Design, Build and Commissioning of 7 MLD Common Effluent Treatment Plant (CETP) and 0.5 MLD Package Sewage Treatment Plant (STP) at DPIA on EPC basis with 4 years Operation and Maintenance -Package B

VOLUME 3

PART 1 GENERAL MECHANICAL SPECIFICATIONS

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Acronyms and Abbreviation

Abbreviations	
SBIA	Shendra Bidkin Industrial Area
AITL	Aurangabad Industrial Township Limited
AURIC	Aurangabad Industrial City
DMIC	Delhi Mumbai Industrial Corridor
DMICDC	Delhi Mumbai Industrial Corridor Development Corporation
MIDC	Maharashtra Industrial Development Corporation
STP	Sewage Treatment Plant
CETP	Common Effluent Treatment Plant
MLD	Million Litres per day
ADF	Average Daily Flow
PDF	Peak Daily Flow
LDF	Lean Daily flow
LMH	Litre/m^2/hour
TSE	Treated Sewage Effluent
DWG	Drawing
MEICA	Mechanical, Electrical, Instrumentation Control and Automation
GA	General Arrangement

1 STANDARD MECHANICAL SPECIFICATION

1.1 Scope

This specification covers the general requirements for mechanical equipment's and installations at Works located within the Aurangabad, India. This part of the sets out the general standards for mechanical Plant used by the Contractor for the Works. Reference to any specific item does not necessarily imply that such plant is to be included in the Works. All Plant used for the Works shall, unless otherwise specified, comply with the provisions of this chapter.

Requirements that are particular to the installation are given in the Employer Requirement – Volume two (2). In the event that the mechanical Specification requirements conflict with these general requirements, then the Employer Requirement – Volume two (2) shall take precedence.

1.2 Standards

In cases where there is a Indian Standard, British Standard, NFPA, ASHRAE, International Standard or Code of Practice which is appropriate to any item of Plant supplied, any component incorporated in the Plant, the testing of the Plant or the installation of the Plant, then that Indian Standard, British Standard or NFPA or ASHRAE or Code of Practice or International Standard shall apply.

1.3 General

1.3.1 Design Features

As far as practicable, all designs shall be as per latest concept and practices. The equipment as a whole shall be new, of robust design for a long reliable operating life. These shall be capable of 24 hours per day continuous operation for prolonged period in the climatic and working conditions prevailing at the site and with the minimum of maintenance. Particular attention shall be given extra temperature and the rating of electrical and mechanical equipment, cooling systems and the choice of lubricants shall be for the temperatures as specified.

Paints used shall be Manufacturers standard but suitable for duly as described. The equipment shall be designed to provide easy access to and replacement of component parts, which are subject to wear, without the need to replace whole units. All Parts in contact with water shall have a life from new to replacement or repair of not less than five years.

Design features shall include the protection of equipment against damage caused by vermin, dirt, dust and dampness and to reduce risk of fire. Equipment shall operate without undue vibration and noise reduction measures shall be adopted such that levels of 80 dB (A) at 1 Meter are not exceeded. Parts shall be designed to withstand the maximum stresses under the most severe conditions of normal service materials shall have a high resistance to change in their properties due to the passage of time, exposure to light, temperature and any other cause, which may have a detrimental effect upon the performance or life of the plant.

All rotating elements shall be dynamically and statically balanced.

All equipment shall have name plates specifying the makes, model, rating and other pertinent information.

1.3.2 Material

All materials incorporated in the Work shall be the most suitable for the service conditions and duty concerned and shall be new and of reputed make/approved quality, free from imperfections and selected for long life and minimum maintenance. Non-destructive tests, if called for in the Specification, shall be carried out.

All submerged moving parts of the plants, or shafts and spindles or faces etc. in contact with them shall be of corrosion resistant materials.

All parts in direct contact with various chemicals shall be completely resistant to corrosion or abrasion by these chemicals and shall maintain their properties without aging due to the passages of time, exposure to light or any other cause. All materials shall conform to material standards as per BIS or any equivalent standard.

Only sound castings and forgings shall be incorporated in the Works. Welding, building up, filling or any other processes to recover castings will not be permitted in respect of any casting associated with pumps, compressors, gear boxes or other such plant subject to pressure or vibration.

Machined surfaces shall be free from blemishes and other surfaces shall be carefully fettled to remove any foundry irregularities including fused-on sand.

1.3.3 Workmanship

Workmanship and general finish shall be of first class quality and in accordance with best workshop practice. All welds shall be as per IS, BS, ASME standards. All tolerances and clearances shall be as per good and sound engineering practices. Should any material be not considered acceptable by the Engineer, it shall be replaced.

1.4 Lubrication, Bearings, Seals and Gearboxes

1.4.1 Bearings

Bearings shall be selected for adequate load bearing capacity, reliability and long life. They shall be sealed for life, minimum design life of 50,000 hours operation at maximum loading, or be fitted with automatic grease or oil lubricators. Lubrication points shall be grouped with a separate nipple and pipe feeding individual bearings. Lubrication points shall be easily accessible.

1.4.2 Gearboxes

Reduction gearboxes shall be robust and continuously rated and selected for reliability and efficiency over the required range of loadings.

Non-submersible gearbox drive casings shall be fitted with filling, level and drain points. Taps shall be fitted to the drain, and the gearbox shall be positioned such that the oil may be collected in a suitable container.

1.4.3 Seals

Gearboxes shall have a life of 100,000 hours, be selected in accordance with the American Gear Manufacturers Association (A.G.M.A) recommendations for horsepower calculation and service factor application and employ a standard reduction ratio.

Except where particularly specified the Contractor shall select a seal, compatible with his Plant and best suited for the worst conditions likely to be met when the Plant is in operation.

Seal materials shall be compatible with and/or resistant to the fluid or gas being handled.

1.4.4 Glands

Glands shall be provided with renewable gland sleeves. Glands subject to abrasive liquors or negative pressures shall embody suitably positioned lantern rings and a clean water continuous flushing system, operative whenever the Plant is in motion.

Gland adjustment nuts shall be readily accessible for routine maintenance.

Gland drain pipework shall be installed, incorporating roding facilities and adequate inclines of 25 mm minimum diameter on water and waste water treatment plant and 12.5 mm on water supply plant, discharging to the nearest sump or drainage channel.

1.4.5 Lubrication

The equipment shall be lubricated by long life lubricants such that working life is not less than 3000 operation hours.

A complete schedule of recommended oils other lubricants shall be furnished by the Contractor. The number of different types of lubricants shall be kept to a minimum. The schedule and the name of the supplier of the lubricants shall be submitted to the Engineer.

Lubricants shall be oil and grease. Contractor shall indicate indigenously available lubricants, with complete specification.

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

Where more than one special type of grease is required, a grease gun for each special type shall be supplied and permanently labelled.

The Contractor shall tabulate all lubrication points, the recommended grease or oil, its grade and the recommended service interval in the form of a chart. The Contractor shall include the supply all necessary oils and lubricants for the initial fill and the first years operation so that testing and commissioning may be carried out without undue delay.

1.5 Fixing of Machinery

1.5.1 Fixing to Structures

Where any Plant included in the Works is attached to building structures, the magnitude of the applied loadings must be stated by the Contractor on his drawings. Cutting of steelwork will not be allowed. Drilling, welding or stud firing into tension flanges or other steelwork subjected to tensile loads will not be permitted on plate girders or any principal steelwork member. Where attachments are allowed, proper clamps or straps will be required. The proposed attachment shall require the approval of the Engineer.

1.5.2 Foundation and Building Works

The Contractor shall satisfy himself, before installing the Plant, that the foundation levels, dimensions and alignment are correct and shall level and adjust the Plant on its foundations preparatory to suitable bedding of bases.

Where fixings are used by the Contractor he shall drill the holes, providing and fixing parts, to the approval of the Engineer.

The drilling through steel reinforcement shall not be permitted without the prior approval of the Engineer.

The Contractor shall supply foundation bolts, packers, frames and grillages necessary for the Works. Where these items are required to be built in, the Contractor shall ensure that both details and materials are available in accordance with the Schedule.

The Contractor shall make good any damage to concrete, brickwork or other finishes caused when undertaking his work. This shall be done to the satisfaction of the Engineer.

Grouting of machinery bedplates and supports shall be undertaken by the Contractor.

1.5.3 Shims and Packing

Packings and Shims shall be positioned close to and on each side of holding down bolts.

Packings and shims shall be of flat stainless steel and so positioned as to be fully covered to a thickness of 60 mm after ‘grouting in’. Alternatively, mild steel packs with zinc rich protective coating are to be provided.

1.5.4 Anchor Bolts

Expansion bolts or self-drill anchor bolts shall be to the approval of the Engineer, and shall not be used within 100 mm distance of concrete edges. Epoxy resin anchors can be used under such circumstances.

Where expansion bolts are used they shall normally be of the type having a loose metal shell for at least 80% of the embedded length which is expanded parallel to the bolt by means of a wedge at each end, the wedge at the lower end being part of or attached to the bolt.

Proprietary fixing bolts shall be fitted in strict accordance with the manufacturer's instructions and the Contractor shall be responsible for the provision of necessary equipment to drill and clean holes and for the actual drilling, cleaning and fixing.

Anchor bolts shall be stainless steel 316.

1.5.5 Machinery Guards

Machinery shall be effectively guarded to prevent injury to persons, and meet current safety regulations in accordance with IS 9474/BS EN 953/ ISO 14120.

Guards to parts of machinery which require regular inspection or maintenance shall be constructed of galvanized steel mesh or other corrosion resistant material which enables the parts to be examined and shall be attached in such a way as to permit easy removal and replacement. Guards shall be attached by means of set bolts or studs in tapped holes. Self-tapping screws shall not be used.

Where hinged access covers or doors are provided in covers or guards, they shall be interlocked with the electricity supply so as to prevent the operation of the machinery except when covers are in position and fixed.

Warning notices labeled 'Danger - This equipment may start automatically', shall be fitted where appropriate.

1.5.6 Bolts, Screws, Nuts, Studs and Washers

Fixings to be used in conjunction with the works shall have thread forms which comply with BS 3643 Isometric screw threads, and also BS 4190.

Exposed bolt heads and nuts shall be hexagonal and the length of bolts shall be such that, when fitted with a nut and washer and tightened down, the threaded portion shall at least fill the nut and not protrude from the face thereof by less than two threads or more than four threads. Threading, machining or cutting of threading rods at site is not permitted.

Fasteners and fixings shall generally be manufactured from nickel-bearing stainless steel.

Pipework flange fixings shall be stainless steel.

Wood screws and fixings shall be of brass with round heads.

1.6 Alignment, Lifting, Dismantling, Noise & Vibration

1.6.1 Alignment

Machinery bedplate design, packing and fixing shall be such as to minimise distortion and vibration. Aligned machinery shall be mounted on either bed or sole plates, permitting removal and reinstatement without a requirement to regrout.

Bedplates shall incorporate fine adjustment of the vertical and horizontal alignment between driver and driven members.

1.6.2 Lifting

Machinery shall be fitted with permanent lifting facilities. Large structures shall be provided with jacking points.

Tapped holes or other provision must be made in main castings for the insertion of jacking screws or the fixing of drawing gear to facilitate dismantling. On items of machinery subject to frequent dismantling, bolts or studs shall be employed in preference to setscrews.

1.6.3 Dismantling

A method statement for the approval of the Engineer shall be produced by the Contractor for any plant removal, demolition of structures, support procedure, protection measures for the existing plant that is not to be removed.

The redundant designated utilities within the demolition areas shall be properly disconnected and capped.

Any debris resulting from the demolition work shall be disposed off site to a designated tip or as mentioned in the particular specification.

All the demolition or plant removal work shall confirm to the local authority regulations for any contaminated or hazardous materials.

1.6.4 Noise

The noise levels emanating from the operation of any plant shall not exceed the limit of 85 dB(A) when measured from a distance of 1m in any direction from the plant in the prevailing site conditions. The plant operation at full load shall be considered.

In case of noise levels exceeding the specified limit, suitable acoustic enclosures shall be used.

These enclosures shall be aesthetically designed and shall be corrosion free as per the specification.

Wherever there is a risk of exposure of personnel to high noise levels, warning signs shall be put up and standard personal protective equipment shall be used.

1.6.5 Vibration

All the equipment shall be statically and dynamically balanced to avoid vibration. Mechanical vibrations levels shall be stated in the equipment technical data sheets and wherever necessary, the equipment shall be provided with vibration dampening mounts. At the time of operation, the

mechanical vibration shall not exceed the limits given below, at recommended points of measurement as per ISO 10816:1995.

Table 1.8.5 Vibration Limits

Equipment	**Velocity of Vibration mm/sec**
All rotating equipment not having reciprocating parts with motor KW less than or equal to 15 KW	1.12
All rotating equipment not having reciprocating parts with motor KW more than 15 KW and less than or equal to 75 KW	1.8
All rotating equipment not having reciprocating parts with motor KW greater than 75 KW	2.8

1.6.6 Name Plate

Each equipment of the plant shall have permanently attached to it in a conspicuous position, a nameplate and rating plate.

Upon these shall be engraved or stamped, the manufacture's name, type and serial number of the equipment, details of the loading and duty at which the equipment has been designed to operate and such diagrams as may be required by the Engineer.

All indicating and operating devices shall have securely attached to them or marked upon them designations as to their functions and proper manner of use.

1.7 Pipework Systems

1.7.1 General

Except where operating pressure dictates that higher pressure ratings are required, the flanges of pipework and fittings shall conform to the requirements of BS EN 1092-2.

In arranging pipework systems, provision must be made for the convenient removal of plant from the pipework system by the use of flange adaptors, unions or conveniently placed bends. Flange adaptors shall not be used simply to accommodate misalignment in the fixing or building in of pipework systems. Flange adaptors shall be supported or tied, or the pipework anchored, to withstand maximum possible system pressure.

Where more than one item of plant is served by a common pipework system, the pipework shall be arranged so that when a single item of plant has been removed the remaining items can be operated safely without the need to provide any special fixings and supports for the pipework system.

To allow isolated sections of pipeline to be drained to remove items of plant, and primed to remove air before being brought into service, ½" vent and 1" (minimum) drain tappings shall be provided as directed by the Engineer. The tappings shall be fitted with gun metal isolation cocks and the open end shall be fitted with a plug. Bright or black finished carbon steel barrel nipples shall not be allowed.

Pipework shall be adequately supported and anchored so that strain is not placed on any pump casing or other associated plant due to the weight of fixing of the pipework.

Necessary anchors, supports, saddles, slings, fixing bolts and foundation bolts to support the pipework and its associated equipment shall be provided by the Contractor. The Contractor shall also provide galvanised steelwork pipe supports, where their inclusion represents the most appropriate technical solution.

Adequate provision shall be included to cater for settlement of rigid structures/pipework systems.

1.7.2 Standard

The piping material & work shall conform to the following standards for material & erection & testing.

- IS 1537 & IS15325 Centrifugal Cast (spun) iron pipes and fittings for water and Sewage.
- IS 1239 GI Pipes & Fittings
- IS 99254 HDPE Pipes
- IS 250025 HDPE fittings
- IS 7534 Code of practice for laying HDPE pipes
- IS 3114 Code of practice for laying cast iron pipes.
- IS 7250 Cast iron sluice Valves
- IS 6325 Rubber for flanged joints
- IS 12567 MS hexagonal bolts and nuts
- IS 6392 Steel pipe flanges
- IS 7634 Testing of HDPE pipes

- IS: 8329:2000 for DI pipes and fittings (Class K7)
- IS: 9523:2000 for DI specials (Class K12)
- IS0 2531 : 1998(E) Ductile iron pipes, fittings and accessories and their joints for water or gas application, issued by the International Organization for Standardization (ISO)
- IS0 7186 : 1996(E) Ductile iron products for sewage applications
- IS0 4179 : 1985 Ductile iron pipes for pressure and non-pressure pipelines – Centrifugal cement mortar lining - General requirements
- IS0 8179-l : 1995 Ductile iron pipes - External coating: Part 1 Metallic zinc with finishing layer
- IS0 8179-2 : 1995 Ductile iron pipes - External coating: Part 2 Zinc rich paint with finishing layer
- IS0 8180 : 1985 Ductile iron pipes -Polyethylene sleeving
- BS EN 16767 (supersedes BS EN 5153 & BS EN 12334) Industrial valves. Steel and cast iron check valves
- EN 12845 Horizontal Centrifugal pump sets and their installations
- ASTM A 312 TP 304 Schedule 10 Standard Specification for Seamless, Welded, and
- Heavily Cold Worked Austenitic Stainless Steel Pipes
- CI non-return valve shall be of the specified size and class and shall in all respects conform to the requirements of BS EN 5153.
- CI sluice valves shall be of the specified size and class and shall in all respects conform to the requirements of BS EN 5153.
- Stainless Steel Pipe shall confirm to the requirements of ERW Pipe ASTM A 312 TP 304 Schedule 10 or BS EN 10312 / BS EN 10088.

1.7.3 Support for Pipe Work & Valves

All necessary supports, saddles, slings, fixing bolts & foundation bolts shall be provided to support the pipe Work. Valve and other equipment mounted in the pipe Work shall be supported independent of the pipes to which they connect.

All valves to be installed in straight lines shall be installed between the flanges with a dismantling joint or SS expansion below at one side of the valve. The dismantling joint must allow a minimum clearance of 20 mm. The pressure rating of the dismantling joint/expansion below shall be same as that of the valve.

1.7.4 Puddle Flange

Puddle flanges shall be fitted to pipes where the structure through which they pass is required to take thrust resulting form 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. Where flanged puddle pipes are provided by the Contractor the minimum length shall be such that the length of the pipe shall be at least 400 mm more than the wall thickness. Puddle pipes shall be installed such that any flanges are at least 200 mm away from the wall to allow good access for installation and maintenance.

1.7.5 Material

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 water, shall not contain any matter which could impart taste or odour or toxicity or otherwise be harmful to health or adversely affect the water conveyed. Nor shall any pipe be adversely affected by the fluid being conveyed through that pipe.

Pipework and valve materials for the following duties shall be as follows or equivalent to the approval of the Engineer:

Table1.11.4.1: Pipework and Valve Materials

Application / Location	Material
Alum solution	upvc/HDPE
Chlorine solution	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
Chemical dosing line	UPVC/HDPE/SS 316
Raw water	GRP / ductile iron
Backwash water / Treated water	HDPE/GRP
Dirty wash water/ Plant return line	GRP/SS304
Service water	GI (below 80mm), ductile iron (80mm and above), SS -304
Air scour	SS 316
Air Grid Piping	SS 316
Sludge	RAS/WAS: GRP/SS 304; Thickened/Dewatered Sludge: SS 304

Table1.11.4.2: Valves: Type & Material Selection

Service	Type	Material of Construction
Sewage: Gravity/Low, Pressure	Gate	CI Body & SS 304 Internals
	Knife Gate	CI Body & SS 304 Gate & SS 410 Spindle
Service Water: Pressure	Gate, Globe, Ball	CI Body & SS 304 Internals
Air	Butterfly, Ball	CI Body & SS 304 Internals
Chemicals	Ball, Diaphragm, Plug	SS 304, PP (Diaphragm of Neoprene/Teflon)
Sludge	Gate, Knife Gate, Plug	CI Body & SS 304 Internals

Table1.11.4.2: Pipe Sizing

Service	Basis	Comments/Limitations
Gravity Lines for Sewage & Water	Velocity between 0.6 to 1.2 m/sec designed as pipe line flowing full	At peak flow, a velocity up to 1.2 m/sec allowable. Min velocity shall be more than 0.6 m/sec.

