design Flow (kg/day)
 - c. kW Required at Peak Flow
 - d. Blower Capacity (m³/sec)
 - e. Oxygen Transfer Efficiency (kg/kW)
 - Chlorination System
 - a. Chlorinator Dosage (mg/L)
 - b. Chlorinator Dosage Rate at Average Flow (kg/day)
 - c. Chlorinator Dosage Rate at Peak Flow (kg/day)
 - Aerobic Digester
 - a. Aerobic Digester Volume (m³)
 - b. Aerobic Digester Volatile Suspended Solids (VSS/day/m³)
 - c. Aerobic Digester Detention Time (days)
 - d. Aerobic Digester Actual Oxygen Requirements (kg/day)
 - e. Aerobic Digester Standard Oxygen Requirements (kg/day)
 - f. Aerobic Digester kW Required
 - Sludge Handling Facilities; example Drying Beds Volume (m³)
 - Membrane
 - a. Type
 - b. Effective pore sizes
 - c. Average flux rate
 - d. Peak flux rate
 - e. Surface area
 - f. Tank requirements
 - Pumping requirements
 - a. Membrane feed pump
 - b. Mixed liquor recirculation pump
 - c. Permeate and back pulse pump
 - d. Membrane basin scum pump
 - e. Drain pumps
 - Standards and Compatibility
 1. The treatment plant shall be designed and manufactured to the highest standards incorporating the latest proven technology and materials and equipment of high quality, suited to its particular application and compatible with all other parts of the system. The Design shall ensure that all items of the plant and auxiliary equipment are compatible with each other.
 2. The design shall comply with the requirements of the standards provided by the following organizations; in addition the Contractor shall adopt the same abbreviations, given herein, in the detailed design documents:

1.	ANSI	-	American National Standards Institute
2.	ASTM	-	American Society for Testing and Materials
3.	ASME	-	American Society of Mechanical Engineers
4.	AGA	-	American Gas Association
5.	BS	-	British Standards Specifications

6.	DIN	-	Deutsches Institut für Normalisierung
7.	ISO	-	International Standards Organization
8.	FM	-	Factory Mutual
9.	NFPA	-	National Fire Protection Association
10.	NBS	-	National Bureau of Standards
11.	SAE	-	Society of Automotive Engineers
12.	UL	-	Underwriters Laboratories
13.	AWWA	-	American Water Works Association
14.	WHO	-	World Health Association
15.	AMAC	-	Air movement and control association
16.	CSI	-	Construction Specification Institute
17.	ICEA	-	Insulated Cable Engineers Association
18.	ICE	-	International Electromechanical Commission
19.	IEEE	-	Institute Of Electrical And Electronic Engineers
20.	NACE	-	National Association Of Corrosion Engineers
21.	NEC	-	National Electric Code
22.	NEMA	-	National Electrical Manufacture Association
23.	NPC	-	National Plumbing Code
24.	OSHA	-	Occupational Safety and Health Administration
25.	UMC	-	Uniform Mechanical Code
26.	BSS	-	British Standard Specification

- Alternative Designs

1. The Specifications are intended to indicate the general performance standards of the plant tenderers may submit offers based upon approved alternative processes provided the performance requirements and guarantees are respected. Alternative offers should be accompanied by the details required in the Tender Submission Requirements and should be submitted in accordance with the Conditions for Tender.
2. However, the Tenderer/Contractor shall submit Tenders based on the processes specified in these performance specifications for the evaluation of the Tender, alternative designs shall not be evaluated but may be considered if Tenderer is selected.

- Other Requirements

1. Notwithstanding any of the conditions and requirements of these Specifications, include for any other items deemed necessary for complete and efficient plant operation.

- Drawings, Specifications, Bills of Quantities and Operation & Maintenance Manuals

1. Fundamental Design Drawings: The Contractor shall prepare and submit fundamental design drawings, not later than one month after the order to commence, for the approval of the Engineer. Four copies of the fundamental design drawings showing, to scale, dimensions of plant components and equipment in plan and elevation, including all necessary calculations that may be required to justify the design shall be submitted. The design drawings shall include manufacturer's drawings, cuts of catalogues, etc..
2. Fundamental design drawings shall include, but not limited to:
 - a. Layout Plan of the Wastewater Treatment Plant showing general arrangement of treatment units and auxiliary building, access roads, setting out details as well as necessary grading and overall dimensions, service connections, etc.
 - b. Site piping layout plans of the treatment plant showing process piping systems (liquid and solid phases), service piping, drainage and flushing pipe systems.
 - c. Site power supply and lighting plans.
 - d. Process flow diagrams showing flows, capacities, power requirements, instrumentation and controls.
 - e. Hydraulic profiles for liquid and solids flows within the treatment plant, showing elevations of the various elements, water levels and their control devices.
 - f. Detailed architectural, structural, mechanical and electrical design drawings for all treatment units and auxiliary buildings.
3. Fundamental design drawings shall be coordinated among all engineering disciplines/trades to permit satisfactory installation and execution of all works and with minimum interference or delay.

4. Equipment and Materials Lists: The Contractor shall submit after 30 days of Letter to Commence lists of equipment and materials, with names of proposed manufacturers, and drawings of interrelated items. Lists and drawings are to show submission dates.
5. Specifications: The Contractor shall submit detailed specifications for review and approval by the Engineer to accompany all drawings describing:
 - a. Type of equipment, performance characteristics, power requirements, motor drive and testing information for all items of the plant.
 - b. Specifications for chemicals to be used, operating and control procedures including proposed applications and rates, and descriptions/specifications of testing equipment and procedures.
 - c. Civil engineering work, including foundations, chambers, positions and sizes of fixings and anchors for equipment, etc.
6. Detailed Design, Shop and Installation Drawings: After approval of fundamental design drawings, the Contractor shall submit for approval, in good time to meet the construction and installation program, four copies of detailed fabrication and installation drawings showing, to scale, dimensions of equipment and ancillaries in plan and elevation and the relation of same to space assigned. Detailed design drawings shall include, but not limited to the following:
 - a. Layout Plans of the Wastewater Treatment Plant showing the general arrangement of treatment units and auxiliary building, access roads, setting out details as well as necessary grading and overall dimensions, service connections, etc.
 - b. Site piping layout plans of the treatment plant showing process piping systems (liquid and solid phases), service piping, drainage and flushing pipe systems. The piping layout shall include all necessary information for the laying out of pipes, including ground and invert levels, length and slope of pipes, as well as details at all pipe crossings showing the crown and invert of all crossing pipes and indicating where necessary concrete encasement requirements.
 - c. Site power supply and lighting plans, with all the necessary information for cable sizes, transformer locations, motor control centers, etc...
 - d. Process flow diagrams showing flows, capacities, power requirements, instrumentation and controls for all unit processes and associated equipment.
 - e. Hydraulic profiles for liquid and solids flows within the treatment plant, showing elevations of the various elements, water levels and their control devices.
 - f. Detailed architectural, structural, mechanical and electrical design drawings for all treatment units and auxiliary buildings.
 - g. Detailed manufacturer's drawings, cuts of catalogues and descriptive literature showing type of equipment, performance characteristics, construction, component parts, dimensions, arrangement, operating clearances, capacity, electrical characteristics, power requirements, motor drive, and testing information.
7. The Contractor shall also prepare and submit for the approval of the Engineer all related architectural, structural, electrical and mechanical shop and installation drawings.
8. Detailed design drawings, shop and installation drawings shall be coordinated with other trades to permit their work to be installed satisfactorily and with minimum interference or delay.
9. The Contractor shall submit certified manufacturer's drawings, templates and installation instructions for all equipment showing operating weights, weight distribution, location of vibration isolation mounts, size and location of anchor bolts, drainage and other openings and other pertinent data to assist in design of bases and supports.
10. The Contractor shall verify exact dimensions in accordance with manufacturer's dimensions and shop drawings, check for error or omission and make corrections to the drawings at no additional cost.
11. The Contractor shall mark clearly in ink catalogues, pamphlets and manufacturer's drawings for proper identification of proposed items and indicate, with justifications, deviations from these Specifications.
12. Shop and installation drawings shall include all pipes, fittings and secondary elements etc., along with their ratings and names of manufacturers. All shall be submitted for the approval of the Engineer.
13. No equipment or materials are to be purchased or delivered to site until drawings, and their corresponding detailed specifications etc. have been approved.
14. Additional Drawings: During the progress of the work, the Contractor shall submit additional design and shop drawings to scale as required by the Engineer and as specified elsewhere.