Pressure Lines for Sewage & Water	Velocity between 0.6 m/s to 2.5 m/sec	In small sections at Pump delivery, a velocity up to 2.5 m/sec allowable. Min velocity shall not to be less than 0.6 m/sec.
Air (Pressurized Lines)	Velocity between 10 - 25 m/sec	Velocity in excess of 25 m/sec not permitted in any section.
Scum & Sludge Lines	Velocity between 0.6 to 1.5 m/sec	Irrespective of flow, diameter shall not be less than 250 mm for gravity lines.
Chemical Feed Lines	Velocity between 0.6 to 1.5 m/sec	irrespective of flow, diameter shall not less than 20 mm.
OCU Duct	Velocity less than 5 m/sec	

1.7.6 Ductile Iron

Iron pipework shall be ductile iron to IS 8329 and IS 9523 of a suitable grade and class to suit the design. Ductile iron pipes and fitting shall be rated for 10 bar (Class K9) or the working pressure of the system whichever is greater. All fittings shall be socketed unless specified otherwise. Flanged Joints shall comply with dimensions and drilling details to BS EN 1092-2

Ductile iron pipes and fittings shall have a cement mortar lining, in accordance with IS 11906 or ISO 4179.

Coatings, linings and Dry Film Thickness (DFT) shall be in accordance with Section 1.12 of this Specification.

For underground applications, Ductile iron pipe work shall be protected with a standard bitumastic finish and wrapping tape. Internal cement lining shall be applied.

Upon completion and testing of the installation, the Contractor shall apply touch-up coating to rectify scratches and chips in the ductile iron pipework coating.

Ductile pipe installed inside chambers or pump dry wells shall be protected with a fusion bonding epoxy powder coating applied internally and externally.

1.7.7 PVC-U

Unplasticised polyvinyl chloride pipes, fittings and specials, gaskets shall be conforming to the below mentioned Indian Standards / BS 4346: Part 1for potable water.

IS: 4985 Unplasticized PVC pipes for potable water supplies

IS: 12235 Methods of test for Unplasticised PVC pipes for potable water supplies

IS: 5382 Rubber sealing rings for gas mains, water mains and sewers

IS: 7328 High density polyethylene materials for mouldings and extrusion

IS: 10151 PVC and its copolymers for its safe use in contact with foodstuffs, pharmaceuticals, and drinking water

ISO: 2045 Single socket for uPVC and uPVC pressure pipes with elastic sealing ring type joints - Minimum depth of engagement

ISO: 3603 Fittings for PVC pipe with elastic sealing ring joints pressure test for leak proofness

The pipes shall be of the spigot and socket type with approved gasket type flexible joint. Where PVC pipes, fittings and specials are to be connected to Ductile iron, stainless steel or steel pipes, „Viking Johnson" type flange adaptors or stepped couplings shall be used.

1.7.8 Polyethylene Pipe

Polyethylene pipes shall comply with below mentioned Indian Standards /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.

IS: 4984: High Density Polyethylene Pipes for Water Supply

IS: 2530: Methods of test for polyethylene moulding materials and polyethylene compounds

IS: 7328: High density polyethylene materials for moulding and extrusion

IS: 7634: L Laying & Jointing of Polyethylene (PE) Pipes

Others Codes not specifically mentioned here, but pertaining to the use of HDPE pipes form part of these Specifications. Relevant Indian Standards shall be applicable where BS Standards are referred hereunder.

1.7.9 Reinforced Cement Concrete Pipes

Design of RCC pipes including reinforcement details and the ends of pipes shall be in accordance with the relevant clauses of IS: 458.

The use of pozzolana as an admixture to Portland cement shall not be permitted. Aggregates used for the manufacture of RCC pipes and collars shall conform to IS: 383. Reinforcement used for the manufacture shall confirm to IS: 432 and concrete shall confirm to IS 456.

1.7.10 Acrylonitrile-Butadiene-Styrene (ABS) Pipes and Fittings

ABS pressure pipes and fittings shall comply with the relevant provisions of BS 5391Part 1 and BS 5392 part 1 respectively.

1.7.11 Chlorination Pipework

All pipework used in the conveyance of gas (either under positive pressure or vacuum) shall be colour coded in accordance with current European or British Standards and shall be labeled throughout its length with the material of manufacture and pressure rating. Materials shall be suitable to withstand pressures, including surge, and have an inherent resistance to the corrosive nature of chlorine. Where it is capable of withstanding the system pressures, PVC-U shall be the preferred material.

Joints in the system pipework are to be kept to an absolute minimum.

All pipework shall be installed in such a manner that it is protected against mechanical damage, including adequate support to prevent sagging and undue strain. Rigid vacuum pipework outside buildings and chambers shall be installed either in suitably covered concrete channels allowing access from above for replacement and affording adequate protection against mechanical damage, ingress

of water and exposure to sunlight, or in buried ducts with regular inspection chambers such that no joints or fittings are beyond ready access by operatives.

1.7.12 Surge Vessels

If required by design, the system shall be provided with a hydro-pneumatic pressure vessel of suitable working capacity to provide surge protection and storage. The vessel shall be of the bladder type. The bladder shall be polyurethane and shall be pre-charged with Nitrogen. The vessel shall be sized to provide sufficient working volume to ensure that the pump starts are limited, to the requirement in the Particular Mechanical Specification.

1.7.13 Air pipework / High pressure duct works

Ductwork, fittings and all associated hangers, supports, dampers, flexible joints, sealants, insulation, access, testing and builder's work connections shall conform to the recommendations of the HVAC as set out in the specification DW/144 unless otherwise stated. Air duct velocities in main duct shall not exceed 12.5 metres per second and duct aspect ratios shall not exceed 4:1. Ductwork shall be true in section independently supported and free from contact with the building structure.

Internal jointing of ducting shall be avoided wherever possible, but if unavoidable, joints shall be constructed so as to minimise air turbulence at these sections. They shall give a smooth internal surface with no reduction in cross sectional area of duct.

Longitudinal standing internally formed joints or stiffening may be allowed however on large section ducts. Any required angle stiffening shall be external and access covers shall be provided at each internal joint.

Ductwork shall be designed to suit the environment in which it is designed to operate. Material of construction shall be polypropylene, PVC-U, GRP or stainless steel.

Ductwork within buildings shall be above ground level.

Ductwork external to building shall be installed below ground level or below tank covers.

The material of construction shall be completely suitable for operation in the prevailing internal and external atmospheric conditions.

Main duct runs and branches shall be installed with damper to allow for flow regulation/balancing and for isolation purposes. Access openings shall be provided adjacent to control/isolation dampers with diameters equal to and greater than 150mm.

Dampers shall provide airtight seal in the closed position.

Pilot test holes shall be provided in all main duct runs and branches for airflow measurement to allow the complete system to be balance. Suitable grommet and sealing plates shall be fitted to the test holes.

Appropriate gas sampling points shall be supplied in ducting running from each major leg at a distance of not less than four duct widths from any bend. Ports for manual sampling shall have a minimum diameter of 30mm. Removable plugs for each of the sampling ports shall be supplied.

Ductwork shall be designed to be laid with falls and be complete with valves situated at low points to enable condensation to be drained. Ductwork should generally fall back to the extraction point to

ensure that condensation falls back to the tanks from which odour is being extracted. The ductwork shall be designed to ensure that the total number of drain points are minimised.

The ductwork installations shall be designed to avoid trappings of fumes or gases in dead ends and prevent the collection of condensation which may be formed internally at any point in the duct work and which cannot be drained through drain valves located at accessible positions.

Air flow meters shall be provided to monitor the total airflow in the systems.

Flexible joints shall be used at connections to items of Plant.

Attention shall be given to adequate and sufficient supporting of ducting, together with accommodation of thermal expansion.

Ductwork supports shall be fabricated from either stainless steel or from galvanised mild steel. Duct supports shall be held off ductwork with neoprene lining to brackets.

Dampers and test points shall be accessible from ground level or from walkways and platforms.

Labels shall be provided as follows:

- Identification of test points
- Identification of drain points
- Identification of isolation/control dampers and commissioned setting of dampers

Airflow rates shall be regulated in accordance with the recommendations and tolerances laid down in CIBSE commissioning code A. A full commissioning record shall be kept together with final airflow rates achieved.

Ductwork shall be smoke tested to ensure that joints are gas tight.

Ductwork shall be earthed to ensure that no uncontrolled static discharge can occur.

Factors to be considered in the design of the air pipework to minimise noise level shall include:

- The diameter of the pipework, to keep velocities low.
- The connection of the blower discharge pipes to the manifold should be "wye", not at right angles.
- No blind flange at the end of the manifold.
- The manifold shall be designed to ensure air travels in one direction.
- The air pipework shall be designed to minimise changes of direction and use large radius bends.
- Flexible connections shall be provided between the diffuser assembly units and the main air supply pipework to allow for any differential movements.
- Expansion and contraction shall be fully allowed for in the design and installation of the air distribution pipework.
- Drain taps shall be provided on the air pipework to allow draining of moisture.
- The pipework and the support brackets shall be galvanised steel.
- Pipework shall have inbuilt flexibility such as packer flanges for reasonable construction tolerances on the structures to which it is attached.

All valves in the air delivery system shall be correctly selected for the duty. Calculations of Cv (head loss coefficient) values for the range of flows and pressure losses across each valve should be prepared to ensure that each valve has adequate range of controllability for the duty.

1.8 Valves

1.8.1 General

Valves shall be as per internationally recognized standards. Flanges shall be machined on faces and edges and drilled to BS EN 1092-2

Valves shall be double flanged and the face shall be parallel to each other and flange face should be at right angles to the valve centerline. Backside of valve flanges shall be machined or spot faced for proper seating of the head and nut. Valve 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. Valve shall be suitable for frequent operation as well as operation after long periods of idleness in either open or closed position.

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. Valves shall be free from sharp projections. Butterfly and non-return valves shall be provided with bypass arrangement having rising spindle gate valves. Bypass may be integral with valve or connected between pipes.

The work of fixing appurtenances, i.e. butterfly valves, sluice valves, air valves, scour valves, etc. shall be carried out carefully so as not to damage them during handling, erection and fixing.

All the butterfly valves and sluice valves for pumping plants and isolation valves on pumping main (except scour valves on pumping main and the isolation valves for air valves) shall be electrically operated. The valves shall have arrangement for manual operation also, operated through a suitable gearbox, by hand wheel. Operation must be possible by one man against maximum design working pressure. For butterfly valves the gearbox shall be provided with self locking devices. A locking facility shall be provided for the BF valve in either the fully open, fully closed or intermediate position. Gate valves and butterfly valves shall be provided with position indicators, to show whether the valve is in the open or close position.

Scour valves shall be provided with extension spindle with supports for operation from operating level / ground level.

Gaskets shall be of Nitrile rubber and ready made matching with respective flanges. Gaskets cut out from rubber sheets are not acceptable.

Valves for operation shall be so geared that under the operating conditions as specified herein, the maximum force on the rim of the hand wheel, crank, or other necessary for operation shall not exceed 20 kg and the maximum torque shall not exceed 5.5 kg/m. A spur, bevel, or worm gear reduction unit, if required, shall be attached to the pinion shaft of the operating mechanism.

1.8.2 Gate Valves

Gate valves shall have resilient seats which shall comply with the requirements of BS 5163. Valves shall be anti-clockwise opening with non-rising spindles and shall be of straight through type with resilient seating. Valve bodies shall be manufactured from ductile iron. Valve gates shall be manufactured from ductile iron faced with moulded EPDM rubber.

Handwheels shall clearly indicate direction of closure in accordance with BS 5163: Clause 17.4. Markings shall be cast into the rim of the valve.

Valve caps and key heads shall be in accordance with BS 5163: Table 5.

Valves shall be 'open end' tested before delivery and copies of manufacturer's test certificates shall be supplied to the Engineer before installation.

Gate valves shall typically be protected via the supplier's standard finish. However any valve associated with pipelines designed to convey sludge shall receive a fusion bonded coating in accordance with the Specification.

Upon completion and testing of the installation, the Contractor shall apply touch-up coating to rectify scratches and chips in the valve coating.

1.8.3 Sluice Valve

Sluice valve shall generally confirm to IS 14846. They shall be of non-rising spindle type except for the valves for bypass. The gate face rings shall be securely pegged over the full circumference. Valve of 400 mm and above shall be furnished with a bushing arrangement for replacement of packing without leakage. They shall also have renewable channel and shoe linings. The gap between the shoe and channel shall be limited to 1.5 mm. Valve of 200 mm and above shall be provided with thrust bearing arrangement for ease of operation.

Valve 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 200 N.

Valves spindles and hand wheels shall be positioned to give good access for operational personnel. 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.

Valves shall have two position marked at the shut end of the scale, first one corresponding to the position of the gate tangential to the bore of the seating and the second position below the first, corresponding to the position of the gate as it sits on the seating after moving a further distance equal to the depth of the seating.

All valves on pump suction and delivery piping shall be with electrical actuators. Operation of valves shall be with electric actuators mounted on floor stand at motor floor. The remaining sluice valves shall be manually operated unless specified elsewhere in this tender document.

The valves shall be provided with position indicator for indication from full open to full close. They shall be provided with cast iron cleaning door at the bottom of sluice valve body. The clearance between the wedge nut housing lugs on the wedge and the inside surface of the valve body shall be adequate to insert the wedge nut into the wedge lug recess either in the direction of water flow or in perpendicular direction when the wedge is in closed position.

All Sluice valves shall be open end tested.

Bypasses for valves 400 mm and over shall be fitted with integral bypasses as follows.

400 mm nominal diameter valve - 50 mm diameter bypass

500 mm nominal diameter valve - 80 mm diameter bypass

800 mm nominal diameter valve - 100 mm diameter bypass

Material of construction shall comply with the requirements given below:

Item	**PN 10 Valves**
Body, Door, Dome	Cast Iron IS 210 Grade FG220
Wedge	Cast Iron IS 210 Grade FG220 Rubber lined with EPDM
Seat, Face ring	IS: 318 Gr. LTB 2
Spindle / Stem	SS: IS 6603 04 Cr17 Ni 12 M0 2 / AISI 316
Bonnet Gasket	EPDM
Internal Fasteners	Stainless steel SS316
Nuts, bolts & washers for	High tensile steel Hot dip galvanized pipe flanges

1.8.4 Butterfly Valves

Butterfly valves shall comply with IS 13095 / BS EN 593 and be suitable for mounting in any position. The materials of construction shall be as follows:

Body - Ductile iron.

Disc - Zinc-free bronze or stainless steel having edges machined with rounded corners and polished to a smooth finish. The valve disc shall rotate through an angle of 90° from fully open to closed.

Shaft - Machined from stainless steel.

Valves that are to operate in throttled positions shall be metal seated. Leakage rates shall not be greater than Rate D for low leakage valve application, as referred to in BS EN593, for all other duties, butterfly valves shall be of the resilient seated type and shall be airtight when shut off at all operating pressures. Seat materials shall be suitable for use in contact with potable water. Butterfly Valves shall not be used for any sewage application. The valves shall be of double flanged long type. Valve shall be suitable for mounting in any position.

The valve seat shall be of replaceable design. When the valve is fully closed, the seal shall seat firmly. The seat surfaces shall be machined smooth to provide a long life for the seal. All fasteners shall be set flush so as to offer the least resistance possible to the flow through the valve.

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 Cast Iron	IS 210 Gr FG 220
Disc Cast Iron	IS 210 Gr FG 220
Shaft	Stainless Steel BS 970 Grade 431 S 29
Body Seat	Nickel weld overlay micro finished
Disc seal	EPDM
Seal Retaining ring	Stainless steel AISI 304.
Shaft Bearing	Bronze with EPDM „O‟ ring seals
Internal	Fasteners Stainless steel AISI 316
Nuts, bolts & washers for pipe flanges	High tensile steel hot dip galvanized

1.8.5 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 1092-2.

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 nitrite 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.

1.8.6 Isolating Cocks

For isolation of small bore pipework 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.

1.8.7 Non-Return Valves

The valve shall be suitable for mounting on a horizontal pipeline and flow direction shall be clearly embossed on the valve body. Valves shall possess high speed closing characteristics and be designed for minimum slam condition when closing.

Single door reflux valves shall be of the swing check type in accordance with IS: 5312/ BS EN 12334:2001. Valves shall be double flanged to BS EN 1092 - 2with external handles to permit manual operation. Dual plate check valves shall conform to API 594 and API 598. They shall have metal to

metal sealing. The spring action shall optimize the equal closing rates of each plate especially when the friction coefficients are uneven due to one plate resting upon one another. The plates shall not drag on the seat while opening. The plates shall not vibrate under full or partial flow condition. Discs when in the fully open position shall offer a clear in-line passage of the same diameter as the connecting pipework.

Non-return valves shall typically be protected via the supplier's standard finish. However any valve associated with pipelines designed to convey sludge shall receive a fusion bonded coating in accordance with the Specification.

Upon completion and testing of the installation, the Contractor shall apply touch-up coating to rectify scratches and chips in the valve coating.

Material of construction of valves shall comply with following requirements

Item	**PN 10 Valves**
Body	ASTM, A 216 Gr WCB
Plate	ASTM, A 351 Gr CF8M
Hinge Pin /Stop Pin/wetted parts	SS. AISI 316
Springs	SS. ASTM A 313
Seat	SS AISI 316
Retainer	Carbon Steel

1.8.8 Air Valves

Air relief valves shall be a double ball type with large and small air outlet orifices for starting and normal running conditions. Air valves shall be specifically designed for use with the normal fluid within the pipe.

The air relief valve body shall be cast iron, the floats grade 316 stainless steel or polycarbonate, the elevator and tappet grade 304 L stainless steel, and the orifice, orifice levers, float guide and guide sleeve a suitable plastic.

The valves shall be pressure tested to 10 bar and have BS EN 1092 – 2 flanges. An isolating gate valve shall be provided with each air relief valve.

The valve shall be capable of exhausting air from pipework automatically when being filled, the air being released at a sufficiently high rate to prevent the restriction of the inflow rate. Similarly the valve shall be capable of ventilating pipework automatically when being emptied, the air inflow rate being sufficiently high to prevent the development of a vacuum in the pipelines. The valve shall also automatically release air accumulating in pipework during normal working conditions.

Air valves shall thus be designed to automatically operate so that they will;

- positively open under internal pressure less than atmospheric pressure to admit air in bulk during pipeline draining operation;
- exhaust air in bulk and positively close as water, under low head, fills the body of the valve during filling operation;

- not blow shut under high velocity air discharge; and
- exhaust accumulated air under pressure while the pipe is flowing full of water

All air valves shall be constructed so that internal working parts which may become necessary for repairs shall be readily accessible, removable, and replaceable without use of special tools and removing the valve from the line. Air valves shall be of single chamber double orifice type and tamper proof unless otherwise directed by the Engineer. A buoyant rigid float shall seal the large orifice and the chamber housing shall be designed to avoid premature closing of the valve by the air whilst being discharged. Small orifice shall discharge small air volume during operation under full internal pressures. All air valves shall be provided with isolating sluice valve and flanged end connection.

The aperture of valves must be properly designed for which the Contractor shall submit design calculations for necessary approvals before the procurement of valves.

All branched outlets including air valve tees will be provided with one ½" BSP coupling duly plugged for measurement of pressure in due course. The closing plug shall be in Stainless Steel (AISI 304 or equivalent) with Hex. Head and shall be provided with copper washer for sealing

Air valves shall typically be protected via the supplier's standard finish.

1.8.9 Pressure Relief Valve

Pressure relief valves shall be capable of relieving pressure in the system to prevent the system being pressurised in excess of a preset maximum allowable pressure. The valves shall be drop tight under normal operating 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 valves.

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 weight or from a spring.

1.8.10 Pressure Reducing Valves

Pressure reducing valves (PRV) shall be constructed of cast iron to BS EN 1561: 1997 Grade 220/260 or ASTM A 126 Class B. The ported guide, seat ring and trim shall be of gun metal to BS EN 1982: 2008 Grade LG2C or stainless steel to AISI grade 303. The valve shall be capable of operation in any position and shall incorporate only one flanged cover at the valve top from which all internal parts shall be easily renewable. Valves shall be double flanged. All controls and piping shall be of non-corrosive construction.

Pressure reducing valves shall be capable of maintaining a constant downstream pressure from a higher constant or variable upstream pressure and they shall be drop tight under no flow conditions.

The valve operation shall be achieved by the interaction of the inlet pressure, outlet 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 outlet 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 1092-2.

1.8.11 Penstocks and Stop logs

Penstocks shall be installed in locations as shown on the layout drawings. The penstocks are either hand operated by hand wheel, square cap and gearbox or power operated by electromechanical or hydraulic actuators. In both these applications due care is necessary to establish the ability by the equipment to sustain a working head of liquid is one or both the directions.

The installations shall be as follows:-

1. Wall Mounted

   Wall mounted penstocks where indicated on the Drawings shall manufactured from the following materials:

Frame	Stainless Steel SS 304/ SS 316
Spindles	Stainless Steel Grade 316L
Seating Face	Bronze to BEAWA Standard P.12.92
Door	Stainless Steel SS 304/ SS 316
Wedges and Wedge Bars	Stainless Steel SS 304/ SS 316

2. Channel Mounted

   Channel mounted penstocks where indicated on the Drawings shall be manufactured from the following materials:

Frame	Stainless Steel SS 304/ SS 316
Spindles	Stainless Steel Grade 316L
Sealing Face	Coplastix-S with Coplastix-N backing strip or approved equivalent.
Door	Stainless Steel SS 304/ SS 316.

   All spindles shall be of the rising type for both installation methods and shall be provided with transparent type stem cover and with maximum/minimum limit stoppers. Penstock to be with minimum turns of operating by hand wheel.

   Stop logs, where indicated on the Drawings shall be manufactured from the following materials:

Frame	Stainless Steel SS 304/ SS 316
Logs	Stainless Steel SS 304/ SS 316
Seals	Sealing of logs to be agreed and approved by the Engineer

Care should be taken while installing penstocks and stop logs. The manufacturer's installation procedure shall be fully complied with and special fixing accessories such as anchor bolts shall be used wherever applicable.

Before final assembly all seating shall be cleaned thoroughly of all foreign materials and final adjustments made with the gate fully closed, the clearance between seating gates shall be checked.

The gate shall then be field operated from the fully closed to the fully open position to verify that the assembly is workable.

Under the design seating heads, penstock leakage shall not exceed the permissible limit of 2.07×10^{-5} m3/s per metre of seating perimeter.

Proprietary lifting equipment shall be supplied by the Contractor where the removal of long stop-logs is potentially difficult.

1.8.12 Adjustable Weir Plates

The adjustable weir plates shall be manufactured from 316 stainless steel and the design shall have the approval of the Engineer. Weir plates shall be complete with fixing nuts, bolts and washers and suitable for a total vertical adjustment of 100 mm. Fixings shall be designed for ease of accurately levelling 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.

1.8.13 Electro-Mechanical Actuators

Actuators shall be well proven for the anticipated environmental conditions. Actuators shall be suitable for external installation without the need for sunshades.

Isolating actuators shall have short time ratings appropriate to duty cycle S2 10 min to IEC 34-1, and a maintenance free interval better than 10,000 open/close cycles.

Modulating and inching actuators shall have a rating appropriate to duty cycle type S4 20% 1200 cycles/hour to IEC 34-1 and a maintenance free interval better than 50,000 hours in normal operation.

Actuated valves and penstocks shall be driven by three phase a.c. electro-mechanical actuators. Each actuator shall be sized to produce at least 150% of the torque requirement quoted by the valve or penstock manufacturer.

Valve actuators shall have an index of protection rating IP67 or above and have totally enclosed drive units and reduction gearing.

Each actuator shall be provided with an integral control and starter system allowing local and remote operation, control and indication. Control systems shall include facilities for valve modulation using a 4-20 mA control signal. Local position indication shall be provided integral with the actuator housing. Actuators shall have position feedback circuits giving a 4-20 mA signal for remote indication. Modulating actuators shall also have position indication at the local control panel. Isolating actuators shall have switches to signal open and closed limit positions at the local control panel.

The actuators shall also have the facility for hand operation, the use of which will automatically disengage the electric motor. The hand operation facility shall be capable of being padlocked in the in-operative state.

Limit switches and torque limiting devices shall be incorporated to prevent over running.

Each actuator drive unit shall be complete with integral starter, anti-condensation heater, local operating buttons, local and remote selector switch. A separate termination section shall be provided for the glanding and terminating of the supply, control and indication cables.

A phase discriminator and monitor relay shall be provided.

Cable entries shall be suitable for conduit and fittings to BS EN 50086-1:1994. Cable glands shall be provided for each actuator.

The actuator shall have volt free contacts to indicate when the valve is fully open, fully closed or has failed.

1.9 Sluice Gates.

1.9.1 General

The construction of sluice gates shall be in accordance with the specification and generally as per AWWA C 501 or IS 13349. The sluice gates shall be capable of performing the duties set in the specification without undue wear or deterioration. They shall be constructed so that maintenance is kept to a minimum. All parts of the sluice gate, including mechanism components, shall be designed for the heads specified with a minimum safety factor of five. All sluice gates shall be of the raising spindle type.

All sluice gates shall be electrically operated. Specifications of all types of gates shall be approved if provided by the Contractor; the actuator specs shall be approved by the Employer's representative.

1.9.2 Constructional features

The sluice gates shall be the standard design of the manufacturer and of robust construction. The special features shall be as follows:

1.9.3 Frame:

The frames shall be of ample section and cast in one piece. All surface-forming joints and bearings shall be machined. The frame shall be of the flange back type and machined on the rear face to bolt directly to the machined face of the wall thimble.

1.9.4 Guide:

The guide shall be bolted to the frame or cast integrally with it and machined on all bearing and contact faces. The length of the guide shall be such that it should support the gate upon the horizontal line of the stem nut pocket. Arrangements shall be such that they should support the gate upon the horizontal line of the stem nut pocket. Arrangements shall be made to prevent lateral movement of bolted-on guides. They shall be capable of taking the entire thrust produced by water pressure and wedging action. Wedges or wedge facings shall be attached to the guides at the point where, in the closed position, they will make full contact with the wedging surface on the slides.

1.9.5 Seating Faces

The seating faces shall be of full width, solid section. They shall be secured firmly by means of counter-sunk fixings in finished grooves in the frame and slide faces in such a way as to ensure that they will remain permanently in place as well as free from distortion and loosening during the life of the sluice gates.

1.9.6 Wedging devices

Sluice gates shall be equipped with adjustable side, top and bottom wedging devices required providing contact between the slide and frame facing when the gate is closed position. All faces shall be machined accurately to give maximum contact and wedging action. Wedges shall be fully adjustable with suitable adjusting screws and lock nuts, and so designed that they will remain in the fixed position after adjustment.

1.9.7 Gate slides

The slide shall be with strengthening ribs where required and a reinforced section to receive the seating faces. The slide shall have tongues on each side extending its full length and the tongues shall be machined accurately on contact surfaces. Surfaces of the slide that meet the seat facing and wedges shall be machined accurately. The maximum allowable clearance between the slide and slide

gate shall be 1.6 mm. An integrally cast stem nut pocket with reinforced ribs shall be provided above the central line of the slide.

1.9.8 Stem nut and Lift nut

A gate shall be provided with lower fixed stem nuts for connecting the stem to the slide and a revolving lift nut located in the lifting mechanism in the headstock. They shall be of ample design to endure the thrust developed during gate operating under maximum gate operating condition loads in opening and closing directions. The stem nut and slide shall be constructed to prevent the turning of the stem nut in the pocket of the slide. The stem nut shall be threaded and keyed or threaded and pinned to the stem.

1.9.9 Stem

The operating stem shall be designed for tensile strength to withstand 90 kg effort on the crank and for a critical buckling compressive load assuming a 36 kg effort on the crank. The threads of the stem shall be machine cut or rolled and of the square or acme type. The number of threads per inch shall be such as to work most effectively with the lift mechanism used. The top of the stem shall be provided with a stop collar. The stem shall be provided with a polycarbonate cover fixed to the headstock.

1.9.10 Stem coupling

The coupling shall be threaded and keyed or threaded and bolted and shall be of greater strength than the stem.

1.9.11 Stem guide

Stem guides shall be cast, with bushings and mounted on cast brackets. Guides shall be adjustable in two directions and so constructed that when properly spaced, they shall hold the stem in alignment. The number of stem guides shall be such that the unsupported length of the stem shall not exceed one hundred times its diameter.

1.9.12 Lifting Mechanism

Sluice gates shall be operated through a suitable lifting mechanism, which shall incorporate gearing if required. The lifting mechanism shall be suitable for operation by one man under all conditions. The lifting mechanism shall incorporate a strong locking device, suitable for use with a padlock or padlock and chain. The manual operation shall be of the hand wheel crank-operated type and shall have a lift nut threaded to fit the operating stem. The crank shall be removable. Ball or roller thrust bearings shall be provided above and below the flange on the lift nut to take the load developed in opening and closing the gate with a torque of 14 kg-m on the crank. Fittings shall be provided to lubricate gears and bearings. The design of the lift mechanism of the hand-operated gates shall be such that the slide can be operated with a torque not more than 7 kg-m on the operator after the slide is unseated from wedges based on the operating head. The maximum crank radius shall be 380 mm.

1.9.13 Gears and bearings

All gears and bearings shall be enclosed in cast iron housing with labyrinth seals. The lifting mechanism shall be of cast iron pedestal, machined and drilled, to receive the gear housing, and suitable for bolting to the operating floor. The gates shall close with clockwise rotation of the crank. The direction of rotation to close the gates shall be indicated on the lift mechanism. A suitable means shall be provided for lubricating the stem threads directly adjacent to the lift nut. An inspection cover shall be provided to access the lift nut and gearing.

1.9.14 Fasteners

All anchor bolts, assembly bolts, screws, nuts etc., shall be of ample section to safely withstand the forces created by the operation of the gate.

1.9.15 Wall thimbles

The wall thimbles shall be made of cast iron and supplied along with the gate. The wall thimbles shall provide a rigid mounting and be designed to prevent the warping of the gate frame during installation. The cross-section of the thimble shall have the shape of the letter 'F'. The front, or mounting flange, shall be machined and attached to the thimble with bolts and studs. The depth of the wall thimbles shall not be less than 300mm. To permit entrapped air to escape as the thimbles are being encased in the concrete, holes not less than 35 mm diameter at not more than 600 mm span, shall be cast or drilled in each entrapment zone formed by the reinforcing ribs or flange and water stop.

1.9.16 Material of Construction

Frame, Guide, Thimble, Stem	C I conforming to IS 210 Gr 260
Guide Bracket, Wedges,	
Door Sealing faces	bronze conforming to IS 318 Gr LTB 2
Spindle	SS AISI 431
Flush bottom resilient seal	Natural or synthetic rubber conforming to IS: 1855
Anchor bolts	SS conforming to IS 6603
Hand wheel	Cast iron
Stem cover	Polycarbonate transparent tube.

1.9.17 Parameters

Type	Rectangular rising spindle.
Size:	As per requirement
Applicable code:	IS 13349
Class	1
Maximum seating head:	as per design
Unseating head:	as per design
Maximum distances between gate centers:	
Line and operating platform:	as per design.

Tests Seat clearance checks, moving tests, leakage tests and Hydrostatic tests as per IS 13349/ AWWA C 501 shall be conducted at the Manufacturer's works in accordance with the Inspection category.

1.9.18 Headstocks

Where remote operation of penstocks, gate or butterfly valves is required they shall generally be as shown on the Drawings, using headstocks or headstocks with operating shaft extensions.

Headstocks for direct connection to valves or penstocks shall be for use with non-rising stem valves. They shall be cast iron and fitted with position indicators. Stem bearings shall be gunmetal bushed.

If operational conditions require, hand wheels shall operate through bevel gears.

If the installation requires, extensions shall be provided between penstock or valve and headstock. Extension lengths shall be adjustable during assembly on Site. Universal couplings shall be fitted next to the valve and the headstock, and the two couplings shall be arranged to give a linear transmission of rotational movement between the headstock and penstock shaft.

1.10 Open Channel Gates

1.10.1 General:

The construction of cast iron open channel gates shall be as per IS 3042 or equivalent standard. The open channel gate shall be capable of performing the isolation duties in wastewater treatment plants for those applications where the height of the water is at least 300 mm less than the height of the opening/shutter. They shall be so constructed that there is no undue wear or deterioration during their operative life and so designed that maintenance is kept to a minimum.

1.10.2 Design & Constructional Details

The open channel gate shall comprise a frame suitable for mounting in the parallel side walls of the channel. The frame shall be self-contained type with a yoke on top, for mounting the operating arrangement. The shutter shall move within the frame guides and be provided with a suitable connecting arrangement, to enable connection to the spindle.

Water sealing on the sides and bottom shall be affected by means of non-corroding seating faces secured in groves of frames and remaining in forced contact with the corresponding sealing arrangement mounted on the shutter. The bottom sealing arrangement shall be flush-bottom type to ensure that, the invert level of the channel on either side of the gate remains flush with the invert of the gate.

The spindle shall be raising type and provided with a stop nut to avoid over-closing of the gate. The rising spindle shall be provided with a transparent scratch-proof and UV-resistant polycarbonate cover tube to protect the threaded portion, from the effect of dust, dirt and rain. The operating arrangement shall be electrical with manual override.

1.10.3 Material Of Construction:

The material of construction for various components shall be as under.

Gate frame, shutter/Door:	Cast iron IS 210 FG 260
Side Guides:	Cast iron IS 210 FG 260
Door Sealing faces:	Bronze, conforming to IS 318 Gr LTB 2
Assembly bolts, nuts and fasteners:	Stainless Steel ASTM A 276 type 304
Stem & connecting pin:	SS AISI 431
Yoke:	Mild Steel to IS: 2062 grade A, epoxy painted
Headstock:	Cast iron IS 210 FG 260
Spindle cover tube/pipe hood:	Polycarbonate

1.10.4 Painting:

The following painting procedure shall be adopted for the gates:

Surface Preparation:	Blast clean to near-white metal finish using shot blasting.
Priming:	1 coat of Epoxy primer.
Finish Painting:	Epoxy paint for gate assembly. Minimum DFT 250 microns inclusive of priming. Yoke & Headstock are to be provided with red oxide primer and epoxy Grey paint having a minimum DFT of 150 microns inclusive of priming.

1.10.5 Shop Testing:

Following shop tests at the manufacturer's place will be conducted.

a. Movement Test: Movement test should be conducted in assembled condition using stems & headstock. The gate should be operated once from full close to full open and back to full close condition with

	a max. The force of 135 Newton-meter on the crank or hand wheel.
b. Dimensional Check:	Important Dimensions shall be checked with reference to the approved GA drawing.
c. Seat clearance check:	With the gate in closed condition, a 0.1 mm thick feeler gauge should not pass through the sealing faces.
d. Material Testing:	Material test certificates for components, such as Frame, Side guides, Shutter, Rubber seals, & Spindle to be furnished for review, at the time of inspection.
e. PMI test:	Positive Material Identification (PMI) test to be conducted for Seating/Sealing faces, Rubber Seal Retainer Bar & Stem/ Spindle during the inspection.
f. DFT measurement:	DFT of Paint with reference to approved G.A. drawing to be measured with paint thickness measurement gauge during the inspection.

1.11Tanks

Tanks shall be designed, erected and tested generally in accordance with BS EN 14015

Welded steel tanks shall be designed with a corrosion allowance of 1.5 mm.

Steel plate thickness shall not be less than 5 mm.

Internal roof support structures shall be protected from corrosion to maintain the design life of the tank.

Tanks shall be provided with drain points that shall terminate with a Bauer type coupling.

High level interconnecting pipework with an isolating valve shall be fitted between adjacent sludge storage tanks of similar purpose.

High level overflows shall be fitted to tanks for emergency situations.

Drilling or welding to the tank structure after the plates have been coated shall not be allowed.

Tanks shall be provided with a davit operated access hatch on the side of the tank for cleaning purposes. The access hatch shall be easily opened and closed with the minimum of dismantling time. The hatch seal shall not be compromised upon operating the hatch and shall be re-usable. The seal shall be designed such that it only requires replacement after more than 15 operations. The hatch design shall provide for the safe access of personnel to the tank for all inspection and maintenance functions.

1.12 Pumps

1.12.1 General Requirements

This specification covers both the general requirement for the water and used water (wastewater) pumping requirement. The specific requirement for the each application shall refer to relevant Process Specifications. Each pumping unit shall be complete with a pump, electric motor, coupling, coupling guard, anchor bolts, and other appurtenances specified or otherwise required for proper operation, all mounted on a common base plate. Pump manufacturer shall guarantee the combined performance of pump and motor set as a package responsibility, and shall be responsible for sizing and sourcing the suitable motor to meet the requirements. The proposed pump shall be selected taking into consideration its suitability and fit for use in the environment and service conditions intended for. All motor enclosures shall be compatible with area of installation and the intended use.

Unless otherwise specified, the pump and motor shall be mounted on a common baseplate assembly or when required a separate motor stool for mounting of the drive motor. Baseplate and motor stool shall be mounted on a suitable concrete foundation. The baseplate and/or motor stool shall be able capable of carrying the weight of the pump and/or motor.

Waterways through pumps shall be smooth and free from recesses and obstructions. Pumps for wastewater and raw water services shall be capable of passing solids:

- Suction pipework up to 100mm diameter - equal to the size of the suction pipework
- Suction pipework between 100mm and 199mm - 100mm diameter
- Suction pipework 200mm diameter or greater - 150mm diameter

1.12.2 Pump Design Requirements

(a) All pumps shall have a non-overloading performance characteristics. The efficiency shall be high at duty point and remain at a reasonable high level over the duty range of the pumping system.

(b) The pump head/quantity characteristic shall be stable at all rates of flow between closed valve and open valve and shall be steep enough to permit satisfactory operation in parallel under all conditions specified.

(c) The head versus flow rate characteristics curve shall be continuously falling from a maximum at closed valve head.

(d) The power delivered to the pump coupling shall be adequate for the full characteristic range from the closed valve conditions to the run-out point.