15. Substitution of Equipment and Materials: Unless otherwise indicated, reference to equipment or material by name, model or catalogue number and list of approved manufacturers to be interpreted as established standard of quality and performance and not intended to eliminate products of other manufacturers having equivalent products.
16. Bills of Quantities: The Contractor shall submit with the Tender, for tender evaluation, detailed priced bills of quantities broken down into all treatment units and buildings, and itemized to include structural and architectural quantities, pipes, valves, chambers, equipment, pumps, electrical system elements, control and instrumentation elements, and all other items that are necessary for the performance of the wastewater treatment facility in accordance with these performance specifications.
17. Operation and Maintenance Manuals: The Contractor shall provide six copies of the Operation and Maintenance (O&M) Manuals in bound booklet in English containing the following information:
 - a. Brief description of each system and piece of equipment with basic operating features
 - b. Descriptive literature of equipment and components with manufacturer's name, model number, capacity rating and operating characteristics
 - c. Service manual prepared by the manufacturer for every major piece of equipment giving operating and maintenance instructions, starting and shutdown instructions, lubrication instructions and list of possible breakdown and repairs
 - d. Manufacturer's list of general spare parts for every piece of equipment, with unit prices
 - e. Manufacturer's list of recommended spare parts for three year of operation for every piece of equipment, with unit prices
 - f. Detailed and simplified one line, color coded flow diagram of each system with tag number, location and function of each valve and instrument
 - g. Detailed and simplified color coded as-installed wiring diagrams of motor controllers and automatic controls with tag number, location and function of each instrument and electrical device with description of sequence of operation and interlocks.
 - h. Detailed planned preventative maintenance system for the process plant and all associated equipment, chlorination system, etc.
18. The O&M manuals shall be submitted in draft form for review and approval prior to final issue and at least four weeks in advance of completion date of treatment facility.
19. The Contractor shall amend and modify the O&M Manual as necessary during the commissioning and testing period as well as during the Defect Liability Period (DLP), all modifications shall be submitted to the Engineer for approval. At the end of the DLP the Contractor shall resubmit the modified/amended O&M Manual to the Engineer/Employer.
20. Record Drawings: The Contractor shall submit an approved complete set of as-built drawings of all unit processes, buildings, including equipment installation drawings, control and instrumentation diagrams as well as all electrical wiring diagrams in tracing and in digital form using AutoCAD.
21. Samples: The Contractor shall submit samples of proposed materials and workmanship for approval as required by the Engineer prior to installation and Construction.

PART 2 - MATERIALS AND COMPONENTS— UNIT/ELEMENT SPECIFIC

2.1 GENERAL

- Plant Life: a design life of a minimum of 20 years is to be adopted for the Plant assuming normal replacement rates of consumables, etc.
- Wastewater Treatment Units: The wastewater treatment plant shall be complete with all treatment components, equipment and appurtenances required to accomplish screening, aeration and mixing, clarification, filtration, chlorination, sludge re-circulation and pumping where needed as well as sludge digestion and dewatering/drying each in separate units.
- Protection Against Corrosion: due to the corrosive nature of the wastewater, all material used in the manufacture of the treatment plant shall be non corrodible where possible; where this is not possible,

materials are to be stainless steel or are to be plastic coated or painted. Any item found to be suffering from corrosion within the Defects Liability Period is to be replaced by the Contractor at no additional cost.

- Noise and Vibration: equipment is to operate under all conditions of load with no objectionable sound or vibration. Any noticeable noise and vibration outside a room in which moving equipment is installed, or annoyingly noticeable inside the room, will be considered objectionable. Noise level resulting from equipment in the same building or nearby buildings is not to exceed 40 decibels as measured with a standard sound level meter on the "A" scale. Noise and vibration conditions that are considered objectionable are to be corrected by approved means, and as directed by the Engineer. Vibration control shall be provided by approved vibration isolators applied and installed in accordance with the manufacturer's instructions.

2.2 PRELIMINARY TREATMENT

- Bar Screen Assembly Bar racks: or mesh screens shall be provided upstream of the grit chambers and shall have easy access for the purpose of inspection and maintenance.
- The selection criteria for the bar racks and/or mesh screens and the respective size of openings shall be based on the expected size range of the solids that need to be removed from the wastewater.
- Mechanically cleaned racks shall be used, two or more units shall be installed so that one unit may be taken out of service for maintenance. Mechanically cleaned bar racks may have spacing as small as 12 mm. A bypass channel with manually cleaned bar rack must be provided in the design. The bypass channel with the manually cleaned rack shall only be used during emergencies such as during power failures, malfunctioning or during maintenance of the mechanical systems. There shall be arrangement for automatic diversion of the flow to the manual rack in case of failure of the mechanical system.
- Screening removal and disposal shall be provided by convenient and adequate means for removing screenings. Facilities must be provided for handling, storage and disposal of screenings. Storage facilities must be covered.
- Separate grinding of screening and return to Wastewater flow is not acceptable.
- Grit Removal Chambers: shall be provided to protect the mechanical equipment from abrasion and the accompanying abnormal wear and tear, all as per the recommendation of the package plant supplier. horizontal-flow grit chambers or other types of grit chambers, such as aerated or vortex-type may be used. At least two mechanically cleaned grit removal chambers shall be considered, the number shall be coordinated with the number of treatment trains. Adequate and flexible control for velocity or air supply shall be provided. Grit washing facilities and temporary storage containers shall be provided before grit is taken away for disposal. The containers shall be covered.
- Flow Measurement: flow metering device shall be provided at the inlet works and shall be of the ultrasonic type or as recommended by the manufacturer. It shall show instantaneous readings as well as cumulative readings. These readings are shown at two locations; the first is at the inlet works, and the other is at the main control panel of the operation of the plant.

2.3 PRIMARY TREATMENT

- The primary treatment I sedimentation tank dimensions shall be selected to maintain the velocity in the tank below the scouring limits so that the settled particles are not scoured from the bottom. The settling tanks shall be at least two in number so that the process may remain in operation while one tank is out of service for maintenance and repairs. The settling tanks shall be provided with proper and safe access for monitoring of operation. The primary settling tank may be rectangular or circular in shape and shall be compatible with the package treatment plant. In any case, the inlet structure of

the settling tank shall be designed in a manner to spread the flow across the tank width, prevent shortcircuiting, and minimize turbulence.

- The selected design parameters such as that of the surface loading, weir loading, or detention time shall be compatible with those of the international standards or guidelines, and shall yield a minimum B.O.D removal of 35%, and a minimum S.S removal of 50% at maximum flow or organic load applications.