(e) The pump efficiency shall be maintained over the whole of the specified duty range, even if this necessitates the use of a larger motor to provide the peak power demand. For vertical spindle suspended pumps the efficiency shall take into account shaft and rising main losses up to and including the pump discharge bend, and the pump coupling.

(f) Water velocities in the suction branch of a pump shall not exceed 2.5 m/s and the discharge branch shall not exceed the manufacturer's recommendation for flow in valves and fittings or 2.5 m/s, whichever is the lower when the pump is operating within its specified duty range. Within this range there shall be no discernible noise due to hydraulic turbulence or cavitation within either the pump or its associated pipework and valves. Where discharge velocities exceed 4.5 m/s at run out condition in the duty range, the use of profiled taper pipes will be permitted. Taper pipes shall be specifically designed to progressively reduce velocity with profiled internal contours, which contain no steps or acute angle from which turbulence or cavitation can occur. Taper pipes shall be considered as part of the pump and be included in all performance calculations and tests.

(g) Pumps for raw water applications shall be capable of passing 80mm diameter solids unless otherwise specified and shall be designed to avoid possible choking by weeds or other tough sinuous materials.

(h) Pumps for sewage, used water (wastewater) and sludge application shall be capable of passing minimum of 120mm diameter solids unless otherwise specified and shall be designed to avoid possible choking by screenings, rags, plastic debris, hair and fibre.

(i) Pumps for sludge applications, selection of the type of pump and impeller shall take into consideration type and content of sludge being pumped.

(j) The speed of main pumps shall not exceed 1,500 rpm without approval of the engineer.

(k) For pumps condition monitoring and protection system, refer to relevant section of the specification and electrical specification.

(l) Pump speeds shall not exceed 1500 rpm nominal except for water supply borehole pumps where 3000 rpm nominal is acceptable. The pump set shall be capable of withstanding accidental rotation in reverse direction.

(m) Pumps shall be arranged for priming by gravity, via normal suction flow path. The total head capacity curve shall be continuously rising towards shut off with the highest at shut off. The head/flow characteristic of any pump shall be stable under all possible operating conditions including parallel operation and with maximum sump surcharge. The pump set shall be suitable for starting with discharge valve open or closed.

(n) Velocities in the suction and delivery branches shall be sufficiently low to prevent hydraulic turbulence and cavitation within the pump and the pipework and sufficiently high to prevent settlement of any suspended solids.

(o) The pump and its drive motor shall be suitably rated to allow for any increased head, due to sliming of the rising main, during the lifetime of the pump. Minimum 15% margin over the power input to pump at duty point will be kept while selecting the motor rating.

(p) Pump suction (except for wet well mounted submersible pumps) and discharge pipework for clean water and effluent duties shall be tapped and plugged with 25mm reducing to 12mm and fitted with a tee. The tee shall be fitted with an isolating cock, suitable for use with a pressure gauge having a 12mm connection and an isolation cock to act as a vent. The tapping shall be located between two and three pipe diameters from the pump, in accordance with BS EN 9906:2000.

(q) Pump suction and discharge connections for sludge and un-screened effluent shall be provided with 50mm flanged connections fitted with a flanged tee. The tee shall be fitted with two flanged isolation valves, one for connection of diaphragm type pressure gauge and the second to act as a vent. Quick closing Dual Plate check valve will be provided at pump delivery pipe to prevent back flow.

(r) Open ends of valves shall be fitted with blanking flanges or plugs as appropriate.

(s) All pressure parts of the pumps shall be subjected to hydrostatic tests prior to assembly to the satisfaction of the Project Manager at 1.5 times the maximum working pressure, obtained with the delivery valve closed and suction pressure at twice the working pressure whichever is higher for a duration of 10 minutes. The Impeller and pump rotating assembly shall be dynamically balanced. Each pump shall be subjected to performance tests for full operating range individually to BS: 5316: Part 2. Test shall be carried out for performance at rated speed with minimum NPSH as available at site. Pump performance shall be within the tolerance limits specified in BS: 5316: Part 2

1.12.3 Pump Construction

(a) Unless otherwise specified, the material section shall be selected based on the reference to the specified operating environment, application, pumped medium and pump duty and the expected service lives of the specified pump unit components.

(b) Materials used in the construction of pumps shall be suitable for the pump duty, the product to be handled and environment that will exist at the installed location. Cast iron shall not be used where the daily peak chloride content of the pumped medium is greater than 1500mg/litre.

(c) Where there is contact or exposure to liquids in which chlorides are present, the wetted parts and components of the pumps shall be manufactured of materials guaranteed against corrosion and wear against chlorides

(d) Unless otherwise specified, parts and materials of equipment in contact with seawater shall be fabricated in Super Duplex stainless steel grade SAF2507 or equivalent.

(e) The casing material shall be designed to withstand any pressure or dynamic loading that can be generated during normal pump operation, including intermittent physical shock loadings caused by solids in flow and shall have resists corrosion and abrasion imposed by constituents in the pumped medium. Access ports shall be provided, if specified, to allow the clearance of blockage and the inspection of the rotor drive components (i.es or flexible shaft).

(f) Pump casing shall be hydrostatically pressure tested to a pressure not less than 1.5 times shut-off head of pump plus maximum suction head unless otherwise specified. The impeller shall be free of blow holes, projections, cracks and inclusions, dynamically balanced.

(g) Pumps for sewage and sludge application shall have impellers with non-clog characteristics designed for municipal sewage pumping. The impeller shall be suitable for the pumping application as specified. The impeller shall be capable of handling solids, fibrous materials, heavy sludge and other matter found in the raw sewage. Mass moment of inertia calculations shall be provided by the pump manufacturer upon request by the engineer. Impellers shall be keyed to the shaft, retained with an expansion ring.

(h) The rotating assemblies shall be statically and dynamically balanced in accordance with BS ISO 1940-1 and designed so that the first critical speed of the pump and its drive is at least 50% higher than the maximum operating speed. Where the rotating assemblies are small and any out of balance forces are negligible the S.O may waive this requirement. The manufacturer is required to state whether or not balancing has been completed.

(i) Pump wear rings shall be easily replaceable.

(j) Unless otherwise specified, all pumps shall be fitted with delivery pressure gauges, automatic air-release valves, casing drains and lifting lugs. Split casing and end suction pumps shall also be fitted with suction compound vacuum-pressure gauges and drain cocks.

(k) Integral flange shall be provided for connection between pump set and pipework. Flanges shall be rated at PN 16 and shall have drillings to BS EN 1092. A ½" BSP female parallel threaded tapping point shall be provided at the flange peripheral for the reception of pressure tubing.

(l) All casing drains shall be piped to the discharge points approved by ENGINEER

(m) All exposed rotating parts shall be provided with suitable guards.

1.12.4 Mechanical Seal

(a) Pumps shall be fitted with cartridge type mechanical seals with a proven record of satisfactory running over a long period when fitted to the pump in question. Mechanical seal shall be the self-adjusting non-water cooled type unless specified otherwise. They shall be designed for easy adjustment and seal removal, the wear surfaces of the seal must be removable from the seal for inspection or repair easily without any special tools for seal maintenance/replacement.

(b) For sewage and sludge application, mechanical seal shall be suitably designed for handling abrasive medium, when required.

(c) All metal parts of seal shall be Type SS 316. Material for the rotating face shall be plated tungsten or titanium or approved equal. Material for stationary face shall be carbon graphite or fluorocarbon or approved equal. The 'O' ring material shall be fluorocarbon or fluoric rubber or approved equal which is suitable for use in the pumping media.

(d) Effective means shall be provided for collecting seal leakage water, and piping to an approved discharge point.

(e) Lubrication arrangements shall be designed to avoid any contamination of the pumped fluid.

1.12.5 Bearings

(a) Pump bearings shall be external to pump casing and removable with the rotating element.

(b) Pump bearing shall be adequately rated ball or roller type and shall be arranged to take up all radial and axial loads during start-up, shutdown and running conditions. Bearings shall be designed for loading 20 percent in excess of calculated maximum loading and shall be suitable for reverse rotation at 150 percent of rated speed or the maximum reverse speed that the pump can reach under installed conditions when driven backwards by reverse flow, whichever is greater.

(c) Pump bearings shall be mounted in dust-proof housing and provided with accessible lubricating points for grease gun greasing.

(d) The life of pump bearings shall at least L10 life rating of 50,000 hr continuous operating hours.

(e) Bearing cooling arrangements if used shall be designed on the closed-circuit principle. Open discharge of cooling water into the pumping station drainage system shall not be permitted. The coolant flow shall be easily visible and local indication of bearing metal temperature shall be provided. Excessive metal temperatures shall result in automatic safe shut down of the pump.

(f) Where water-lubricated bearings are used, means shall be provided to ensure that such bearings are supplied with adequate quantities of strained water at adequate pressure that bearings are flooded with water before the pump starts and that a failure of the water supply results in safe shut down of the pump.

1.12.6 Others

(a) The pump motor assemblies or pump and motor if they are installed separately, shall be provided with jacking bolts to facilitate adjustments during installation.

(b) In the design and selection of the pump set, the following shall be taken into consideration to ensure that the pump set can operate satisfactorily, with minimal noise and vibration, and without cavitation or any other abnormalities:

1) The various duty points as specified in process specifications.

2) The level of pump impeller with respect to the water levels in the pump sumps.

3) Other relevant site conditions e.g. Presence of sewage in the pump sump.

4) The layout of the pumps and pipework configuration.

(c) The layout of the pumps and pipework configuration as shown on the Drawings is intended to be indicative and for the purpose of tendering only. The Contractor and the pump manufacturer shall confirm the adequacy and suitability of the pipework configuration and pump layout

(d) The Contractor shall also confirm that the pump sets will operate satisfactorily without any hydraulic deficiency.

(e) Any modifications or alterations to the layout for a proper and efficient operation of the pump supplied shall be the responsibility of the Contractor and shall be at no extra cost to the Contract.

(f) Also any civil modifications for the proper installation of the new pump sets shall also be the responsibility of the Contractor and shall be at no extra cost to the Contract.

(g) The pump manufacturer shall supply to the Contractor all the relevant pipe clamps, lifting beams, ropes and slings for future overhauling of pump and motor.

1.12.7 Pumping Auxiliaries

(a) Pressure Gauges

(i) Pressure gauges shall be installed on the pump delivery and pressure- vacuum compound gauge complying with the requirements of BS EN 837-1 shall be installed on pump suction. Gauges shall be Budenberg Schaffer or VDO Diaphragm type or approved equal.

(ii) All gauges shall be suitable for liquids or gases containing solids and corrosive medium. Diaphragms type shall be used for used water (wastewater) and sludge application unless otherwise specified.

(iii) The normal operating pressure of the pump shall be approximately 60 per cent of the gauge range. Over range protection of 1.3 times the maximum scale reading shall be provided on the pressure gauges.

(iv) Gauge accuracy shall be within 2% of the full-scale range. All gauges shall be replaced if they do not maintain above standard of accuracy for the duration of defect liability period.

(v) All pressure gauges shall be in accordance with BS EN 837 and have the following:

1) A 100mm diameter stainless steel case with a toughened window glass sealed and held in by a steel spring ring.

2) A stainless steel movement mechanism filled with glycerine liquid to damper the pointer from vibration & sudden impact.

3) A diaphragm to suit the pumping media.

4) A stainless steel connector of male NPT.

5) A dial of black lettering and scales on a white background and shall bear legend showing service and units of graduation.

6) A gauge cock to enable the gauge to be removed.

7) An isolation valve

(vi) Unless otherwise specified, the gauges supplied shall be of stainless steel construction and filled with pulsation dampening fluid. Additional pulsation dampers shall be installed wherever necessary.

(vii) Tappings shall be provided at both the suction and discharge flanges for connection of pressure gauges. For wastewater and sludge applications, pressure gauges shall be independently mounted on a stub branch line not less than 50 mm NB for pipe sizes of 50mm and above. For pipe sizes below 50mm the stub branch shall be the same size as the pipe.

(viii) As far as possible, all pressure gauges shall be mounted either on walls, pumps supports or brackets that do not have any vibration. Direct mounting of the pressure gauges on to pump casings or pipes are to be avoided. They are also to be mounted at a height suitable for ease of reading. Where the pressure gauges are not visible from the operating floor level, they shall be grouped into a common panel. The location of the panel shall be agreed by the engineer prior to installation. Suitable pipework, fittings and shut-off cock shall be provided to connect each gauge to its tapping. Gauges shall be flush mounted and labelled with their function.

(b) Small-bore pipework and fittings

The pump shall have tapped openings for air relief, drainage and gauge connections. All small piping associated with each pumping unit shall be of copper tubing or brass pipe and nipples. All tapped holes shall be fitted with bronze plugs. Suitable air relief valves and strainers shall be provided.

(c) Pump inlet and discharge pipe work manifold

(i) Pump inlet and discharge pipework manifolds shall be pre-fabricated with the appropriate number and size of tapped bosses for the connection of pressure gauges, efficiency measurement equipment, vents, drains or injection points for chemicals etc. Pipework manifolds shall not be drilled and tapped after installation

(ii) A minimum of two set of tapped bosses shall be provided on every pump inlet and discharge pipe. The tapped bosses shall be at least two pipe diameters from each pump flange face, preferably on a straight piece of pipe, and shall be on the horizontal or lower vertical centre line. Each boss fitted with ½ inch BSP female thread gate valves and plugged.

(iii) Air valves shall be connected to pipework via an isolation valve to allow the pipeline to remain in-service while maintenance of the air valve is carried out

(d) Flow switch

(i) Water lubrication lines to each pump shall be provided with a flow switch and a sight glass. The flow switch shall be of brass, incorporating an orifice, a drag disk and a micro switch and connectors, housed in an anodised cast aluminium enclosure. The flow switch shall be suitable for mounting in any position and shall be suitable for a maximum pressure rating of 10 bar.

(ii) The pump and the motor vibration monitoring shall consists of vibration sensors mounted on the pump and the motor if required. Refer to Electrical and ICA specification.

(iii) Unless otherwise specified, dry running protection shall be provided.

(e) Limit Switch

Minimum one (1) set of limit switches for the following locations:

1) Manual suction valves to indicate the fully open and fully closed position. Where full open status is absent, the pump set shall not run.

2) Actuated delivery valve of each pump set to indicate the fully open and fully closed position and trip the motor if this valve is shut.

(f) Vibration Monitoring System (VMS)

VMS shall be provided for each pump and motor in to individual Local Control Panel (LCP) or a common LCP (common for more than one motor) vibration monitoring panel in each switch room as specified in system architecture schematics / drawings. The vibration monitoring panel shall have tag no. XXX-VMP-YYY. The Vibration Monitoring System shall meet the requirements specified herein, and be compatible with the motor vibration sensors specified in this section. Program, test calibrate, fully configure and place the Vibration Monitoring System into operation.

(i) General:

1) The VMS features:

- microprocessor-based system with programmable firmware update options;
- programmable operating range;
- programmable alarm delays;
- dual channel modules;
- AND/OR danger voting logic;
- timed OK/Channel defeat; and
- Modbus TCP/IP interface to the PLC.

2) The VMS for each pump-motor shall each include an eight position slot rack which shall contain the following quantities and types of plug-in modules:

- power supply module (position 1);
- system monitor module (position 2);

- three dual channel radial shaft vibration monitoring modules;
- one dual channel thrust (axial) position monitoring module; and
- one dual channel key phasor (timing) monitoring module.

3) Appurtenances: Provide transducers, probes, software, accessories, rack, interconnecting cables, power supply modules, and monitoring modules as necessary.

4) VMS shall be from a reputed manufacturer with local service facility.

(ii) Vibration Transducers: (All transducer shall be from the same manufacturer as VMS to maintain compatibility and integrity of the VMS system)

1) Timing Transducer:

- Consisting of a Proximity Probe, calibrated extension cable, and Proximitor Sensor.
- Provide Keyphasor timing probe for motors, similar to radial vibration transducers permanently installed by motor manufacturer. Probe shall contain a minimum 8-millimeter tip diameter mounted in a 0.375-inch by 24 threads per inch stainless body.
- Proximitor Sensor: Proximitor Sensor, linear range from 10 mils to 90 mils, plus or minus 6.5 percent accuracy.
- Cable: Shielded, triaxial as recommended by VMS manufacturer.
- Elements shall be fully protected in sealed weatherproof conduit and housings.

2) Radial Shaft Vibration Transducers:

- Each transducer shall consist of a Proximity Probe, calibrated extension cable, and Proximitor Sensor.
- Provide permanently installed radial shaft displacement proximity probes on motors with sleeve bearings.
- Use Orthogonal X-Y Proximity Probes at each radial bearing housing.
- Mount probes at plus or minus 45 degrees from true vertical centreline.
- Probes to contain a minimum 8-millimeter tip diameter mounted in a 0.375-inch by 24 threads per inch stainless steel body.
- Proximitor Sensor: Proximitor Sensor, linear range from 10 mils to 90 mils, plus or minus 6.5 percent accuracy.
- Cable: Shielded, triaxial as recommended by VMS manufacturer.
- Elements shall be fully protected in sealed weatherproof conduit and housings.

3) Bearing Housing Velocity Transducers:

- Use antifriction bearings and bearing housing velocity transducers permanently installed by motor manufacturer.

- Locate transducers at each bearing, measuring in axial, horizontal direction.
- Minimum rated operating frequency shall be less than minimum motor operating speed.
- Vibration element shall include shielded signal cable enclosed in an IP 55 housing.

4) Thrust Position Transducer:

- Each transducer shall consist of a Proximity Probe, calibrated extension cable, and Proximitor Sensor.
- Use vertical synchronous motors, permanently installed axial shaft displacement proximity probes.
- Probes shall observe thrust collar or top end of shaft.
- Probes shall contain a minimum 8-millimeter tip diameter mounted in a 0.375-inch by 24 threads per inch stainless steel body.
- Proximitor Sensor: Proximitor Sensor, linear range from 10 mils to 90 mils, plus or minus 6.5 percent accuracy.
- Cable: Shielded, triaxial as recommended by VMS manufacturer.
- Elements external to motor enclosure shall be fully protected in sealed weatherproof conduit and IP 55 housings.

5) Motor Casing Velocity Transducers:

- For vertical motors over 250 horsepower, permanently installed velocity transducers.
- Each element shall be a velocity transducer with a velocity output in IPS RMS.
- Minimum rated operating frequency shall be less than minimum pump operating speed.
- Vibration element shall include shielded signal cable and enclosed in IP 55 housing.

6) Vibration transducer and timing transducer shall be prewired to terminal junction box mounted on motor.

(iii) Vibration Monitoring Systems shall be connected to the PLC via Modbus TCP/IP communications. This communications link shall effectively communicate all data relevant to the operating purpose of the Vibration Monitoring Systems. Provide data configuration software and documentation to allow communication with the PLC.

(iv) Vibration Monitoring System alarm contacts shall be configured to be normally closed, open in alarm condition and open on loss of power.

(v) All cables requiring special calibration for optimum performance shall be calibrated by the vibration monitor manufacturer or an authorised representative thereof.

(vi) High vibration trip signal shall be hard wired to respective HVSG circuit breaker of the motor.

(vii) Necessary VMS graphics shall be built in to the PLC / HMI (SCADA) for each pump-motor.

(viii) Necessary software for VMS shall be provided for remote monitoring and analysis of VMS from a centralised SCADA.

(ix) Loop the Pump and Motor Major and Minor Vibration;

1) Program PLC to monitor vibration monitoring panel alarm outputs. In the event of either a MINOR or MAJOR Vibration ALARM condition, the PLC shall Alarm MCS.

2) In the event of a MAJOR Vibration condition, the PLC shall issue an EMERGENCY SHUTDOWN of the respective pump-motor.

3) Hard wired signal from VMS for individual motors shall be wired to directly trip the motor circuit breaker without going through PLC. All necessary cabling and accessories shall be provided.

(x) The Contractor shall be responsible to engage a vibration expert to carry out vibration analysis. The vibration expert shall ensure that the vibration analysis will be carry out satisfactory and not affect any guarantee on pump performance. Vibration analysis report shall be submitted to ENGINEER for approval.

1.12.8 Pump Performance

(a) The Contractor shall guarantee the flow rate, the total head and the efficiency of the pump when tested at the manufacturer's factory.

(b) The pump shall operate at its duty point within the acceptance tolerances for flow and total head as dictated in BS EN ISO 9906, Class Grade 1, unless otherwise specified.

(c) All positive displacement pumps shall be tested on accordance with BS 599.

(d) For critical pumps system, motors shall be designed to operate continuously. Motors shall comply with requirements in the Electrical Specifications.

(e) In addition to confirming the hydraulic performance of the pump set, the test shall demonstrate that vibration is within the specified limits, the mechanical performance is satisfactory, the pump is free from overheating and noise level is within specified limited.

1.12.9 Centrifugal Open Coupled Sewage Pumps

1. General

Pumps shall be designed to handle sewage and run unattended for long continuous periods. They shall be capable of passing fibrous matter, rags, paper, plastics and solids.

The pump and motor units shall be continuously rated.

Where a major overhaul is required during the design operating life, this will be dependent upon bearing life, which shall be 100,000 hours minimum. The NPSH requirements of the pumps, based on the 3% output drop criterion shall be at least 2 m less than the NPSH available at every working condition.

Components likely to become worn in the course of normal operation shall be capable of being easily replaced making use of readily exchangeable components. Low maintenance costs, reliability and trouble-free operation shall be prime considerations when selecting pump units.

Pump units shall be provided from within manufacturer's standard range which shall meet the quantity/head duty requirements within the high efficiency band of the pump characteristics. The pump curve shall have non-overloading power characteristics unless agreed otherwise by the Engineer.

Pump units shall be quiet in operation, free from vibration and the shaft speed shall not exceed 1500 rpm. The velocity of vibration shall be within 4.5mm/sec.

All rotating parts shall be statically balanced during manufacture and dynamically balanced after assembly.

2. Pump Volute Casing

The pump casings shall be of close grained Cast iron to IS210 Gr.FG260 free from blowholes and other imperfections.

Castings shall be manufactured and pressure tested in accordance with BS EN ISO 9906.

The pump casing shall be fitted with renewable suction wear rings.

Access shall be provided in the pump casings in the form of large handholes, for inspection and cleaning of the pump interior.

Pump casings shall be provided with a drainage cock at the bottom of the lower casing section and an automatic air release valve and cock on the top of the volute casing section. The discharge from fittings shall be piped to the station drainage system. Small bore pipes shall be heavy grade copper tubing.

3. Impellers

The impellers shall be stainless steel ASTM A743 CF8M. The working faces shall be accurately machined and finished smooth with each impeller being balanced statically and dynamically to ensure smooth running.

The impellers shall be of the single bladed open or spiral vane type or two port single entry choke resistant type. Where the two port entry type is utilised the vanes shall be supported on both sides of their entire length by the outer shroud. The impellers shall have auxiliary vanes on the outside of the shrouds to minimise the recirculation of the liquid within the pump casing and to reduce the pressure around the shaft seal.

The impellers shall be securely keyed and locked to the pump shaft.

The impeller diameter shall be machined to comply with the required duties and maximum efficiencies.

4. Fittings

Each pump shall be fitted with the following fittings as standard requirements:

- A combined automatic air release and siphon breaker valve shall be fitted into the pump delivery pipework;

- 25 mm bore gland drainage pipe from the invert of the sill on the top gland cover and leading down to discharge into the dry well drainage channel to prevent contamination of the pump casing or walkways;

5. Shafts and Sleeves

   The pump shafts shall be constructed from high tensile alloy steel and shall be fitted with a hardened steel sleeve extending through the full length of the shaft seal.

   Transmission shall utilise universal joints and a splined slip joint at the pump connection. Universal joints shall have needle roller bearings. The weight of the transmission shafting shall be carried by a thrust bearing in the motor stool. The splined shaft shall ensure that no load is transferred to the pump from the shafting. Normal shaft running speed shall be well below the first critical speed. The Contractor shall submit his calculations to confirm this.

6. Glands

   Pumps shall be supplied with soft packed glands if appropriate.

7. Drive Coupling

   A suitably sized rubber bushed flexible coupling shall be fitted between each pump and driving motor. The coupling shall be fixed to the pump and motor shafts using keys and keyways.

8. Pump Motor

   The motor speed shall not exceed 1500 rpm.

9. Temperature Transducer Pockets

   The pump Non-Drive End bearings and the pump Drive End bearings shall be fitted with temperature pockets for the reception of resistance thermometer probes.

10. Pressure Gauge Tappings

    Each pump set shall be provided with both delivery and suction gauge tappings such that when fitted they are in an upright position. Each tapping shall be isolated with a gun-metal gauge cock.

11. Pressure Gauges

    A pressure gauge shall be provided and installed at the above suction and delivery tappings. The gauges shall be of the diaphragm operated sewage installation type.

12. Guarding

    The Contractor shall include for guards to completely enclose the moving parts of plant.

13. Engraved Nameplates

    Each pump shall be provided with engraved nameplates as follows:

    - Duty Plate: Indicating the type, impeller diameter, output at normal duty, normal duty head, speed, serial number and pump curve number.
    - Identification: Corresponding with the pump control panel designation e.g. 'Pump No 1'. The characters shall not be less than 30 mm high.

1.12.10 Split Case Centrifugal Pumps

1. General

Pump units shall be designed to handle the process fluid and run unattended for long continuous periods. The pumps shall be electric motor driven.

Pump units shall be designed to handle the process fluid and run unattended for long continuous periods. The pumps shall be electric motor driven.

Pump and motor units shall be continuously rated. Components likely to become worn in the course of normal operation shall be capable of being easily replaced making use of readily exchangeable components. Low maintenance costs, reliability and trouble-free operation shall be prime considerations when selecting pump units.

Pump units shall be provided from within manufacturer's standard range which shall meet the quantity/head duty requirements within the high efficiency band of the pump characteristics. The pump curve shall have non-overloading power characteristics unless agreed otherwise by the Engineer.

The pump and its driving motor shall be separate machines, open coupled, using a flexible coupling to form an integral unit mounted on a suitable common rigid baseplate or base frame. A flywheel may also be incorporated in the drive train if required for surge suppression. Each component shall be dowelled to facilitate re-assembly.

Pump units shall be quiet in operation, free from vibration and the shaft speed shall not exceed 1500 rpm.

All rotating parts shall be statically balanced during manufacture and dynamically balanced after assembly. The rotating parts shall be supported in substantial bearings of approved design.

2. Pump Volute Casing

The pump casings shall be of close grained cast iron to to IS210 Gr.FG260 free from blowholes and other imperfections. Castings shall be manufactured and pressure tested in accordance with BS EN ISO 9906.

The casing shall comprise of two sections, split to provide complete access to the impeller and other rotating parts without disturbing the pipework connections.

The sections of casing shall be secured together using substantial stainless steel studs and nuts. To ensure accurate re-alignment of the casing section stainless steel dowels shall also be fitted.

To facilitate the dismantling of the casing halves equally spaced tapped holes shall be provided in one casing flange to allow jacking bolts to separate the joint.

Renewable suction wear rings and interstage bushes manufactured from zinc free bronze, or LG4 Bronze to BS EN 1982 2008 shall be provided.

Each pump shall be fitted with a drainage cock at the bottom of the lower casing section and an automatic air release valve and cock on the top of the upper casing section. The discharge from each of these fittings shall be piped to the station drainage system via a tundish. Small bore pipes shall be galvanised mild steel.

3. Impellers

Impellers shall be stainless steel ASTM A743 CF8M, keyed to the shaft and securely locked in position, the whole assembly being both statically and dynamically balanced. Impeller surfaces shall be machine finished free from blowholes and imperfections.

The impeller diameter shall be machined to comply with the required duties and maximum efficiencies.

4. Shafts and Sleeves

Shafts shall be of mild steel protected with renewable stainless steel sleeves, where they pass through any wear inducing sealing arrangement.

5. Bearings

Bearings shall have a design life of 100,000 hours.

6. Glands

Split case pump units shall be supplied with soft packed glands.

7. Drive Coupling

A suitably sized rubber bushed flexible coupling shall be fitted between each pump and driving motor. The coupling shall be fixed to the pump and motor shafts using keys and keyways.

8. Pump Motor

The motor shall be sized to allow for the provision of flywheels for surge suppression as necessary.

9. Temperature Transducer Pockets

The pump non-drive end bearings and the pump drive end bearings shall be fitted with temperature pockets for the reception of resistance thermometer probes.

1.12.11 End Suction Centrifugal Pumps

1. General

Pump units shall be designed to handle final effluent and run unattended for long continuous periods. Pumps shall be Electric motor driven.

Pump units and motors shall be continuously rated. Components likely to become worn in the course of normal operation shall be capable of being easily replaced making use of readily exchangeable components. Low maintenance costs, reliability and trouble-free operation shall be prime considerations when selecting pump units.

Pump units shall be provided from within manufacturer's standard range which shall meet the quantity/head duty requirements within the high efficiency band of the pump characteristics. The pump curve shall have non-overloading power characteristics unless agreed otherwise by the Engineer.

Tapped holes or other provisions shall be made in the main casting and impeller of the pump for the insertion of jacking screws or fixing other such drawing gear necessary to facilitate the dismantling of the pump.

2. Pump Casing

The pump casing shall be of close grained cast iron to to IS210 Gr.FG260, free from blowholes and other imperfections, suitable for use with final effluent.

3. Mechanical Seals

   Pumps shall be fitted with a mechanical seal with both the rotating and stationary faces being tungsten carbide or other approved materials. The pump mechanical seal design should he such that prolonged periods of dry running do not affect the pump or mechanical seal.

4. Pump Motor

   The motor speed shall not exceed 1500 rpm.

1.12.12 Submersible Pumps

General:

This specification covers the design, performance, manufacturer construction features, testing and delivery to site of submersible sewage non-clog of pump set. The design, manufacture and performance of pumps shall conform to the latest applicable to all currently standards matching the service requirement. Nothing in this specification shall release the Contractor of his responsibility. The Pumping machinery in the pump house shall be designed to handle the peak flow, average flow as well as the lean flow and shall be designed as per CPHEEO manual.

Design Feature:

1. Pump should be capable of handling sewage.
2. The pump shall be of a non-clogging type with handling solid size of up to 65mm.
3. Pump shall be capable of working for a long period of time without cleaning and maintenance.
4. Pump internal should be easily replaceable and sufficient wear resistance and corrosion resistant to work under submerged condition with sludge and bear possible wearing due to moving grit particles.
5. Pumps shall be capable ow working for long time without cleaning.
6. Pump shall be suitable to operate at all flow rates within its capacity and should have decreasing head-flow characteristics.
7. Pump should be free from vibration and rotors shall be perfectly balanced both statically and dynamically. Rotors shall be adjusted for dynamic balance with a tested and approved method.
8. Full vane type impeller is recommended over vortex type impeller. Wherever possible the same should be used.
9. Shaft for the pump should be of high tensile alloy steel with full length shaft sleeve.
10. Pump should have special duct foot bend flanged elbow.
11. Motor for pump should be suitable to work under submerged condition, should be IP 68 certified.
12. Insulation windings on the motor shall be of class ’F’ insulation.
13. The motor shall be suitable to operate on, 415+-10% c/s +-5%, 3 phase A.C. supply.

Material of Construction:

Pump casing	:	2.5% Ni. C.I. conforming to ASTM A48/ ISO 185 (M)
Riser pipe/Delivery pipe	:	C.I. Conforming to IS 1729/ IS: 1538
Impeller	:	C.F. 8
Impeller shaft	:	S.S. – 410
Impeller key	:	S.S. – 316
Impeller Bolt.	:	S.S. – 316
Mechanical seal	:	Silicon carbide v/s Silicon carbide
Chain	:	S.S. 410
Guide Rail	:	S.S. 410 having wall thickness of 4 mm
Eye Bolt	:	S.S. 410
Bush	:	S.S. 410
Special fittings	:	C.I. Conforming to IS: 1538
Gland packing	:	Graphited asbestos.
Hardware in contact with sewage	:	S.S. 410

Construction:

Pump Casing shall be of 2.5% Ni. C.I. and conforming to relevant I.S. with hardness of 250-270 B.H.N. The internal surfaces shall be free from rough spots and must have central line discharge.

Intermediate oil chamber should separate the motor unit from pump unit and should be filled with non-condense oil. Mechanical seal should be provided one between oil chamber and motor. The purpose of the lower seal should be to prevent the entry of the pumped liquid it to the oil chamber and the function of the upper seal to prevent the entry of oil from the chamber to the motor.

Necessary in built safety device should be incorporated within the pump itself which shall give timely warning of the impending failure of the mechanical seals, therefore seal monitor system should be installed in the pump. Moisture sensor shall be provided in the oil chamber to detect failure of mechanical seal.

The impeller shall be made of stainless steel CF8M grade. The impeller shall be properly balanced dynamically as well as statically. The impeller shall be properly machined for liquid passage.

The pump shall be designed to take care of the additional thrust produced and handling solids upto 100mm dia. Impellers shall be securely fastened direct to the extended shaft of motor with keys, taper housings of lock – nuts.

The impeller shaft shall be made of stainless steel containing minimum 12% chromium stain less steel and having Brinell hardness not less than 200. It shall have a surface finish between 0.75 microns or less.

The shaft shall be straight within 0.125 mm for 3 meter length total dial indicator reading. The maximum permissible error in the axial alignment of the shaft axis with the axis be 0.05 in 150 mm.

Bearing shall be of antifriction type. The bearing shall be able to take normal axial thrust loads due to balanced hydraulic loads on the impellers plus weight of rotating parts of pumps. Pumps shall be designed with a minimum 40,000 hours run. The bearing shall be grease lubricated for life and shall be maintenance free.

It will have C.I. pedestal, bracket, delivery duck foot bend. SS410 Guide rail pipe, upper guide rail holder complete. The pedestal and bracket shall provide automatic coupling between pump delivery and discharge bend.

Double mechanical seals of approved make and type shall be provided to prevent pumped liquid entering into the motor winding. The seals shall be running in a oil bath. The oil bath shall have moisture sensor to senser water leakage. The sensor will be for tripping the pump and also for alarm.

Pumps shall be provided with SS410 Steel lifting chains of suitable capacity. One end of the chain shall be adhered to the pump and the other end fixed near the upper bracket for guide rail/wire rope assembly by the means of SS410 D-Shekle. The chain shall comprise of 100 mm dia. SS rings fixed at an interval about 1 mtr. for engaging the hook of chain pulley. The standard lengths of C. I. riser pipe shall be 1.00 meter, 1.5 meters, 2.5 meters or 3 meters. No part in the column pipe such as the flange outside diameter shall exceed the bowl outside diameter

Mechanical seals shall be fitted to the pump shafts which shall prevent water from entering the oil casing and oil from entering the motor casing. A moisture detection system shall be provided in the motor stator casing, wired to initiate an external alarm. Double Mechanical seals shall be provided to protect the motor from ingress of liquid along the shaft. The preliminary and secondary seals shall be oil-lubricated with tungsten carbide or silicon-carbide faces and they shall be equipped with an electrical monitoring system for seal failure detection. Sensors are to be provided to detect if leakage of liquid into the oil housing is above 30 % concentration.

Pump units shall be provided from within manufacturer's standard range which shall meet the quantity/head duty requirements within the high efficiency band of the pump characteristics. The pump curve shall have non-overloading power characteristics unless agreed otherwise by the Engineer. The pump set shall be suitable for starting with discharge valve open or closed.

The submersible pumps shall be supplied and installed complete with bolt-less self-aligning duckfoot assemblies giving automatic connection, and rising pipework to the sump top. All pipework and fittings shall be ductile iron.

Each pump shall be provided and installed with its own stainless steel guide rails, fittings and all necessary support brackets. A lifting chain, of a material suitable for use in the process fluid shall be attached to each pump to enable the pump to be raised and removed from the wet well without the necessity for personnel entering the well.

Each pump shall be supplied complete with a suitable length of submersible cable. The length of the cable shall be so as to allow connection to a connection box adjacent to the wet well.

The submerged cable shall be a multi-core flexible cord, vulcanised rubber insulated with tough rubber sheath and outer PCP sheath to BS 6500.

Following accessories suitable for each pump set shall be supplied:-

Automatic coupling (Pedestal type)	:	1 set.
Guide Rail Pipe approx. 12 mts.	:	1 set
Stainless steel chain with cycle	:	1 set
Approx. 12 mts. Shackles	:	1 set
90° C.I.duct foot Bend	:	1 set

Delivery Pipe:

The delivery C.I. piping shall commence from 90° discharge duck foot bend outlet to the start of rising main. The piping shall be inclusive of detachable/ dismantling joints as per the following: -

The pipes shall generally conform to class 'B' IS:1536 and pipe: fitting shall conform to IS: 1538.

The material of pipes and fittings shall be of good gray cast iron confirming to IS: 210 grade PG -200. The pipes shall be uniform bore and straight in axial length. Double flanged pipes shall be within a tolerance of ±1.5 mm.

The C.I. Pipes and fittings shall be able to withstand double the working pressure or 1.5 times the pressure at shut off head whichever is greater for 5 minutes and a certificate to this effect will be submitted along with the material before payment.

Dismantling joints shall be of cast iron with suitable ring.

Hydrostatic test pressure shall be as per IS:1538.

Diameter of column pipe shall be as per actual requirement i.e. as per enclosed layout drawing

Submersible Motor

The motor shall be integral part of the pump. The enclosure of the motor shall be I.P. 68. Each phase of the motor shall be provided with the moister bimetallic electro mechanical detectors. The motor winding shall be designed for minimum 10 start stop per hour. The insulation of winding shall be of class 'F' insulation. The motor shall be suitable to operate on, 415 ± 10% c/s ± 5%, 3 phase A.C. supply. The design, manufacturer and performance of the equipment shall comply with all currently applicable statutes, regulations and safety codes in the locality where the equipment will be installed, unless otherwise specified the motors shall conform to the latest applicable Indian Standards, B.S. or IES standards.

Motor shall be capable of satisfactory operation for the application and condition on duty as required by the driven equipment's. Motor shall be capable of giving rated output without reduction in the expected life span when operated continuously under either of the following cases of supply: - (Conditions specified in data sheet)

a. Variation of supply voltage from ± 10% the rated voltage.

b. Variation in supply-frequency from ± 5% the rated frequency.

c. Combined voltage and frequency variation ± 6% Motors shall be suitable for the method of starting specified.