2.4 BIOLOGICAL TREATMENT

- The biological treatment shall consist of an activated sludge process, sludge recirculation, and excess sludge disposal system. It shall also include an aeration mechanism to supply the needed oxygen.
- The number of aeration tanks shall be calculated based on the design flow rate and consideration for operational flexibility and ease of maintenance. A minimum of two tanks shall be provided. All aeration tanks shall have a freeboard of at least 0.5 m under the peak flow conditions. Sufficient mixing shall be provided to prevent deposition of solids in the tank under any flow conditions. Criteria for power requirements for mixing shall be maintained.
- The aeration system shall be designed such that it shall maintain the dissolved oxygen not to be less than 2.0 mg/L under all conditions of flow or organic loading and in all areas of the tank. Diffused air system or surface mechanical aerators may be used. Any of these systems shall have enough capacity to provide the necessary oxygen transfer and mixing of the activated sludge. The subsurface diffuser system shall have devices and arrangements for removing, cleaning and replacing diffusers without dewatering the tank. They shall also have non-clog diffusers. The diffuser system shall have individual diffuser header assemblies with air control valves with the provision for throttling of the airflow.
- A service walkway across the top of aeration tank to allow access to the aeration system for service and maintenance shall be provided; the service walkway shall be designed to support the necessary loading and shall be of non-skid metal plate and have a handrail on both sides. Suitable drainage facilities shall be provided for all walkways and storage areas to prevent slippery. Suitable lighting shall be provided in all work and access areas.
- The blowers used with the air diffuser system shall be equipped with automatic reset and restart mechanisms to place the units back in operation after periods of power failure.
- Aeration System
- The aeration system shall be capable of maintaining a minimum of 2.0 mg /l of dissolved oxygen in the mixed liquor at all times and provide thorough mixing of the mixed liquor. Careful consideration should be given to maximizing oxygen utilization per unit power input. The aeration system shall be designed to match the diurnal organic load variation while economizing on power input.
- The air required for pumps, aerobic digesters, filtration and other air-use demand shall be added to the air requirements for the biological treatment. The blowers shall be provided in multiple units, so arranged and in such capacities as to meet the maximum air demand with one unit out of service. The design shall also provide for varying the volume of air delivered in proportion to the load demand of the plant. Aeration equipment shall be easily adjustable in increments and shall maintain solids suspension within these limits.
- Diffuser systems shall be capable of providing for 200 percent of the design average day oxygen demand. The air diffusion piping and diffuser system shall be capable of delivering normal air requirements with minimal friction losses. For minimum mixing and oxygen requirements, an air supply of 0.5 l/s/m³ of the tank volume shall be provided with the largest blower out of service. The spacing of diffusers should be in accordance with the oxygen requirements throughout the length of the aeration tank. Individual assembly units of diffusers shall be equipped with control valves with indicator markings for throttling or for complete shutoff. Diffusers in any single assembly shall

substantially form a uniform pressure loss. Non-clog type of diffusers shall be utilized and diffusers should be designed to permit continuity of service. Air piping systems should be designed such that head loss from blower outlet to the diffuser inlet does not exceed 3.4 kPa at average operating conditions. Air filters shall be provided in numbers, arrangements, and capacities to furnish at all times a sufficient air supply free from dust to prevent damage to blowers and clogging of the diffuser system used.

2.5 CHLORINATION SYSTEM AND CHLORINE CONTACT TANK

- The chlorine contact tank shall have a minimum capacity of contact time of 30 minutes at average flow and 20 minutes at peak flow, and is to be divided into two separate compartments. Internal baffles shall be provided to prevent short circuiting and to ensure uniform mixing. A 90 degree V-notch weir shall be provided at the chamber inlet together with a gauge for direct flow measurement.
- The Chlorination system shall employ single stage chlorination to provide continuous automatic feed of chlorine to the inlet of chlorine contact tanks. An accurate measurement and control of residual chlorine in the treated wastewater at the outlet of chlorine contact tanks shall be provided. The control of residual chlorine shall be done by constantly testing a water sample for residual chlorine and automatically adjusting the chlorine dosing apparatus to maintain the desired residual chlorine in the water.
- Chlorination shall be done by using hypochlorite solutions or by chlorine gas. A stand by unit of chlorine solution preparation and feeding system should be provided. A minimum of two (2) chlorine feeders shall be provided and the standby unit or a combination of units of sufficient capacity should be available to replace the largest unit during shut-downs. Spare parts shall be available for all feeders to replace parts which are subject to wear and damage. Warning signs shall be provided by means of two rigid plastic standard toxic hazard warning signs bearing the word 'CHLORINE' in English, minimum size 600 x 300 mm, fixed in prominent positions of the chlorination plant building or on the chlorination chamber as appropriate.
- Alarms and breathing apparatus: if the chlorination system relies upon the use of chlorine gas (but not if it uses hypochlorite salts) provide adequate safety measures to deal with escape of chlorine into the chlorine building or chamber. Such measures shall include, as minimum, provision of an automatic audible alarm to operate when chlorine in the atmosphere exceeds a pre-set level and provision of suitable breathing apparatus housed in an accessible cabinet, with break-glass door, outside the chlorine building or chamber.
- The chlorination unit shall also be provided with metering and weighing devices such that the daily chlorine consumption and the quantity remaining in the container can be measured.
- In case chlorine gas is used as a disinfectant, the following safety measures must be incorporated into the design of the facility:
 1. Mann system for chlorine leak detection shall be provided. Suitable safety equipment such as gas masks and repair kits shall be provided near the chlorination unit at an easily accessible place.
 2. At least one positive pressure, self-contained breathing apparatus shall be provided outside the chlorination room. A safety shower with eyewash shall be located near the chlorination facility.
 3. Chlorine handling instructions and precautions shall be posted in the chlorination room in English languages and at proper location.
 4. Chlorine cylinders shall be protected from direct sunlight to prevent overheating of the cylinders. During winters, temperatures in the chlorination room shall be controlled to avoid freezing.
 5. The Chlorination room shall be provided with adequate exhaust ventilation at floor level. The ventilation system shall be capable of at least 60 air changes per hour. Emergency caustic scrubbers with automatic operation shall be installed in the chlorination room.

- Chlorine in solution form shall be handled in polyvinylchloride (PVC) piping.
- Chlorination facility shall be established in a separate enclosure or room and shall be walled off from the rest of the plant buildings and shall only be accessible from outdoors. A fixed glass viewing window shall be provided in an inside wall.
- The exhaust fan and lighting switches shall be located at the room entrance. The exhaust system outlet shall be directed away from the fresh air intake and away from other occupied areas.

2.6 TERTIARY TREATMENT SYSTEM AND STORAGE TANK

- The Storage tank shall have a minimum capacity of 3 days and is to be divided into two separate compartments. Internal baffles shall be provided to prevent short circuiting and to ensure uniform mixing.
- Tertiary treatment system shall be used to ensure the usage of effluent for irrigation and service systems. Tertiary treatment system shall include but not limited to transfer booster pump set, pressure tank, coagulant Solution tank and Feeder, Multimedia filter, Activated Carbon Filter, Chlorine Solution tank and feeder, pipes and valves, Control panel and wiring with all necessary materials / accessories required for a proper operation.