Any joints in the motor insulations such as at coil connections or between slot and end winding section shall have strength equivalent to that of the slot sections of coil. The insulation shall be given tropical and fungicidal treatment for successful operation of motor as per the applicable standard. Motor shall have class 'F' insulation.

1.12.13 Progressive Cavity Pumps

1. General

   Progressive cavity pumps shall have an output characteristic that is substantially independent of change in head.

   Pumps shall be designed to run unattended for long periods.

2. Casings

Casings shall be of close grained cast iron to IS 210 GR. FG220 or FG260 capable of withstanding pressures that may be produced due to normal operating pressure surges. Flanges shall be in accordance with BS EN 1092.

Casings shall be mounted on base plates manufactured from cast iron. Casings shall be accurately aligned and located by dowels or machined spigots. Holes shall be provided in the base plates or stools for foundation bolts.

Casings shall not be integral with the stool or base plate, but shall be designed to allow the ready removal of the pump complete from the stool or base plate. Easy access to suction pipe connections must be available.

Stools or base plates shall be fixed to concrete plinths.

3. Glands

Casings shall be sealed against leakage along the rotor shaft by a soft packing stuffing box, which shall contain a bronze lantern ring to facilitate greasing and efficient sealing of the gland.

The gland housing shall be cast iron and split to facilitate packing of the gland.

A grease stauffer shall be provided for lubrication of the gland.

4. Stator

A resilient stator shall be fitted into a rigid housing and be intimately bonded to it.

Stators shall form a double internal helix of constant circular section in which a single helical rotor shall rotate to form progressive cavities.

Stator materials shall be compatible with the liquids and materials being pumped. Stator materials shall generally be natural rubber, nitrile rubber or Hypalon depending on the application.

The stator housing shall be flanged cast iron and jointed to the casing. A flanged delivery connection at the free end of the rotor shall be flange jointed to the stator housing. The suction flange may be part of the casing or be an interleaving flanged casting between stator housing and casing.

Where pumps incorporate long stator housings such housings shall be supported from the base plate.

5. Rotating Parts

The rotating parts shall have a smooth finish and the materials shall be compatible with the liquid and materials being pumped. Rotors shall generally be hard chrome plated stainless steel, tool steel or nitralloy.

Coupling rods shall generally be hard chrome plated mild steel or hard chrome plated stainless steel. The rod shall be joined to the rotor and input shaft by flexible joints preferably of the ball and socket type.

Shaft diameters shall be to BS 4506; shaft keyways shall be to BS 4235 Part 1 or ISO 3912.

The drive shaft shall be supported in heavy duty ball or ball and roller bearings. Bearings shall have life of 100,000 hours.

Where variable output is required from the pump, this shall be achieved by a hydraulic speed variator fitted between pump and drive motor. Where fixed speed output is required or a compact pump arrangement is required then the drive shall be through anti static veebelts.

6. Pump Fittings

Pumps shall be equipped with the following fittings as standard requirements:

- A drainage pipe to allow drainage of gland seepage liquid.
- Suction and delivery pressure gauges.
- An engraved nameplate indicating material of rotor and stator, output at normal speed, and serial number.
- A 25 mm plugged tapping on the suction side for manual flushing the pump.
- A pressure relief valve on the delivery side the discharge of which shall be piped to the suction pipe.

1.12.14 Screw Pumps

1. Screw Pumps

Screw pumps shall comprise a welded steel fabricated central tube with a free start cold formed screw fabricated into a smooth continuous form, welded to the centre tube and designed for minimum deflection.

When it is necessary for the central tube to be constructed of more than one length of plate, a welded joint shall not be positioned in the centre of the flight but shall be positioned at each end, and all such joints shall be full penetration butt weld with fatigue design to BS5400 Part 10. Tube end plates shall be manufactured from Grade 43 steel accurately machined to carry bearing stub shafts. The central tube shall be watertight.

The spiral blades shall be formed from steel plate. The blades shall be secured to the centre tube by a continuous weld and the periphery of the screw blade shall be finished to ensure a uniform clearance between the screw and trough.

Bearing stub shafts of ample dimensions complete with machined location shoulders and mounting flanges shall be bolted to the tube end plates. Top stub shaft units shall extend through the bearing housings to receive the driven half coupling.

Where the upper stub shaft of the screw pump passes through the structure, substantial removable anti-splash closing plates shall be installed and sealed to the structure. Plates shall be not less than 3 mm thick mild steel, split for ease of removal.

The screw pump shall have a speed of rotation not greater than that given by the equation $50 = ND^{0.667}$ where N is in rpm and D is the outer diameter of the screw in metres.

2. Screw Pump Bearings

The top bearing shall be arranged for plinth mounting with all loadings transmitted to the motor room floor. It shall be self aligning and designed to support all thrust loads and radial loads at the top of the screw and shall be rated for a life of 100,000 hours under all combined loadings and,

where applicable, speeds imposed by the screw. The service factor shall be at least two under maximum load conditions. The bearing shall conform to BS ISO 281

The bottom bearing shall be designed to withstand all radial forces and end support loads.

The bottom bearing shall be of bronze or gunmetal sleeve type. The sleeve shall incorporate positive means to prevent rotation of the sleeve bearing.

The bottom bearing shall be supported in a cast iron or fabricated steel housing mounted on a horizontal plinth.

The bottom bearing shall be sealed to prevent the ingress of grit and liquid.

Replacement of the bottom bearing shall be possible without the need to remove the bearing base or the screw or require the use of external cranage.

The bottom bearing shall be suitable for continuous operation either in air or submerged and it shall be automatically lubricated whilst the screw is rotating.

3. Bottom Bearing Lubricator

A positive displacement metering pump, (lubricator), shall be provided for each screw pump to provide a return oil lubrication system for the bottom bearing. The lubricator shall incorporate a means of flow control that shall have a positive minimum setting to prevent premature failure of the bearing. The flow control device shall be provided with locking facilities.

The lubricator shall have an independent drive motor interlocked with the respective screw pump motor.

The lubricator shall incorporate a reservoir which shall hold sufficient lubricant for seven days continuous operation of the screw at maximum lubrication rate possible from the lubricator. A lubricant contents indicator shall be provided on the reservoir in the form of a positive depth gauge.

A lubricant flowmeter shall be installed within the return pipework which shall provide a pulsed output when lubricant is being returned from the bottom bearing. The flowmeter shall operate in conjunction with a pulse continuity relay which shall stop the pump upon a failure of the lubricant system. There shall also be a visible means of indication of the return flow. A filter shall be provided between the return oil pipe and the reservoir.

Pressure and return pipes shall be stainless steel throughout.

4. Screw Pump Drive System

The gearbox reducing the speed between the prime mover and the screw pump shall be of robust construction having the output shaft at right angles to the input and suitable for mounting on a plinth inclined at the same angle as the screw pumps to the horizontal. The concrete plinth shall be provided by the Civil Contractor in accordance with the Contractor's design requirements.

The speed reducer shall be of the totally enclosed oil bath lubricated type fitted with oil level sight glass, dipstick, filler and drain plug, large inspection covers and an oil breather.

Bearings shall be either splash or forced lubricated.

Efficient long life shaft seals shall be fitted to all external shafts to prevent loss of lubricant.

The speed reducer shall be rated for:

- Continuous operation, in the climate and temperature of the place of installation.
- A gear design life of 100,000 hours at a service factor of 1.5 at the motor full load rating. All bearings shall be rated for a life of 100,000 hours at speed reducer full torque rating in accordance with AGMA 420.04 Specification and all other combined loadings and speeds imposed by the screw.

Where speeds reducer external cooling equipment is required this shall be a separate system to any other cooling system.

Screw pumps shall be driven through flexible couplings, of the pin and buffer type to prevent end thrust and radial loads being transmitted to the speed reducer. Couplings shall be arranged to allow coupling belts and buffers to be replaced without disturbing the drive or driven shafts.

A back stop device shall be fitted to the speed reducer shaft to prevent reverse rotation of the screw pump under the head of liquid in the flights when the screw pump motor is de-energised.

The screw pump shall be driven by a squirrel cage induction motor. The motor shall be protected IP55. The motor shall be horizontally mounted.

Power transmission from drive motor to speed reducer shall be through multiple V belts. Pulley ratios and centres shall be selected to ensure the maximum belt contact and bosses shall be a tight fit on the shafts and shall have fitted keys.

Drive motors shall be mounted on slotted slide rails with belt tensioning screws and locknuts provided for adjustment.

The complete drive system shall be guarded to prevent accidental contact with moving parts.

5. Side Profile Plates

A side profile splash guard on the high liquid side of the screw trough shall be provided to prevent liquid running back down the side of the trough.

The guard shall be fabricated from steel plate not less than 5 mm thick. The guard shall be strengthened and returned to the trough side wall to prevent build up of debris behind the guard and also allow liquid to run back into the screw.

A channel section shall be provided for casting into the screw trough along the full length of the screw pump.

The guard shall be securely bolted to the channel section cast into the civil structure.

6. Trough Profiling

The screw pump trough shall be profiled by welding a steel strip of suitable thickness along the complete length of the screw and turning the screw using the Contract motor.

Screeding of the screw pump trough to form the profile will be carried out by the Civil Contractor acting under the guidance and direction of the Contractor.

Profile, finish and running clearance between screw pump and trough must be in accordance with the requirements of the Contractor. Should this not be the case the cost of any remedial work shall be split equally between the Contractor and the Civil Contractor.

7. The Contractor shall provide dry running protection for progressive cavity pumps.

   The Contractor shall submit details of the proposed system for the approval of the Engineer.

1.12.15 Chemical Dosing Pumps

Chemical dosing pumps shall be of the piston, piston diaphragm or mechanical diaphragm type. Pump design shall incorporate positive stroke return. The maximum stroking speed shall not exceed 100 strokes per minute.

Stroke adjustment shall be manual, or by an electrical or pneumatic controlled stroke positioner with step less adjustment between zero and maximum stroke length. Where flow-proportional dosing is required, the variation of output shall be achieved by varying the speed of the pump motor and not the pump stroke length.

A stroke length indicator and digital stroke counter shall be fitted.

Pump liquid ends shall be selected for compatibility with the pumped liquid. Suction and discharge valves shall be the single ball type allowing a free flow self cleaning action. Ball and seat materials shall be resistant to abrasion.

Pumps shall incorporate a variable stroke mechanism to allow the output to be varied while the pump is running. Stroke adjustment shall be manual or where specified by electrical or pneumatically controlled stroke positioner. A stroke length indicator and digital stroke counter shall be fitted. Pumps shall be driven by a flange mounted IP 55 motor, via an oil bath reduction gearbox and variable stroke mechanism giving stepless adjustment between zero and maximum stroke length. Where flow proportional dosing is required the variation of output shall be achieved by varying the speed of the pump motor and not the pump stroke length.

The normal operating range of dosing pump shall be not less than 6:1.

a. Mechanical Diaphragm

Diaphragm rigidly coupled to the drive train. Single suction Pumps and discharge valves. Glandless.

Accuracy: 3% of stoke.

b. 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, AISI 316 stainless steel, glass, or Hastelloy C. Diaphragm materials shall be butyl rubber, PTFE, or Hypalon and glands shall be PTFE or Neoprene.

Each pump shall be provided with inlet and outlet isolating valves and where necessary, with pressure relief and non-return valves. Dosing pumps shall be provided with back pressure loading valves and pulsation dampeners in the delivery lines depending on the downstream conditions.

A relief valve shall be incorporated in the delivery lines under conditions where the pump discharge pipe can be shut off or where pressure may rise to an excessive point. The relief valve shall be sized to handle the system pressure and to discharge maximum pump output freely, and shall be located in the discharge line between the pump and the first downstream isolating valve or in the case of dosing

pumps the back pressure loading valve. Relief valves when used on pumps handling non-hazardous chemicals shall discharge the vented liquid to waste. When used on hazardous chemicals the valve outlet shall be piped back to the suction supply tank or bunded area. The open end of the return pipe shall be located where it is visible, so that any relief valve leakage/operation can be detected.

Pump transferring/dosing chemicals to systems under pressure shall incorporate a pressure gauge on the pump delivery. Air cocks shall be provided for release of air where necessary.

Unless otherwise specified flushing connections shall be provided at each pump inlet and flushing shall be manual. When flushing, water shall be discharged either locally through a drain valve or to the point of application of the chemical. Facilities shall also be provided for flushing chemical pump suction and delivery manifolds and delivery lines to point of application.

Dosing pumps and motors shall preferably incorporate an integral reduction gearbox drive which shall be totally enclosed and oil bath lubricated. The gear box shall incorporate the cams for the diaphragm drive and shall be provided with filling and drain connections and visible oil level indication.

1.12.16 Pump Fittings & Ancillaries

1. Pressure Gauge Tappings

   Each pump set shall be provided with both delivery and suction gauge tappings such that when fitted they are in an upright position. Each tapping shall be isolated with a gun-metal gauge cock.

2. Pressure Gauges

   A pressure gauge shall be provided and installed at the above suction and delivery tappings. The gauges shall be of the diaphragm operated sewage installation type.

3. Guarding

   The Contractor shall include for guards to completely enclose the moving parts of plant.

4. Engraved Nameplates

   Each pump shall be provided with engraved nameplates as follows:

   - Duty Plate: Indicating the type, impeller diameter, output at normal duty, normal duty head, speed, serial number and pump curve number.
   - Identification: Corresponding with the pump control panel designation e.g. 'Pump No 1'. The characters shall not be less than 30 mm high.

1.13Blowers

1.13.1 Air Blowers

1. General Requirements

   (g) The blower shall deliver oil free air.

   (h) The blowers shall be constructed in a manner that eliminates vibration occurring to the plant or being transmitted into the building structure.

   (i) The design and all materials shall be selected to suit the installed environment and climatic conditions.

(j) The blower assembly shall be of a compact modular design, which will ensure a small footprint area to minimise civil construction costs.

(k) The blower and all associated equipment shall be supplied as an integrated package with a view to optimizing availability, prolonging the period over which the design output is maintained, and prolonging the intervals between rebuilds. Appropriate de-rating margins shall be applied as necessary to achieve these ends.

(l) The choice of blower and blower design shall take into account the potential for resonance within the system including those known to occur with multiple blower manifolds.

(m) The blower silencers, air manifold and the overall air system shall be designed to eliminate the effects of resonant frequencies and vibration over the whole operating range of the blowers.

(n) Blowers shall be selected from the manufacturer's standard range to meet the total head requirements of the complete system and provide the range of flows specified. They shall have a non-overloading power characteristic and be sized with an allowance for the variations in atmospheric pressure, temperature, and relative humidity as specified in the Particular specification.

(o) The blowers shall be sized to give maximum operating efficiency at the standard conditions. The blowers shall be capable of operating over the stated operating range. Blower powers shall be quoted for the minimum, standard, and maximum operating conditions.

(p) The Blowers shall be selected and sized to enable continuous increase is air supplied from 45% capacity of one Blower to 100% of all duty blowers in parallel.

(q) Blower Isentropic efficiency shall be greater than 80% at the BEP and greater than 75% over the full range of air output and pressure associated with this duty.

(r) Cooling systems for the blowers shall be self-contained and discharge any hot air generated to the outside of the main building structure.

(s) Special tool required for maintenance shall be delivered with the blower.

(t) Lifting

(i) The blower and any components weighing over 25 kg, that are likely to be removed for maintenance, shall either:

1) Incorporate clearly identified, permanent lifting points located to give a safe, balanced, lift; or

2) Be designed in such a way that standard lifting accessories (e.g. slings) can easily be attached.

(ii) With respect to item (i) above, if lifting points are not designed for lifting the blower/component, they shall be clearly marked accordingly.

(iii) The blower shall be provided with lifting lugs.

2. Corrosion protection

(i) All blower components and associated pipework (including valves and fittings) shall be designed and assembled to avoid galvanic corrosion.

3. Guarding

(i) Guarding shall comply with BS EN ISO 12100 and BS EN 953 or equivalent.

(iv) Guarding of machinery (e.g. belt drives) shall be independent of the acoustic enclosure, if provided.

(v) Blower components and associated pipework that present a burns hazard shall be insulated/guarded as specified.

(vi) Components that require regular inspection, cleaning or maintenance shall be readily and safely accessible and where appropriate, easily replaceable.

(vii) Components shall be designed to avoid the need for the use of special tools for maintenance. If special tools are required, they shall be provided.

4. Support structure

(i) Support Structure (Baseplate or Support Frame) and Mounting Arrangements

(viii) The blower stage and its drive system shall be securely fixed to a rigid support structure.

(ix) The support structure material shall be as stated in the tender and suitable protective coating system shall be proposed to ENGINEER for approval.

(x) The support structure shall be designed to prevent the collection of liquids and debris during operation. The ends of all sections shall be sealed to prevent the ingress of corrosive liquids, after all corrosion resistant coatings have been applied.

(xi) If necessary, to prevent excessive levels of vibration being transmitted to the surrounding building or plinth, the support structure shall be provided with anti-vibration mountings.

5. Air filters and silencers

(i) Air filters on the inlet to compressors/blowers shall be of the dry element two stage, high volume, and pleated type and shall have differential pressure gauge to determine when cleaning or element replacement is required.

(xii) The efficiency of the filter shall be greater than 93% removal for particles 5 microns and larger. The intake silencer shall be located downstream of the filter and it shall be acoustical absorption type with fibre glass packing.

(xiii) The inlet filter/silencer shall be designed for maximum air flow at absolute minimum pressure drop, and connected directly to the inlet of the compressor via a flexible connection.

(xiv) The filter has to have a minimum standard of EU3 in accordance to DIN 24185 or equivalent.

6. Local Control Panel

(i) Each blower shall be equipped with a separate Local Control Panel (LCP). Each LCP shall include integrated controls that controls stop / start of blowers and output per blower to meet a single air flowrate demand signal generated by the plant PLC / SCADA systems.

(i) The integral control system shall include all control of blower components as well as comprehensive condition monitoring and associated control interlocks to protect the blowers and associated systems from potential damage. Control philosophy shall be fail safe operation i.e. all controls and instruments shall fail in an alarm situation. The controls shall be designed so that the blower cannot operate unless the controls are energised, nor can they operate with any defective controls, unless otherwise specified.

7. Motor

(i) Each blower unit shall be connected to the motor via gearbox and/or flexible coupling.

(xv) The motor shall comply with the General Specification _ Electrical.

(xvi) Each coupling shall have a power rating of not less than 1.25 times the motor nameplate power when the misalignment is within the coupling manufacturer's tolerance limit.

8. Acoustic Enclosures

(i) The enclosure shall be selected based on its noise reduction performance, maintainability and its ability to withstand the elements.

(xvii) For major overhaul the enclosure shall be designed to allow for partial disassembly to allow access to both blower and motor by a lifting device. The enclosure shall be fitted with lifting points for complete removal.

(xviii) The enclosure shall be provide with a suitable method of ventilation for blower cooling. The enclosure shall include a temperature sensors designed to signal an alarm in the event of the cooling fan failing due to over temperature.

(xix) Filter pressure, loss indicator, and discharge pressure gauge shall be visible from outside the enclosure.

(xx) The enclosure shall incorporate hinged doors or lift-off panels to provide safe access to all blower components requiring inspection, cleaning or maintenance. The structural integrity of the enclosure shall be maintained when one or more panels are removed. Doors/panels shall comply with the following requirements, as a minimum:

1) Doors shall open to a minimum angle of 90^{o} and be restrained against wind loads when open;

2) Panels shall be easily removed and manipulated by one person (e.g. fitted with suitable handles) and have a maximum weight of 25 kg;

3) Doors/panels shall be securely held in place when closed/in position and shall be lockable by padlock;

4) Seals shall be provided around doors/panels to maintain the acoustic performance of the enclosure;

(xxi) Where provided, 'walk-in' type acoustic enclosures shall be provided with all appropriate warning signs/notices.

(xxii) The enclosure shall have an outer skin of steel or thick GRP, and an inner skin of zinc coated perforated steel. The space between the outer and inner skins shall be filled with high density mineral wool.

(xxiii) All routine inspection and servicing shall be achievable without the need to remove the enclosure. Hinged access doors shall open to at least 90 degrees, and be fitted with stay put type stays. Lift off access doors shall not exceed 25 kg in weight.

(xxiv) For major overhaul, the enclosure shall be designed to allow partial dismantling to allow access to both blower and motor by overhead crane or other permanent lifting device. The enclosure shall be fitted with lifting points for complete removal.

(xxv) Enclosure discharge ventilation and pressure relief valve ventilation shall be ducted or vented away from the enclosure so that the high temperature air is dissipated away from the enclosure and any personnel access.

(xxvi) The enclosure shall incorporate over temperature detection device the output of which should be suitable for control and monitoring.

(xxvii) Filter pressure loss indicator and discharge pressure gauge shall be visible from outside of the enclosure.

9. Spares

(i) The Supplier shall provide the first fill of lubricants to all components/systems requiring lubrication. All grease lubricated bearings and associated lubrication pipework shall be fully charged with grease.

10. Air intake

(i) Air intakes shall be positioned in a manner, which avoids collection of contaminants such as engine exhaust fumes and excessive dust and always away from any extractor fan discharge points.

(xxviii) Air may be admitted to the room, which houses the blowers either through an external wall or, where this is not possible, via an intake duct. Where air is delivered to processes on a continuous basis, the blowers shall be connected to the intake duct in order to draw air from outside the building and not from the room itself.

(xxix) A louvered panel or panels shall be installed at the air inlet point together with filters. The filters shall comprise removable panels with convoluted elements mounted in frames. The elements shall be of the washable type and a spare set shall be provided to facilitate substitution for this purpose.

(xxx) Unless otherwise specified, the intake ducting shall be in galvanised steel and of adequate proportions to minimise pressure drop and vibration. Where necessary to suppress low frequency noise, a silencer of the multiple aerofoil or `beam splitter' type shall be installed within the duct close to the inlet point.

(xxxi) Where air is drawn by the blowers directly from the room, appropriate provision shall be made to protect equipment and pipework from low ambient temperatures. Where air is drawn from outside the building, then heat from the machines must be dissipated effectively at times of high ambient temperatures.

(xxxii) The room shall be properly ventilated.

11. Submittals

Supplier shall provide the following information at Tender stage:

(i) A typical general arrangement drawing of the blower indicating the designation, overall dimensions/footprint and typical layout of key components/systems and the following information as minimum :-

1) The maximum blower design speed and maximum allowable bower operating speed.

2) The maximum blower power input.

(ii) Typical blower performance curves

(iii) A component/system schedule or asset list including, for each major component/system, the component/system manufacturer and all relevant technical specifications (including details of materials);

(iv) A lubrication schedule detailing all components/systems requiring lubrication, the method and frequency of lubrication and the type and manufacturer of the lubricants;

(v) A schedule of spares required for 2 years of normal operation (plus associated costs and lead times);

(vi) A typical control philosophy; and

(vii) A typical commissioning plan (including timescales for completion).

With respect to (i), the drawing shall indicate, where appropriate, the minimum clearance distance required for the removal of components (including acoustic enclosures, if provided) for refurbishment or replacement with the equipment in situ and details of interfaces with other equipment.

1.13.2 Centrifugal Blower

1. General

(i) The Centrifugal radial flow blowers shall be designed for energy optimisation, high operating efficiency and low maintenance costs. The running costs for the design life of the plant shall be evaluated to achieve maximum efficiency.

(ii) The centrifugal radial flow blower shall be able to provide variable flow rate, controlled by a combination of inlet and outlet guide vanes with fixed speed motors.

(iii) A fully automated blower control system shall be included as part of the blower installation to monitor critical parameters of the blower and to control performance.

(iv) Centrifugal blowers shall be supplied, as applicable, with the following features:-

1) A blow-off/unloading valve, silencer and failure detection system

2) Pressure relief valve set to 10% above system operating pressure, and capable of 100% blower discharge flow fitted with an accumulation not in excess of 10% of set pressure.

3) In built self-diagnostics together with real time condition monitoring.

4) Inlet process air filter.

5) A surge protection system

6) Inlet filter differential pressure indicator local to the filter. An electronic alarm signal shall be integral with the controls.

7) Inlet silencer.

8) Discharge silencer and compensation bellows in pipeline.

9) Suitably sized non return valve on blower discharge.

10) An isolating valve

11) An outlet pressure gauge with isolating valve. The gauge full scale deflection shall be between 1.5 and 2.0 times the maximum outlet pressure;

12) An inlet air temperature sensor, with high level switch (to detect reverse flow); and

13) A vibration sensor with high level switch

14) Blow off (Bypass) valve and silencer.

15) High discharge air temperature alarm.

16) Diffuser according to blower type and application.

With respect to item (i), the blow-off/unloading valve shall discharge to a safe position, away from the blower inlet.

2. Design Selection

(i) Operation of several centrifugal blowers on line shall be possible without special requirements. The condition of several units running in parallel with different air flow settings shall be met and the safety margin between discharge pressure and surge pressure shall be maintained at the same value for each machine operating in parallel.

(i) Starting or stopping of any individual blower shall be possible without altering the airflow of the plant.

(ii) A surge control must be installed and designed to detect the incidence of pneumatic surge.

(iii) Operating pressure should be no greater than 85% of the blower maximum continuous pressure rating.

(iv) The safety margin between the maximum outlet pressure required and the surge pressure shall be a minimum of 3.5 % of the maximum outlet pressure required.

(v) Blowers shall have performance curves to enable satisfactory flow diversion between blowers in parallel operations. This shall be achieved by cascade control to provide the most efficient means of operation. Alternative shall be proposed and submitted to ENGINEER for approval. Blowers shall achieve a wide dynamic volumetric operating range with each blower demonstrating a minimum of 45% turndown.

(vi) All losses for silencers, check valves and the drive system shall be included in the total power figure stated in the tender and the blower output shall be rated to take such losses into account.

(vii) Unless otherwise specified, vibration levels shall not exceed 2.8 mm/s (rms).

3. Mechanical Construction

(i) The blowers shall be of the single stage centrifugal integrally geared type with integral electric drive motor and gearbox. The volumetric air output shall be controlled over the required range by speed variation of the impeller or by mechanical means such as adjustable inlet/outlet guide vanes.

4. Impeller and Shaft Seals

(i) The design of the impeller shall incorporate a backward curved vane profile for inlet guide vane control and radial impeller for variable diffuser control.

(ii) The impeller shall be manufactured from forged aluminium alloy or high grade alloy steel. Fabricated steel or aluminium impellers shall not be used.

(iii) The machined as one, not welded, casted or riveted made of Aluminium alloy or high grade alloy steel.

(iv) The design shall be such that vibration or flexing on the shaft does not occur within the operating speed range of the blower.

(v) The impeller shall be attached to the shaft by shrink fit and locknut arrangement. The shrink fit construction shall ensure sufficient attachment and centreing of the impeller at all operating conditions. The impeller shall be dynamically balanced.

(vi) The design of the rotating element shall ensure that the first critical speed does not occur within +/- 20 % of the operating speed range of the blower.

(vii) Any responsive lateral critical speed of the rotating assembly shall be at least fifteen (15) percent from the normal operating speed.

(viii) Any torsional resonances of the package shall be at least ten (10) percent from the normal operating speed.

(ix) All shafting shall conform to "Design and Selection of Components for Enclosed Gear Drives" (AGMA 6001-D97).

5. Volute Casing

(i) Inner Volute casings shall be made of grey cast iron and the outer volute shall be ductile cast iron. Discharge flanges shall be drilled to DN 2501 DN10. All joints of the casing shall be machined.

(ii) Seals shall be of the non-contact, multi-point labyrinth type and be readily replaceable. The high speed air and oil seals shall be located in a vented chamber.

(iii) Venting and drainage facilities shall be provided at the highest and lowest points on the casing.

(iv) The volute casing shall be mounted on the gear case flange. All mating surfaces shall be accurately machined and be provided with deep registers, dowels and spigots where necessary, to ensure correct alignment.

(v) The volute casing outlet shall be provided with a flexible expansion joint to accommodate vibration and/or expansion or contraction of the outlet pipework. If necessary, the expansion joint shall be protected from distortion during service by tie-rods.

(vi) The volute casing outlet shall be provided with an outlet cone to maximise the recovery of velocity head

6. Adjustable Guide Vanes

(i) An adjustable guide vane assembly and outlet vane diffuser system shall be mounted integral with each blower. Inlet guide vanes shall be made in an aerodynamic, streamlined design in cross section and located radially.

(ii) The inlet Guide vanes and outlet guide vanes shall be able to regulating in the Isentropic Head (pressure and temperature) and the flow to optimise the blower efficiency.

(iii) 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 the required flow. The regulation program must be individually designed for each blower and based on the measured result from the performance test for each blower.

(iv) Variable diffuser vanes shall be provided for capacity control and designed to obtain high diffuser efficiency in the entire regulating range.

(v) The purpose of a combined inlet guide vane and variable diffuser vane system shall be to facilitate the turn down of each blower from 100 to 45 % air flow rate capacity. Also efficiency shall be maximised over the entire turn down range, especially when the blower is operating under off design conditions (lower temperature and/or pressure).

(vi) Full details of any variable inlet guide vane and/or variable diffuser vane systems supplied with the blower for regulating blower performance shall be provided with the tender.

7. Blower Efficiency

(i) The blower shall achieve and maintain a high volumetric efficiency. Volumetric efficiency shall not be allowed to fall below a level where it adversely effects air temperature rise and overall blower efficiency. The blower speed shall not be turned down to the substantial detriment of volumetric efficiency or cooling.

8. Impeller Shaft Seals

(i) The shaft seals shall be of a non-contact, multi-point, labyrinth type and operated dry.

(ii) The impeller shaft shall be provided with seals to prevent the ingress of oil and contaminants into the volute casing and avoid contamination of the gearbox oil.

(iii) Shaft sealing arrangements shall ensure oil free air delivery.

(iv) The shaft sealing arrangement shall ensure a process air quality of Class 0 in accordance with ISO 8573-1.

(v) Rotating components and shaft seals shall withstand the pressures, temperatures, and corrosive/erosive properties of the air.

(vi) A vented space between air and oil seals shall be provided.

(vii) Any leakage shall be minimized by having small clearances between female and male parts. The female part shall be made of aluminium or bronze to avoid damage to the shaft in the event of a seal rub.

(viii) Uniform shaft diameter without multiple slinger rings in each sealing area will not be acceptable.

9. Gears

(i) The rotor shall be driven by a step up gearbox. Speed increasing gear shall be of the helical type. The pinion shall be integral with the rotor shaft. The gears and shafts shall be made of case hardened alloy steel forgings with gear teeth precision ground.

(ii) All gears shall be rated in accordance with "Fundamental Rating Factors and Calculation Methods for Involute Spur and Helical Gear Teeth" (AGMA 2101-C95).

(iii) The gears shall be manufactured to a minimum AGMA quality number of twelve (12) per "Gear Classification and Inspection Handbook" AGMA 2000-A88.

(iv) The gearbox shall be of ample size and rated to transmit the maximum torque and power input requirements to the blower under all operating conditions.

(v) The gearbox shall incorporate a pressurised oil lubrication system to lubricate the gears and bearings. The system shall incorporate the following items, as a minimum:

1) An oil reservoir with thermostatically controlled oil heater;

2) A main oil pump (mechanically driven) with suction strainer;

3) An auxiliary oil pump (electrically driven) with suction strainer;

4) An oil cooler;

5) An oil filter with visual condition indicator;

6) All necessary pressure relief valves, non-return valves, fittings and pipework etc. to ensure effective, fail-safe operation;

7) All necessary instrumentation and protective devices to ensure effective, fail-safe operation (including, as a minimum, oil temperature and pressure and bearing temperature monitoring sensors); and

8) Readily accessible oil drain and fill/vent points to allow oil removal/replacement 'in situ' without excessive spillage and without disturbing blower mountings and/or ancillary equipment. An effective oil mist vent filter shall be provided.

(vi) The auxiliary oil pump (if required) shall ensure effective gearbox lubrication during blower start-up and run-down. It shall also act as a standby unit if the main oil pump fails.

10. Bearings

(i) Hydrodynamic, oil pressure lubricated bearings shall be required with sufficient oil film thickness under all operating conditions.

(ii) All bearings shall be of bronze construction and having a minimum L10 life of 100,000 hours.

(iii) Slow speed shaft radial bearings shall be cylindrical, journal type (hydrodynamic bearing).

(iv) Fast shaft radial bearings shall be multi-segment and babbitted, designed to suppress hydrodynamic instabilities and provide sufficient dampening to limit rotor vibrations. Fast shaft thrust bearings shall be multiple segment, tapered land type and designed for thrust in both directions. Material bronze alloy.

(v) Rolling element (i.e. ball bearings) are not allowed to be used for any bearing in the gearbox when main motor nominal power is equal or higher than 250kW.

11. Surge Protection (if applicable)

(i) An electrically actuated blow off valve venting directly to atmosphere shall prevent surge conditions arising in the process air pipework. The valve shall be open during blower start up and when the air flow is less than that at surge point.

(ii) An automatic control system, shall be included to monitor the air flow/pressure and modulate the blow off valve as required. The control system shall automatically open the blow off valve and shut down the air blowers on detection of a surge condition.

12. Oil Lubricating System (if applicable)

(i) A complete oil system shall be provided with each blower. The system shall be capable of supplying clean oil at suitable pressure and temperature to lubricate the speed increasing gears and bearings. All components shall be installed integral with the blower base plate and arranged to permit ease of accessibility for operation, maintenance, inspection, and cleaning.

(ii) The lube oil system shall consist of a reservoir in the base, one or two positive displacement pumps with strainers, and an oil to oil or oil to water heat exchanger, one oil filter, and mechanical appurtenances. A pressure gauge, thermometer, adjustable high and low temperature switches and adjustable high and low pressure switches shall be installed on each lube oil system. The oil system shall be integral in the base and the interior of the reservoir shall be descaled and rust proof by the application of a permanent coating of the manufacturer's standard.

13. Motor

(i) Unless other specified, the motor shall be rated to IP55, 220 Volt, 50Hz, IE2, insulation class F with temperature rise B and temperature measurement in the windings as well of anti-condensation heater and shall comply with Electrical specification.

(ii) Flexible shaft couplings and guard shall be replaceable without disturbing the blower stage and/or its drive (i.e. spacer-type couplings shall be fitted). Couplings shall be designed with a service factor of 1.5 as minimum (based on the maximum blower power input).

(iii) Where the V-belt drive required, the V-belt transmission shall incorporate an automatic belt-tensioning device. V-belt drives shall be designed with a service factor of 1.5 as minimum (based on the maximum blower power input) and shall be subject to ENGINEER approval.

14. Base Frame

(i) The motor, blower and gearbox (if specified) assembly shall be mounted on a base frame irrespective whether the motor/blower arrangement is vertical or horizontal. The base frame shall be equipped with anti-vibration mountings to prevent the transmission of vibration to the support structure, silencer, filters or connected pipework. Details of all static and dynamic loads transmitted to the foundations shall be included in the Contractor's design procedures.

(ii) The mounting mounts shall be St.SIS 1312 or better for damping natural rubber hardness 60.

15. Service Factors

The blower, incl. motor, shall as a minimum fulfil following service factors:

Gear	≥ 1,8 according to DIN 3990 Part 21
Bearing	≥ Minimum life time of 100.000 hours at any axis
Coupling	≥ 1,5

16. Instrumentation and Control Signals:

(b) The minimum instrumentation shall be included as following:

1) Inlet filter differential pressure gauge;
2) Inlet air high temperature sensor;
3) Surge indication switch (surge monitor);
4) Oil high temperature sensor;
5) Oil temperature gauge;
6) Oil low pressure sensor;
7) Oil pressure gauge;
8) Oil filter differential pressure indicator;
9) Self-acting thermostatic valve for water cooled oil cooler;
10) Variable diffuse position transmitter and indicator; and
11) Inlet guide vane position transmitter and indicator.

(c) Minimum controls signals which shall be provided as following:

1) Hand/Auto;
2) Oil pump running;
3) Blow off valve open/closed;
4) Diffuser position (Min/max);
5) Inlet guide vane position (Min/max);
6) Blower motor tripped/healthy;
7) Blower motor temperature normal/high;
8) Vibration warning;
9) Vibration tripped/healthy;
10) Oil pressure normal/high;
11) Surge event; and
12) Recirculation event.

(d) The minimum requirement for the control of the blower as following:

1) Variable inlet guide vane (VIGV) and variable diffuser vane (VDV) systems shall be automatically adjusted according to the Control System settings.
2) The blow-off/unloading valve shall automatically open during blower starting and shut-down.
3) If a number of blowers are operating in parallel, starting and stopping of any individual blower shall be possible without altering the overall flow rate of the plant.
4) The blower shall automatically shut-down (or starting shall be inhibited) under the following fault/alarm conditions :-
   i) Low low - gearbox oil pressure;
   ii) High high - gearbox oil temperature;
   iii) High high - gearbox bearing temperature;
   iv) High high - inlet air temperature (reverse flow);
   v) Blow-off/unloading valve fault;
   vi) Surge conditions; and
   vii) High High' blower vibration.

Re-starting of the blower shall not be possible unless the fault/alarm is manually reset at the LCP.

1.13.3 Positive Displacement Blower

1. General

(i) The blower shall be provided with the following items, as a minimum:

1) A blow-off/unloading valve and silencer;

2) A pressure relief valve (PRV), set at 110 % of the maximum operating pressure and rated to pass the maximum blower flow rate;

3) A non-return valve;

4) An outlet pressure gauge. The gauge full scale deflection shall be between 1.5 and 2.0 times the maximum outlet pressure;

5) Flexible connections to the blower stage inlet and outlet, to prevent transfer of vibration; and

6) Inlet and outlet silencers.

With respect to item (1), the blow-off/unloading valve shall discharge to a safe position, away from the blower inlet.

With respect to item (2), the PRV shall discharge outside the acoustic enclosure (if provided). Full details of the PRV shall be provided with the tender.

With respect to item (5), the inlet and outlet connection details (pipework sizes and flange details) required/provided shall be as stated in the tender submission.

With respect to item f), outlet silencers shall be of the reactive type.

2. Rotary Lobe Blower

The Rotary lobe blower shall incorporate twin, lobed rotors, rotating in opposite directions in the blower casing. Rotor shaft rotation shall be synchronised by timing gears to prevent contact between the rotors.