2.7 AIRLIFTS, DRAIN LINES AND MISCELLANEOUS PIPING

- All airlifts, drain lines, and miscellaneous piping shall be made of galvanized steel pipe for diameter of 75 mm and smaller and ductile iron pipe for larger diameters.
- The fittings for the galvanized pipes shall be galvanized malleable iron; fittings for the ductile iron pipe shall be cast or malleable iron. The air supplied to the airlifts is to be regulated by gate valves.
- All external pipe connections including influent, effluent, sludge draw-off, plant drain and air piping connections are to be terminated with flanged ends at the outer tank walls.
- Return sludge airlifts made of ductile iron for the transfer of sludge from the clarifiers to the aeration tanks, shall be provided. Airlifts are to be sized for a minimum of 100 per cent of the average daily design flow of the plant. Airlifts pipe should be at least 75 mm in diameter. Manually operated valves are to be furnished for regulation of the air supply to the return sludge airlifts.
- Waste sludge airlifts for the transfer waste sludge from the clarifier to the aerobic digesters as required, shall be provided. The waste sludge airlifts are to be attached directly to the return sludge airlifts to ensure the maximum concentration of waste sludge. The waste sludge airlifts are to have a capacity of not less than 25 per cent of the design average rate of wastewater flow. . Sludge airlifts shall be equipped with a manually operated valve to regulate the air supply.
- Adjustable decanting airlifts with enough capacity are to be provided to return aerobic digester supernatant liquor to the aeration tanks. The intake of these airlifts is to be vertically adjustable to a minimum of 45 cm to allow supernatant removal from 20 cm to 65 cm below the design water level in the digester.

2.8 FOAM CONTROL SYSTEM

- A water spray system for the control of foam shall be provided including submersible pumps of adequate capacity installed in the clarifiers to supply water to circular spray nozzle headers on the tank walls. The nozzles are to be designed to produce a flat, hard spray when discharging Approximately 8.0 liter/min at 0.7 kg/cm² and are to be spaced at distances not exceeding 1.20 m center to center along the inner wall of the aeration tanks.

2.9 SLUDGE STABILISATION AND DISPOSAL

- The sludge stabilization system shall include provisions for aerobic digestion, supernatant separation, sludge concentration, and mechanical dewatering. Some of these provisions may be accomplished by separate tanks or processes. or in the sludge stabilization tank.
- The volume/capacity of the sludge stabilization tank shall be based on the solids retention time of 15 days minimum with solids concentration of 2 percent and with supernatant separation performed in another separate tank (compartment). If supernatant separation is to be performed in the sludge aeration tank a minimum of 25 percent additional volume should be provided.
- Air Requirements: sufficient air shall be provided to keep the solids suspension and maintain dissolved oxygen at 2.0 mg/l
- Supernatant Separation: facilities shall be provided for the effective separation of supernatant. Separation facilities are recommended, however, supernatant separation may be accomplished in the aeration sludge tank if an additional volume, of 25 percent is provided. The supernatant draw of the unit shall be designed to prevent recycle of scum and grease back to plant process units.
- Scum and Grease Removal: facilities shall be provided for the effective collection of scum and grease from the sludge aeration tank for final disposal to prevent its recycle back to the plant process and to prevent long term accumulation and potential discharge in the effluent.
- Mechanical Dewatering Facilities shall be provided for the treatment plant. Dewatering facilities may also include chemical preparation and addition, sludge hauling and storage.. The design shall provide for odor control in sludge storage tanks including covering or other appropriate means besides the aeration process.

2.10 ALARMS

- Alarms shall be provided for all Sewage treatment systems to provide warning of loss of power (from the normal supply) and failure of any portion of the Sewage treatment system.
- All required alarm devices shall be independent of the normal power supply of the Sewage treatment plant.
- Individual alarm devices shall be connected to a master alarm in a location where they can be conveniently observed by an attendant or other responsible person designated by the management of the Sewage treatment plant. In cases where the plant is not attended full time, the system shall be connected to an alarm at the security office, utilities office, fire station or other full-time service unit with which arrangements can be made to alert the person in charge of the plant.

2.11 SAFETY AND INDUSTRIAL HYGIENE

- A. The Contractor shall provide for the following safety and hygiene measures:
 1. Lifesaving buoys/markers/floats and other Personal Flotation Devices (PFD'S) as well as rescue poles shall be provided adjacent to large bodies of Sewage.
 2. Personal protective equipment shall be provided.

2.12 LABORATORY EQUIPMENT AREA

- Workshop: The Contractor shall submit for the Engineer's Approval within the tender phase a complete list of the mechanical items needed for the proper operation and maintenance of the Wastewater treatment plant including tools machinery, measuring devices benches and any other equipment needed for the same application. In addition, the Contractor shall submit for the Engineer's Approval within the tender phase the proposed layout for Laboratory area showing the adequate area requirement and furniture for the Engineer evaluation and approval.
- The Contractor shall submit for the Engineer's Approval within in good time to meet the approved construction and installation schedule the detailed design drawings along with all necessary shop and installation drawings.
- Laboratory Equipment:
 1. Laboratory Equipment: The Contractor shall submit for the Engineer's Approval within the tender phase a list of the necessary laboratory equipment needed for the proper operation and quality check of the influent and effluent Wastewater water. Laboratory equipment is to include all necessary tools including but not limited to the following:
 - a. Benches and Laboratory swivel chairs
 - b. Microscope.
 - c. Portable Laboratory suiting the application.
 - d. PHTMV meter.
 - e. Incubator.
 - f. Multiple stirrer.
 - g. Hot plate.
 - h. Spectrophotometer (Wastewater)
 - i. Autoclave.
 - j. Fume Cupboard.
 - k. Two sinks, Water tap etc.
 2. Laboratory area Power Supply: The Laboratory area shall be provided with all necessary power supply equipment, lighting, socket outlets and electrical connections to the laboratory meeting laboratory application requirement of adequate power supply and rating including the necessary protection. All connections shall be made from the nearest power supply source. 3. Laboratory Water Supply and Drainage System: The Laboratory area shall be provided with all necessary water supply and drainage connection; these shall be supported by all necessary design calculations for the sizing of pipes, fittings, and connections, for the water supply and building wastewater discharge and storm water drainage. The Contractor shall submit for the approval of the Engineer the proposed pipe materials which shall be selected to suit the application/use intended and to ensure the satisfactory operation of the laboratory.

2.13 MECHANICAL EQUIPMENT

- Air blowers: Air blowers shall be of the volumetric type cast iron, with chromium plated nickel shaft on ball bearings, helical control gear immersed in oil, semi elastic coupling sleeve under protective casing, horizontal motor with attachment brackets and enclosure, one metal pedestal common to the complete assembly. Blower shall be provided with the following accessories:
 1. At suction inlet: air filter, silencer and flexible connection
 2. At discharge outlet: silencer, check valve with light weight clapper, safety valve, flexible connection.

Overhead Traveling Cranes: The Overhead Traveling Crane equipment shall conform to the following:

1. Type: Electric travelling cranes shall be of the single or double girder, dual rail overhead travelling crane specifically designed and supplied to fit the dimensions of the structures within which they are installed as shown on drawings. They shall include but not be necessarily limited to: crane bridge, hoist unit, control gears and crane controls, all as required for proper and safe operation of the crane.
2. Crane Bridge: The crane bridge shall be of welded, high strength, rolled carbon steel, and shall consist of a single or double girder designed to safely carry the full rated load of the crane with stresses and deflections not exceeding those permitted for class II duty according to BS 2573 or approved equal. The girder shall be of universal beam or double box web fabricated plate box section fitted with a suitable track on which the trolley carrying the hoisting machine shall run. The crane bridge shall be provided with steel end stops with rubber buffers to prevent over running or damage due to collision. The crane end carriages shall be steel sections and shall be designed in the form of a box to incorporate the suitable wheel assemblies. Each end of the carriage shall incorporate the necessary rubber buffers. The drive machinery shall be provided with a suitable number of travel wheels. The wheels shall be heat treated and machined to uniform diameter. Wheels shall be designed to be easily removable for maintenance. All wheels shall be protected by guards. No wheels shall be overhung. The drive unit shall consist of a drive motor with gearbox directly coupled to the wheels axle.
3. Hoist Unit: shall be fabricated from steel sections and mild steel plate adequately braced to resist stresses and shall be welded together to form a rigid frame. The trolley drive shall consist of a drive motor fitted with a steel machine cut pinion engaged with travel spur gearing. The wheels shall be of the single flanged type supported on fixed axles. The wheels axles shall be fitted with ball bearings lubricated for life. The hoisting machinery shall be provided with one mechanical load brake and one magnetic motor brake with electric wire rope hoist of open barrel design. The motor shall be mounted on the barrel with an enclosed oil immersed gearbox. The brake motor and system shall be designed so that the brake can be effected in a minimum of time. The hoisting machinery shall be equipped with a wire rope guide and with safety limit switches to prevent over and under winding. The wire rope shall be flexible steel of 180 kg/mm² minimum breaking load and minimum factor of safety of 6. The load block shall be fully enclosed, with antifriction sheaves and forged steel hook mounted on an anti-friction thrust bearing. The hook shall be X-rayed to reveal any hidden defect.
4. Control Gears: shall be of damp and dust proof sheet steel panels mounted on the hoist trolley. The panels shall have hinged access doors and shall be incorporated with isolator switches, low voltage step down transformers, contactors, fuses and all wiring. The starter of the travel drive motor shall be of type to give smooth acceleration of the motor when starting. The control gears shall be fitted with over limit switches.
5. Crane Controls: The crane shall be controlled from a push button pendant suspended from an independent track running the full span of the crane. The pendant shall be incorporated with an emergency stop mushroom head button which shall isolate all power circuits by tripping out the main contactor.
6. Marking: The safe working load shall be clearly marked in large print on the unit in English and Arabic on the finish coats. Stencils shall be supplied with the cranes for purposes.

2.14 PUMPS

General Materials and Products

1. Materials for pumps are to be suitable for pump operating conditions and adequate for total heads to which pumps are subjected. Corrosion resistant materials are to be used. Pump shafts shall be of stainless steel. Assembly arrangements are to include isolation of dissimilar metals to avoid galvanic interaction. For raw and return sludge pumps all anchor bolts, nuts and washers shall be hot dip galvanized.
2. Connections: pumps are to have factory plugged connections for casing vent, drain and suction and discharge pressure gauges.
3. Impellers and rotating assemblies are to be statically and dynamically balanced at factory.
4. Packing Rings are to be installed in alternative layers staggered 90 degrees. Packing is to be tightened for seal while permitting prescribed amount of leakage for lubrication.

5. Seals: pumps are to have shaft packing or mechanical seals compatible with pump design and nature of liquid pumped in accordance with manufacturer's recommendations or as specified.
6. Operating Characteristics: pump operating point of specified flow and head is to fall near the point of maximum efficiency as obtained from manufacturer's published data.
7. Horsepower rating of pump drive motor is to ensure non-overloading of motor throughout capacity range of pump for impeller diameter selected.
8. Common Base: where applicable, pumps are to be provided from factory complete with electric motors mounted on common steel base and properly aligned.
9. Pressure Gauge: to be provided in the suction and discharge lines and to be bourdon tube type, minimum 100 mm dial diameter, with flangeless back and 12.7 mm male threaded bottom connection with isolating cock and graduated in kg/cm² with 0.1 kg/cm² divisions. Gauge to have black finished cast aluminum case, threaded black epoxy cast aluminum ring with gasketed glass face, type 316 stainless steel spring tube, stainless steel precision movement and micrometer adjustment on needle. Pressure gauge shall be liquid-filled with viscous lubricant constantly bathes internals and dampens effect of vibration and pulsation.

• Vertical Dry Pit Direct Coupled Pump

1. Type: vertical, dry pit, end suction, centrifugal type, specially designed for application. Pump is to be directly coupled to vertical electric motor through flanged connecting piece and machine rabbet fitted to pump bearing bracket and to electric motor to form a self-contained compact unit ensuring permanent alignment of motor and pump. Motor shaft is to be connected to pump shaft with heavy duty flexible coupling. Pump is to have substantial cast iron stool support flange connected to pump casing with machined rabbet fit and with flanged suction elbow with cleanout opening and cover.
2. Casing: best quality close grained cast iron, with inspection opening and cover and tapped holes for air release and pressure gauges etc.
3. Impeller for raw sewage application is to be best quality bronze, of open, balanced non-clog design capable of handling raw sewage and passing an 80 mm sphere. Impeller is to have on its back, grit expeller vanes to prevent grit from working up impeller and causing wear. Impeller is to be screwed to shaft and arranged to tighten with rotation. Locknut is to prevent impeller from unscrewing when motor stops or is turned in opposite direction. A replaceable stainless steel wearing as plates to be added to provide a renewable projective surface.
4. Shaft: best quality stainless steel, stress-relieved and turned and ground to fine tolerances. Shaft is to be fitted at gland box end with renewable, stainless steel sleeve.
5. Bearings: pump is to have heavy duty ball and roller outer and inner bearings mounted in accurately machined cast iron housings and sealed with end caps, with provision for absorbing shaft end thrust. Bearings are to be grease lubricated. Pump is to have grease nipples and a grease gun is to be provided from factory. Bearings are to have first filling of grease at factory.
6. Seal Gland: comprising cast iron stuffing box of removable split type, renewable gun-metal neck bushing, screwed gun-metal nut, spring loaded locking device and lantern ring for water seal. Porous fine grade stone filter is to be mounted on pump and connected to pump discharge and to gland seal chamber to maintain filtered water supply to seal gland. Gland spanner, packing extractor and first filling of gland packing are to be provided with each pump from factory.
7. Motor: vertical, totally enclosed, fan cooled, squirrel cage type, continuously rated, of weatherproof and tropicalized construction (IP 56 with class F insulation), suitable for operation in ambient temperature specified. Motor horsepower is to ensure non-overloading of motor throughout capacity range of pump.
8. Control: pumps are to be provided from factory with float less control relays with electrodes for automatic control. Sets of electrodes are to be installed in wet sump at levels shown on the Drawings.
9. Operation: level regulators are to start and stop pumps at preset levels through the motor control panel. Starting sequence of pumps is to be automatically alternated through the electric alternator in motor control panel. In the event of a fault in one pump, electric alternator is to switch off defective pump and start stand-by pump and with an alarm signal. Means are to be provided for permitting manual selection of lead and lag pumps.

10. Motor Control Panel: comprising heavy gauge welded sheet steel case. with non-lift-off front door and concealed hinges, weatherproof and tropicalized, with baked-on enamel finish, wall mounted and containing, but not necessarily limited to, the following:
 - a. triple pole hand operated isolating switch mechanically interlocked to front door
 - b. circuit breakers for branch circuit protection
 - c. three line star/delta contactors
 - d. stop/start push buttons mounted on front door
 - e. triple pole thermal overload relays with single phase prevention
 - f. electric alternator
 - g. 24 V control circuit transformer
 - h. indicating lamps for pump in operation
 - i. running hour meter
 - j. current meter for each phase
 - k. accessories required for automatic operation of pumps as described
 - l. interconnecting and interlock wiring
 - m. Motor control panel to include a separate panel for well level indicators and H2S gas indicator.
11. Factory Painting: pump outer casing are to be protected at factory by shot blasting and priming with suitable epoxy. Casing is then to be given one undercoat and one top coat of chlorinated rubber of approved colour to 3 mils thickness for each coat.

• Submersible Pump

1. Type: non-clog, centrifugal, submersible, quick-disconnect type, suitable for application and designed to permit quick and easy ground level removal of pump from pit for service or inspection without disconnecting or disturbing discharge piping and electrical connection. Pump design is to permit pump to be automatically connected to discharge elbow in a tight and leak-proof manner without axial or lateral movement and without further adjustment. Pump is to be designed to withstand dry running.
2. Components: each pump is to be supplied complete with the following:
 - a. lose-coupled submersible vertical electric motor
 - b. required length of durable multi-conductor electric cable
 - c. special quick-disconnect flanged discharge elbow with integral bracket for floor mounting and lower guide rail holder
 - d. required length of galvanized steel guide rails
 - e. upper guide rail bracket
 - f. rail-guided lifting assembly
 - g. lifting yoke and galvanized chain for raising and lowering pump.
3. Casing: best quality close grained cast iron volute, horizontally split. Passageways are to permit smooth flow of liquid served and are to be free from sharp turns and projections. Pump volute bottom and impeller are to have easily replaceable stainless steel wear rings.
4. Impeller: bronze single channel type running in volute, suitable for service required, non-clog and dynamically balanced for smooth operation.
5. Internals Parts including studs, nuts and screws are to be stainless steel.
6. Motor: class F insulation, designed for use in hazardous locations, suitable for continuous duty, with horsepower to ensure non-overloading of motor throughout capacity range of pump. Motor is to have cast iron frame, stainless steel shaft, double mechanical shaft face seals of carbon/tungsten carbide, built-in thermal overload protection and moisture sensing probes.

7. Bearings: pump and motor bearings are to be heavy-duty, permanently lubricated and sealed ball bearing type, not requiring relubrication on site.
8. Level Regulators: pump is to be supplied from factory with ultrasonic type level sensor system of corrosion resistant material, to make it suitable for either starting or stopping motors.
9. Automatic Control: level regulators are to start and stop pumps at preset levels through the control panel. Levels are as shown on the Drawings. In the event of a fault in one pump, control panel is to switch off defective pump and start stand-by pump and with an audiovisual alarm. Starting sequence of pumps is to be automatically alternated through the control panel.
10. Motor Control Centre: weatherproof and tropicalized for outdoor installation, with lockable cover and completely assembled, wired and tested at factory ready for installation with simple external electrical connections. Panel is to contain, but is not necessarily limited to, the following:
 - a. motor starters
 - b. over-riding starter buttons
 - c. indicating lamps for pump in operation
 - d. reset buttons for overload relays
 - e. electric alternator for required number of pumps
 - f. 24 V control circuit transformer
 - g. running hour meters to record time each pump is in operation
 - h. accessories required for automatic operation of pumps
 - i. audio-visual (light and sound) fault indicator
11. Factory Painting: pump outer casing is to be factory protected by shot blasting and priming with epoxy suitable for duty. Casing is then to be given two coats of epoxy resin, to 5 mils thickness each coat.

Plunger Sludge Pump

1. Type: positive displacement, multiple cylinder, single or double acting type, specially designed for handling sludge and having large diameter pistons working at slow speed and short stroke.
2. Components: pump is to comprise pump body, pistons, cylinder liners, suction and discharge valves, adjustable eccentrics, crank-shaft, piston rods, crank-shaft and piston rod bearings, reduction gearbox, protected V-belt drive, electric motor and accessories all assembled on common cast iron baseplate, aligned and tested at factory and delivered as a compact unit ready for installation and operation with simple piping and electrical connections.
3. Pump Body: close grained cast iron, with integrally cast crank-shaft bearing housing supports with machined flanges for mounting flanged suction and discharge valves.
4. Suction and Discharge Valves: ball or hinged flap type, with flanged cast iron valve chambers with wide passageways and full face openings to prevent choking. Valves are to have easily removable covers for easy access to inside. Valve balls or flaps are to be covered with rubber.
5. Eccentrics: to be easily adjustable for varying length of stroke and quantity delivered.

6. Glands between pistons and pump body are to be standard soft packings or sealing rings arranged for easy replacement.
7. Crankshaft Bearings: heavy duty, grease lubricated, ball bearing type, mounted in machined moisture and dustproof cast iron housing and with easily accessible grease fitting for positive bearing lubrication.
8. Piston Rod Bearings: bronze sleeve journal type, drip feed oil lubricated, with easily accessible lubrication drip feeders and lubrication lines.
9. Reduction Gearbox: totally enclosed type, with gears running in oil.
10. V-belt Drive: motor is to be connected to countershaft of gearbox by suitably guarded V-belt drive. Motor base is to be adjustable for belt tension adjustment. Drive is to incorporate shear pin overload release for positive overload protection.
11. Motor: totally enclosed, fan cooled, squirrel cage, continuously rated type, weatherproof and tropicalized., for operation in ambient temperatures specified and fitted with ant condensation heater. Motor horsepower is to ensure no overloading of motor under all conditions of load.
12. Air Chambers: pump is to be fitted at factory with the following:
 - a. adequate air chambers on both suction and discharge to even out pulsations
 - b. combined pressure relief and by-pass valve easily settable to any desired pressure and piped from discharge side to suction side of pump
 - c. means to start pump without load and gradually apply pressure to delivery pipe.
13. Accessories: pump is to have pressure gauge on discharge side, combined pressure and vacuum gauge on suction side, drain plugs, air release valves, sampling connection, revolution counter and accessories recommended by the manufacturer.
14. Automatic Operation: level control electrodes are to start and stop duty pump's at preset levels through the motor control panel. Electrode switches are to be weather-proof and tropicalized and electrodes and holders are to be suitable for use in liquid served.
15. Motor Control Panel: comprising heavy gauge welded steel case with non-lift-off front door and concealed hinges, weatherproof and tropicalised, with baked-on enamel finish, wall mounted and containing. but not necessarily limited to. the following:
 - a. triple pole hand operated isolating switch mechanically interlocked to front door
 - b. circuit breakers for branch circuit protection
 - c. three line star/delta contactors
 - d. stop/start push buttons mounted on front door
 - e. triple pole thermal overload relays with single phase prevention
 - f. hand/off/auto switches
 - g. duty/standby selector
 - h. anti-condensation heaters
 - i. current meter for each phase
 - j. accessories required for automatic operation of pumps
 - k. running hour meter
 - l. interconnecting and interlock wiring
16. Factory Painting: steel surfaces are to be factory protected by shot blasting, zinc sprayed to 3 mils thickness and given one coat of priming paint, one undercoat and one top coat of

chlorinated rubber of approved color to 3 mils thickness each coat. Cast iron surfaces are to be shot blasted, primed and finished with one undercoat and one top coat of chlorinated rubber of approved color to 3 mils thickness each coat.

- End Suction Centrifugal Pump

1. Type: horizontal, base mounted, end suction, single stage, centrifugal type, directly connected to motor through heavy duty flexible coupling, with heavy gauge coupling guard.
2. Base: pump and motor to be mounted on common steel base reinforced against deflection, with drip rim, drain tapping, bolt holes and grouting hole.
3. Pump Casing: high tensile strength close grain cast iron with smooth waterways, register fitted and bolted to bearing frame for permanent alignment, with bronze wear rings and tapped and plugged bottom drain and top vent connections.
4. Impeller: bronze or chrome molybdenum, enclosed type, fitted to shaft with key and locked in place.
5. Shaft: one piece stainless steel, sized to carry axial and radial thrust with minimum deflection.
6. Mechanical Seal: cartridge design with silicon carbide rotary face and ceramic or tungsten carbide stationary face.
7. Bearings: pump rotating element to be supported by two heavy duty grease lubricated ball bearings mounted in heavy iron frame with supports to base for maximum rigidity.
8. Electric Motor: totally enclosed, squirrel cage, induction type with permanently lubricated and sealed ball bearings. Motor Horsepower: is to ensure non-overloading of motor throughout capacity range of pump.

- Split Case Centrifugal pump

1. Type: horizontal, base mounted, horizontally split case, double suction, single stage, centrifugal type, directly connected to motor through heavy duty flexible coupling and with heavy gauge coupling guard.
2. Base: pump and motor to be mounted on common steel base reinforced against deflection, with drip rim, drain tapping, bolt holes and grouting hole.
3. Pump casing: cast iron, high tensile strength alloy, designed for working pressure of 1.7 MPa, fitted with easily removable bronze wear rings dowelled to casing. Casing to be divided at horizontal centerline and the two halves accurately machined, dowel aligned and bolted together.
4. Suction and Discharge Nozzles to be in-line piping design, cast integrally with lower half of pump casing to allow rotating element to be removed without disconnecting suction and discharge flanges.

5. Impeller: bronze or chrome molybdenum, enclosed, double suction type, fastened to shaft by stainless steel key and screw locked adjustable shaft sleeves.
6. Mechanical Seal: tungsten carbide/ceramic material.
7. Bearings: pump rotating element to be supported by two heavy duty grease lubricated ball bearings for both radial and thrust loads, mounted in machined moisture proof and dustproof cast iron housings bolted to pump casing with register fits to ensure permanent alignment. Bearing housing supports to be cast integrally with lower half of pump casing. Bearings to have grease seals and water slingers to protect bearings from contamination and easily accessible grease fittings for positive bearing lubrication.
8. Electric Motor: totally enclosed, squirrel cage, induction type with permanently lubricated and sealed ball bearings. Motor Horsepower: is to ensure non-overloading of motor throughout capacity range of pump.

2.15 ELECTRICAL ELEMENTS

- Panel boards
 1. The main incoming to the main panel board shall be air circuit breaker and outgoings are to be molded case circuit breakers to be in accordance with IEC 60947-1&2, enclosures shall be in accordance with IEC 60439-1 with over-current, short circuit and earth leakage protective devices, IP42 enclosure, copper bus with current density not more than 1.5A/mm², compression type main and neutral lugs, indicating lamps, directory, etc.
 2. Distribution panel boards shall be floor/wall mounted metal cased with incoming moulded case switch and outgoing moulded case circuit breakers. Final branch circuit panel board is to be metal cased, single/three phase, surface mounted with suitable rated isolating switch and earthing terminal busbar with suitably rated outgoing miniature circuit breakers.

- Wires and Cables
 1. All wiring for lighting installation shall be copper conductor with PVC insulation with minimum size of 2.5 mm² in heavy gauge PVC pipes.
 2. All wiring for socket and power installation shall be copper conductors with PVC insulation with minimum size of 4 mm² in heavy gauge PVC pipes.
 3. All wiring for all mechanical equipment shall be copper cables XLPE/PVC or single core PVC wires in conduits shall be used as appropriate.
 4. All terminals are to be proofed against moisture ingress and labeled at both sides of the cables.
- Earthing System
 1. System: TN-S according to FEE -wiring regulations.
 2. System Equipment: annealed copper conductors bare or PVC insulated according to IEE Regulations.
 3. Earth Source: Copper-clad steel earth rods: each rod shall be driven to a minimum depth of 3 meters.
 4. Earth Busbars: Hard drawn copper.
- Wiring Devices And Components
 1. Lighting switches: Grid type, 10A, rocker, 1-pole with suitable earthing terminal to BS 3676 and IEC 60669-1.
 2. 1-phase socket outlets: rated 16A, 250 V, 2 pin round holes, earth contacts.
 3. Suitably rated disconnect switches shall be provided for all equipment.
- Lighting System
 1. The Contractor shall provide all lighting fixtures with suitable degree of protection as approved to give illumination levels as per CIBSE recommendations for all working and circulation areas.
 2. The lighting source shall generally be fluorescent.

- Remote Motor Control Panel: The Contractor shall provide a free-standing, floor mounted control panel, IP54 rated, fully gasketed and complete with a lockable door and door interlocked isolator. Circuit breakers, motor starters, selector switches, time clocks, relays and alarm devices necessary for the operation of the wastewater treatment plant shall be provided. Circuit breaker load centre shall also be supplied and shall comprise individual circuit breakers for all plant equipment, adequately sized to handle the required load. Individually enclosed circuit breaker and starter with stop-start push button and running pilot lights shall be supplied for the sludge drive motor and froth spray pump.
- Bridge-Mounted Electrical Equipment:
 1. A terminal type junction box shall be supplied to allow conduit and wire termination for all bridge mounted equipment. When the central panel is remote from the plant, safety disconnects are to be furnished for all bridge mounted motors. An airlift skimmer control with hand-off auto selector, solenoid valve and adjustable limit switch shall be supplied. The skimmer control shall be adjustable from 15 to 60 per cent of full scrape arm rotation to allow automatic cut-on when the skimmer arm passes the scum collector box and cut-off at a predetermined percentage of rotating by the skimmer arm.
 2. The gear reducer for the sludge drive is to be torque protected by a built-in over-torque limit switch with contacts in the motor starter and alarm circuit. Should the sludge drive unit become overloaded the alarm circuits are to be activated.
 3. A push button to silence alarm horn, with automatic reset after the alarm condition has been cleared, is to be provided. The alarm light is to remain ON until the alarm condition has been cleared and automatically reset.
 4. All conduits and wire sizing shall be in strict accordance with the IEE regulations. All bridge mounted equipment are to be pre-wired at the factory.

2.16 CENTRAL CONTROL AND MONITORING

- System: the plant shall be centrally controlled and monitored from a central operator desk linked to remote sensing devices to provide a complete automatically controlled and monitored system.
- Control Desk: The plant shall be provided with Control Desk that will ensure automatic operation. The Control desk shall include warning indicators, visual/audible alarms, automatic shut-down and correction devices.
- Metering: volume and flow rate of liquid are to be metered: tank level indicators shall be provided.
- Dissolved Oxygen Controllers shall be provided to ensure the continuous monitoring of the dissolved oxygen content in aeration and sludge digestion tanks. In case dissolved oxygen drops below 2.0 mg/l, an alarm signal shall be activated at the central operation console.

2.17 CONSUMABLE, SPARE PARTS, TOOLS AND ANCILLARIES

- Consumables: The Contractor shall provide a twelve month supply of chemicals over and above those required for commissioning and testing. Prior to Taking Over.

- Consumables and Spare Parts: an itemized list of consumable and basic spare parts for one (1) year operation shall be provided. Manufacturer's recommended spare parts for two (2) years normal operation for all items of plant and equipment are to be supplied, to the approval of the Engineer.
- Tools: all specialist maintenance tools are to be provided for normal maintenance and servicing of the plant. Hand tools to be presented in a steel lockable tool box or boxes and larger equipment to be suitably packed for protection until needed on site.

PART 3 - EXECUTION

3.1 GENERAL

- Delivery and Protection: all materials and equipment are to be adequately packed and prepared for overseas shipment including boxing, crating, skids, lifting eyes and slings. Special care is to be taken to protect all materials and equipment against corrosion and damage during transportation and any period of storage after delivery. Adequate temporary storage of the components of plant are to be provided by the Contractor to the approval of the Engineer.
- Installation: the Wastewater treatment plant units and equipment shall be installed in accordance with the manufacturer's instructions upon prepared foundations. These are to be designed taking into account ground conditions and the loads to be imposed upon them.
- Painting: all metal work is to be sand blasted before painting with a primer compose of two coats of lead or approved rustproof paint before leaving the manufacturer's works. A third coat of red lead of rust proof paint is to be applied after completion of erection. Two finishing coats of epoxy polyamide paint are to be applied to the metal work expose to the atmosphere. Two coats of approved epoxy coating are to be applied to surfaces in contact with Wastewater. The finished thickness of the coating is to be not less than 2.0 mm. All equipment is to have a factory applied enamel paint finish.
- Material and Equipment: the Contractor shall supply all necessary materials and construct suitable foundations for the equipment.
- Labor: skilled labor shall be used to install and set the pumps, chemical dosing equipment and other equipment as per manufacturer's instructions.
- Pipe, Fittings and Valves shall be accurately laid to lines and grades as directed by the Engineer.
- Pipe Supports: all necessary pipe supports shall be provided.
- Protection on Site: close open ends of work with temporary covers or plugs during storage and construction.

3.2 TESTS

- Tests: all items of plant are to be tested as provided under the appropriate internationally recognized standards related to the manufacture of that item. Results of all such tests are to be supplied to the Engineer.

- Tests at Factory: all materials and components are to be tested at the place of manufacture in accordance with approved industrial standards. Tests are to be carried out by an independent inspecting agency approved by the Engineer. Inform the Engineer at least one month in advance of the date proposed for tests.
- Test Certificates: provide the Engineer with copies of test certificates signed and stamped by the inspecting agency before shipping the goods.
- Test on Site: carry out tests on Site as laid down by the manufacture and as ordered by the Engineer to show that the treatment plant conforms with all design criteria.
- Test at Works: on completion of plant fabrication; carry out test run of the plant under simulated operating conditions to verify design assumptions to the approval of the Engineer. On successful completion of the tests, replace all consumable items and prepare the plant for shipment. Submit test readings and results to the Engineer.
- Tests before Taking Over: the complete full installed and commissioned Wastewater Treatment Plant is to be subjected to a test for 8 hours per day for a total of 24 hours for each unit. On completion of the 24 hour test the plan is to be further tested for a total of 24 hours with all units working together, monitored by the Engineer's Representative, with the collection of all data deemed necessary. Wastewater for system testing shall be provided by the Contractor in sufficient quantities on site. After completion of tests, tanks are to be flushed and cleaned if system is not to be put in the normal operation immediately.
- Operation Test: after the plant has been used for 90 days, a final 24 hour test is to be carried out on all units monitored by the Engineer's Representative and the plant is to be adjusted to optimum operational efficiency. Wastewater for system testing shall be provided by the Contractor in sufficient quantities on site.
- Defects: if any defects arise during the tests, they are to be rectified and the tests are to be recommenced from the start.
- Taking Over: the Certificate of Completion will be issued by the Engineer as stipulated in the Conditions of Contract upon the completion and approval of all the tests described above.

3.3 CONCRETE STRUCTURES

- General: design and construct reinforced concrete foundations for all plant, with all necessary anchors and fixings and sleeves for services etc.
- Reinforced Concrete is to be sulfate resisting, grade not less than Class A.
- Plain Concrete is to be sulfate resisting, grade not less than Class B
- Blinding Concrete is to be sulfate resisting, grade not less than Class C
- Protective Treatment: all concrete in contact with ground is to be protected with bituminous solution as a minimum and/or with membranes depending on the groundwater table level, all to the approval of the Engineer. In addition, all reinforcement shall be protected against corrosive environments that are specific to concrete in contact with wastewater.

3.4 LABELS, TAGS AND CHARTS

- The Contractor shall label and identify equipment, instruments, controls, electrical devices, valves, etc. as to duty, service or function. Label controls and electrical devices to indicate clearly what they control. All labels shall be attached to equipment, etc. or to adjacent permanent surfaces in an approved permanent manner.
- Tags shall be used to label all controls and instruments that cannot be easily identified with Bakelite labels. The Contractor shall tag valves and controls except equipment shut-off valves located at the equipment.
- The Contractor shall submit for approval a schedule of equipment and devices to be labeled and tagged, with suggested nomenclature.
- The Contractor shall prepare and submit for the approval of the Engineer the following Charts and Schedules:
 1. Schematic flow diagrams of each piping system with location and function of each valve and with type and size of each essential feature of the system.
 2. Schedule for equipment lubrication and maintenance and essential operating instructions.
- All approved charts and Schedules shall be mounted on wooden plaques or 6 mm Masonite boards, covers with heat bonded clear plastic laminate or frame under glass and permanently fix with four brass screws at approved locations.
- Nameplates: each piece of equipment is to have a conspicuous certified nameplate permanently attached at the factory printed or stamped clearly with name and address of manufacturer, equipment model number, serial number, date of manufacture, electrical characteristics, performance rating or duty, pressure, temperature or other limitations and other pertinent data.

3.5 TREATMENT PLANT OPERATION

- The contractor shall provide skilled operators and all required material, power and labor and shall operate and calibrate / adjust the treatment plant till the end of the defects - liability period.

3.6 TRAINING

- Training: instruct and train Employer's designated personnel in the operation and maintenance of every part, device and piece of equipment in the systems, with emphasis on proper start-up and shutdown procedures, preventive maintenance and lubrication procedures with recommended lubricants, overhaul and maintenance methods, adjustment and calibration of instruments and controls, the use of special tools and safe practices.
- Training: Provide details of the proposed training program with the tender submission. Submit full details for approval after contract award.
- Training: the Employer will bear all expenses of his personnel allocated for training.

3.7 GUARANTEE, MAINTENANCE AND OPERATION

- Guarantee is to apply for perfect performance and mechanical operation of the systems, acceptable noise and vibration levels and reasonable consumption of power, fuel and water.
- Guarantee Period: in addition to his liability to replace defective material and workmanship during the Maintenance Period of 365 days (one year) in accordance with the Conditions of Contract the Contractor shall provide a written guarantee that the plant will operate and perform in accordance with the standards stated in this Specification for a minimum period of three (3) years after Taking Over without failure if operated in accordance with the instruction manuals.
- Maintenance: the Contractor shall provide a regular (monthly) inspection and adjustment service and a call-out service for a period of 365 days (one year) after taking over. In the case of failure of the plant; the service shall be at no additional cost to the Employer except in the case of misuse of the plant by the Employer.
- Operation: in the event that a contract is awarded to the Contractor for the operation of the plant after Taking Over, the guarantee provisions of this Section will still remain in force.
- Defects During Guarantee Period: if during guarantee period any equipment or material proves defective or any part of the system fails to function properly, equipment is to be replaced, and defects and malfunctions corrected by and at the expense of the Contractor and as directed by the Engineer.
- Guarantee: if during guarantee period any piece of equipment is replaced or rebuilt, the guarantee period for this equipment is to be extended for a new guarantee period equal to the original guarantee period.
- Maintenance and Operation: the Contractor shall provide the necessary skills and labor to assure proper operation and to provide regular and preventive maintenance required for equipment and controls during the guarantee period, on a continuous 24 hour basis.
- Maintenance and Operation: the Contractor shall check all controls monthly to ascertain that they function as designed. The Contractor shall act promptly to correct problems arising in the operation of equipment or system.
- Maintenance and Operation: the Contractor shall provide Employer with monthly inspection certificates of equipment, record findings on a check list and certify that each piece of equipment has been examined, is operating as intended, has been properly maintained as recommended by the Manufacturer.
- Spare Parts: for normal wear and tear to be provided by Employer.

END OF SECTION