3. Rotary Screw Blowers

The blower shall incorporate a pair of asymmetric, screw type rotors, rotating in opposite directions in the blower casing and resulting in internal compression within the blower. Rotor shaft rotation shall be synchronised by timing gears to prevent contact between the rotors.

4. Design Selection

(i) The volumetric performance of the blower (i.e. its flow rate and pressure characteristics) shall meet the requirement as specified in particular specification.

(ii) Blowers with a motor rating up to 15 kW shall be limited to 70 % of the blowers maximum design speed. Blowers with a motor rating of 15 kW and above shall not exceed 2800 rpm or 70 % of the blowers maximum design speed whichever is the lower.

(iii) Operating pressure should be no greater than 85 % of the blower's maximum continuous pressure rating.

(iv) The blower shall be capable of satisfactory operation in parallel with a number of other blowers.

(v) The blower shall achieve and maintain a high volumetric efficiency. Volumetric efficiency should not be allowed to fall to a level where it adversely effects air temperature rise and overall blower efficiency. Variable speed blowers shall not be turned down to the substantial detriment of volumetric efficiency or cooling.

(vi) Where variable output is required, this shall be achieved by electric squirrel cage motor and static inverter. The blower, motor, inverter and cabling installation shall be designed as a complete system.

(vii) All losses for silencers, check valves and the drive system shall be included in the total power figure stated and the blower output shall be rated to take such losses into account.

(viii) The blower stage and drive system shall be effectively isolated from its support frame and acoustic enclosure to prevent transmission of noise/vibration to the surrounding environment

(ix) Unless otherwise specified, vibration levels from the blower stage shall not exceed 12 mm/s (rms). The actual maximum vibration level from the blower stage verify on site and the point of vibration measurement shall be proposed to S.O for approval.

(x) Unless otherwise specified, vibration levels from the blower package shall not exceed 30 mm/s (rms). The actual maximum vibration level from the blower package shall be verify on site and the point of vibration measurement shall be proposed to ENGINEER for approval.

5. Blower Casing

(i) The casing shall be fitted with a front cover plate which can be easily removed to give access to the rotating components.

(ii) The front cover plate shall be of a wear resistant material and fully compatible with the casing material. When the weight of the cover exceeds 25 kg, provision shall be made for its support during removal.

(iii) Shaft seal arrangements shall ensure an oil free air delivery.

6. Rotors and Rotor Shaft

(i) Rotating components and seals shall withstand the pressures, temperatures and corrosive properties of the blow air.

(ii) Rotors and shaft shall be suitably marked to ensure correct alignment and synchronisation on re-assembly.

(iii) The rotor shafts shall be provided with seals to prevent the ingress of oil into the casing and to avoid contamination of the timing gearbox oil.

(iv) The sealing arrangements shall be as submitted and approved by ENGINEER..

(v) The sealing arrangements shall ensure a process air quality of Class 0, in accordance with ISO 8573-1.

(vi) All rotating assemblies shall be statically and dynamically balanced.

(vii) All critical speeds shall be at least 20 % higher than maximum operating speed.

(viii) The rotating assemblies shall be supported on roller bearings having a minimum L10 life of 100,000 hours.

(ix) The rotors shall be dynamically balance and not exceeding the maximum vibration levels as specified in General specification workmanship

(x) For rotary lobe blower the following shall be comply:-

1) the rotors and rotor shafts shall not be machined from a single forging/casting, the method of fixing the rotors to the shafts together with the information of the rotor and shaft materials shall be submitted and approved by ENGINEER

2) Lobes shall be positively located on their shafts.

(xi) For rotary screw blower the following shall apply:

1) The rotors and rotor shafts shall be machined from a single forging/casting. The rotor geometry and the rotor/ shaft material shall be submitted and approved by the ENGINEER

7. Gearbox and Bearings

(i) The rotors shall be driven by a permanent mesh gearbox. The gearbox shall be integral with the blower casing.

(ii) Cooling, if required, shall be by air. Lubrication shall be self-contained.

(iii) The timing gear life and service factor shall be stated in the tender submission.

(iv) The timing gears shall be oil lubricated and method of lubrication shall be stated in tender submission.

(v) The timing gear lubrication system for rotary screw blower shall incorporate readily accessible oil filling and drain points to allow oil removal/replacement 'in situ' without excessive spillage and without disturbing the blower stage mountings and/or ancillary equipment. Oil level windows/sight glasses shall be provided.

(vi) The gear case for rotary lobe blower shall incorporate readily accessible oil filling and drain points to allow oil removal/replacement 'in situ' without excessive spillage and without disturbing blower stage mountings and/or ancillary equipment. An oil level window/sight glass shall be provided.

8. Bearings and Bearing Lubrication

(i) All bearings shall be rated for a minimum L10h life (or equivalent) of 40,000 hours for rotary lobe blower unless specified.

(ii) All bearings shall be rated for minimum L10h life (or equivalent) of 60,000 hours for rotary screw blower, unless specified.

(iii) The drive-end and non drive-end bearing details (i.e. type, manufacturer, designation, etc.) and method of lubrication shall be submitted and approved by ENGINEER.

(iv) Automatic grease dispensers, if provided for rotary lobe blower, shall provide a clear indication of grease contents. The minimum capacity/life of the grease dispensers shall be as stated in the tender.

(v) If oil-lubricated bearings are provided for rotary lobe blower, bearing housings shall incorporate readily accessible oil filling and drain plugs to allow oil removal/replacement 'in situ' without excessive spillage and without disturbing blower stage mountings and/or ancillary equipment. Oil level windows/sight glasses shall be provided

(vi) Oil lubrication systems if provided for rotary screw blower, it shall incorporate readily accessible oil filling and drain points to allow oil removal/replacement 'in situ' without excessive spillage and without disturbing the blower stage mountings and/or ancillary equipment. Oil level windows/sight glasses shall be provided.

9. Motor

(i) Where pulleys and belts are used the motor shall be fitted to slide rails to allow belt tensioning and removal.

(ii) The suitable method of blower cooling shall be proposed and approved by ENGINEER

10. Base Frame

(i) The blower, gearbox and motor shall be mounted on a rigid base frame. Components shall be located by fitted dowels to ensure accurate axial alignment. Anti-vibration mountings shall prevent the transmission of vibration to the support structure, silencers, filters or connected pipework. The base plate shall be surface protected.

(ii) Details of all static and dynamic loads transmitted to the foundations shall be provided.

11. Control and instrumentation

(i) The blower shall be provided with the following items as minimum:

1) A high outlet air pressure sensor; and

2) A high outlet air temperature sensor.

(ii) Where a unit is to be used in parallel with other machines, or will need to start against a pressurised discharge, unloading valves for starting shall be provided. Valve position switches and recirculation air temperature switches shall be provided for control and monitoring.

(iii) The minimum control requirement for the blower shall be following:

1) The control system shall be designed so that either blowers may be selected as the duty unit and the other blowers as the stand-by unit. This selection shall be made locally and indicated on the SCADA system.

2) Blowers shall be fully controlled from a local panel with only monitoring provided on the SCADA system. An available signal shall be provided for each air compressor and these shall be connected to the SCADA system for indication and alarming.

3) The blower shall be designed to be fail-safe, such that failure of any essential components/systems shall generate an alarm and, if necessary, shut-down the blower.

4) The Control System shall optimise the efficiency of blowers operating in parallel or cascade control.

5) The blower shall start and stop automatically as required by its Control System.

6) During starting, the blower shall not dwell at or near any critical speed, but shall rapidly accelerate through it.

   The blower shall automatically shut-down (or starting shall be inhibited) under the following fault/alarm conditions. Re-starting of the blower shall not be possible unless the fault/alarm is manually reset at the LCP:

   - Motor starter fault (overload, earth fault etc.) (all drives);
   - High drive motor insulation temperature (thermistor trip);
   - High outlet air pressure;
   - High outlet air temperature;
   - Low oil pressure (if appropriate); and
   - High oil temperature (if appropriate).

7) Operation of an emergency stop pushbutton on the LCP (unless otherwise specified) shall cause the blower and all auxiliary plant to stop in both Hand and Automatic modes.

8) No alarm or shutdown shall isolate the LCP display, if an LCP is provided

1.13.4 Test and Inspection

(a) The blower shall be performance tested in accordance with the relevant standards as follows:

(i) For Centrifugal blowers:

1) ISO 5389 – turbo compressors –performance test code

(ii) For Positive Displacement Blowers

1) BS 1571-2 – Specification for testing Positive displacement compressors and exhausters.

2) DIN EN 1021-1 – Compressors and vacuum pumps 02-2011

(b) Test certificates confirming all performance test results, including vibration measurements, shall be provided for ENGINEER approval.

(c) Variable speed blowers (if applicable) shall be string tested throughout their entire operating speed range using the 'contract' motor and inverter.

(d) Witness testing (if required) shall be performed at a speed to be dictated by the ENGINEER

(e) For the blower driver balance test, to verify the performance and wire power consumption, including all consumers related to running the blower i.e. cooling units, PLC's and related equipment. The test shall be witnessed by the client.

(f) The test should be carried out in a certified test facility with instruments calibrated by a third party inspector. In case harmonic currents or currents of high frequencies can be foreseen, the power shall be measured by a power analyser with a band width of 0.1 – 1 MHz and the current transformer shall be capable of measuring not less than 500 kHz.

(g) To verify the blower performance over the whole operation range and operation mode based on the control philosophy, below operation parameters shall be the basis for the test :

Operational levels	*Allowed tolerances*
• 100% Operation	• Flow ± 0%
• 80% Operation	Pressure ± 0%
• 60% Operation	• Power ± 4%
• 45% Operation	

(t) Further to the site performance test the following has to be provided for each blower by the supplier:

(i) Inlet and outlet pressure transmitters;

(ii) Inlet temperature transmitter; and

(iii) A thermal mass flow meter.

1.13.5 Control Philosophy

(a) General (All Blowers)

(i) The control system shall be designed so that either blowers may be selected as the duty unit and the other blowers as the stand-by unit. This selection shall be made locally and indicated on the SCADA system.

(ii) Blowers shall be fully controlled from a local panel with only monitoring provided on the SCADA system. An available signal shall be provided for each air compressor and these shall be connected to the SCADA system for indication and alarming.

(iii) The blower shall be designed to be fail-safe, such that failure of any essential components/systems shall generate an alarm and, if necessary, shut-down the blower.

(iv) The Control System shall optimise the efficiency of blowers operating in parallel by load sharing or cascade control.

1) Normal Operation

- Hand Mode

  Starting and stopping of the blower shall be performed manually with 'start' and 'stop' push-buttons on the LCP.

- Off Mode

  The blower shall coast to a stop under its own inertia. This position shall also be used to clear a fault and allow restarting of the blower after it has shut down for any fault condition.

- Automatic Mode

  The blower shall start and stop automatically as required by its Control System.

  During starting, the blower shall not dwell at or near any critical speed, but shall rapidly accelerate through it.

2) Shut-Down

The blower shall automatically shut-down (or starting shall be inhibited) under the following fault/alarm conditions. Re-starting of the blower shall not be possible unless the fault/alarm is manually reset at the LCP:

- Motor starter fault (overload, earth fault etc.) (all drives);
- High drive motor insulation temperature (thermistor trip);
- High outlet air pressure;
- High outlet air temperature;
- Low oil pressure (if appropriate); and
- High oil temperature (if appropriate).

3) Emergency Stop

Operation of an emergency stop pushbutton on the LCP, (unless otherwise specified) shall cause the blower and all auxiliary plant to stop in both Hand and Automatic modes.

4) Miscellaneous

No alarm or shutdown shall isolate the LCP display, if an LCP is provided.

1.13.6 Associate Plant and Equipment

(b) Air Pipework

(i) Unless otherwise specified, air pipe unless otherwise specified, pipe sized to limit the air flow velocity to less than 8 m/sec at the normal system operating pressure.

(ii) Metal Pipework shall be earthed to discharge static electricity.

(iii) Drainage points shall be provided and at not less than 30m intervals. Drainage points shall be formed by equal tees with a down pointing leg fitted preferably where changes of direction occur. Branch take offs shall be from the top of the main. The bottom of any falling pipe shall be drained.

(iv) The pipework system shall be fully hydraulically pressure tested.

(v) The pipework system shall be designed to avoid resonance and vibration.

(vi) Thermal expansion and contraction system shall be included in the pipework system. Sufficient and suitable bellow type expansion joint with supports, guiding pipe and control rod shall be provided to accommodate the pipe movement. The metal bellow and guiding pipe, shall be made of stainless steel 316, unless otherwise specified. The details of the pipework arrangement shall be submitted to ENGINEER for approval.

(vii) Pipework up to and including 50 mm N.B. shall be in steel to BS EN 10255 with heavy fittings in malleable iron to BS143 screwed to BS EN 10226-1. Threaded joints shall be made with a temperature resistant jointing compound. PTFE tape shall not be used.

(viii) Pipework over 50 mm N.B. shall be in steel to BS EN 10216 grade 360 or 430 with flanged joints drilled to BS4504 PN16 or higher rating where applicable, unless otherwise specified.

(ix) Carbon steel pipework, if specified, shall be hot dip galvanised in accordance with Painting and Protective Coatings General Specification. No other internal coating is required.

(x) Sufficient bellow type expansion joint with supports, guiding pipe and control rod shall be provided to accommodate the pipe movement. The metal bellow and guiding pipe, shall be made of stainless steel 316. The details of the pipework arrangement shall be submitted to ENGINEER for approval.

(xi) Particular care shall be taken at points where condensation is likely to form or to accumulate such as following compression or cooling of ambient air or discharge of reactivation air from dryers.

(xii) Appropriate traps and automatic drain valves discharging to approve points shall be installed.

(xiii) Unless otherwise specified, thermal insulation and cladding or protection guard where fitted shall be arranged in a manner which provides access to valves and other components for maintenance purposes.

(xiv) Pipework which connected to blowers shall via flexible connectors, with the pipework immediately downstream of the flexible joint being suitably supported.

(xv) Test points shall be provided at the outlet and inlet pipework and shall be proposed and submitted to ENGINEER for approval.

(xvi) Wall penetrations and pipework supports shall be designed to limit the transmission of noise / vibration.

(xvii) Equipment foundations, supports and restraints etc shall be designed and installed with due regard to all static and /or dynamic forces that will be imposed upon them by the installed equipment, including , as a minimum, forces arising due to surge, thermal effects and vibration.

(c) Air flow control valves

(i) Air flow regulating valves shall be globe type constructed of stainless steel 316C16 to BS EN 10213. Valve spindle shall be stainless steel type 316S16 to PD 970. Gland packing and seating ring shall be PTFE. Valves shall be sized in accordance with BS EN 60534 – 2. Flanged valves shall have integral flanges drilled to BS EN 1092 with pressure designation to match the pipework system. The flow control range of the valves shall be 10:1 or greater.

1.14Diffuser

1.14.1 General

The aeration system shall be provided to meet the aeration requirement as per the process design requirement. Sufficient design calculations are to be provided along with manufacturer standard one having supplied diffuser during last five years to various waste water treatment plant.

1.14.2 Design

The membrane diffuser shall be developed specifically for releasing 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.

Air diffuser assemblies shall be of the tubular, non-clog, fine bubble type with a flexible perforated air release membrane. Disc and panel diffuser designs are not acceptable. The perforations shall be die cut I-shaped. The diffuser membrane shall be constructed from EPDM/PU and be suitable for continuous or intermittent aeration. Each membrane shall be held in place by two 316 stainless steel band clamps. The membrane shall include UV inhibitor and compounds designed for resistance to chemical attack, weathering, fatigue, and aging. The diffuser assemblies shall have double backflow prevention to prevent liquid from passing into the aeration header. Backflow prevention shall consist of self-sealing slits and membrane clamping over the circumference of the diffuser support pipe. The membrane exterior surface shall be smooth as to inhibit biological film growth. The membrane shall inflate during aeration and deflate when the airflow is discontinued, further restricting biological film growth.

The membrane shall be cleanable in place with water from a high pressure wash. Diffuser membrane shall have a thickness of 1.9 mm +/- 0.2 mm and shall meet the following Specifications:

(a) Durometer, Shore A: 45 +/- 5.

(b) Minimum Tensile Strength: 1,160 psi.

(c) Elongation at Break: 500% +/- 100%.

Tube membrane:

Each membrane shall have a 28 mm wide non-perforated strip at the top and bottom of each diffuser to reduce bubble coalescence and improve air distribution.

All Diffusers shall be modular and each module shall be retrievable type. The retrievable type of modules of diffusers shall be with the help of a rail and electric winch and shall be capable of handled by one person. The Retrieving shall be done without draining the Basin and without stopping the plant and without bypassing the plant. After retrieving the diffusers, they shall have the features like swiveling arrangement for each module and should be easily cleaned standing on the walkway of the diffusers.

Tube diffuser shall be of non-buoyant design. An EPDM gasket shall be used to provide an airtight seal between the air header and the manifold piping. Diffuser mounting saddle/grommet shall be of injection molded, nylon. Diffuser designs that thread directly into the air distribution header or fittings without distribution of diffuser loads to the pipe shall not be acceptable.

1.14.3 Construction

The materials of construction for both support disk/tube 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/PU 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.

The fine bubble aeration system will comprise:

(d) Stainless Steel (SS316) dropllegs and headers

(e) SS316 Manifold and air distributors

(f) SS316 diffuser holders and retainer rings.

(g) Stainless Steel Supports and anchors

(h) Bolts, nuts and gaskets for aeration system flange connection.

(i) Air distribution purge system

(j) Membrane tubular diffusers with integral O-rings gaskets and subplates.

The following design features will be incorporated in the fine bubble aeration system:

(a) Fabricated manifold with fixed threaded union joints for connection to the air distributors.

(b) Manifold sections connected fixed threaded union or flanged joints to prevent rotation or blow apart

(c) Manifold distributor connections and support designed to resist thrust generated by expansion/contraction of air distributors over a temperature range of 70 Deg C.

(d) Air distributors perpendicu;ar to the air manifold.

(e) Fabricated distributors with single diffuser holders solvent welded to the crown of the air distributor for complete air seal and strength

(f) Distributors and holders designed to resist a dead load of 90kg applied vertically to the outer edge of the diffuser holder.

(g) 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

(h) 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

(i) Air distributor support spacing at a maximum of 2400mm

(j) 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

(k) Supports designed to be adjustable without removing the air distributor from the support

(l) Diffuser assembly comprising: diffuser membrane with integral ‘O’ ring, sub-plate, holder, retaining ring and air flow control orifice.

(m) Integral check valve incorporated into the membrane diffuser assembly

(n) PVC support plate incorporated to form an air plenum under the diffuser and support for the membrane when the air is off

(o) Retainer ring threads designed with minimum cross section of 3mm and to allow for one complete turn to engage threads.

(p) 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.

(q) Two parts by weight of titanium dioxide per 100 parts of resin will be added to PVC compounds for manifolds, air distributors, joints and PVC diffuser assembly components to minimize ultraviolet light degradation.

(r) All PVC joints will be factory solvent welded. Field solvent welding will NOT be permitted.

(s) Diffuser membranes will be manufactured of EPDM/PU with precision die formed slits.

(t) Carbon black will be added to the EPDM material for resistance to ultraviolet light.

(u) 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 Sm 3 /h per m 2) of material. Proportionately thicker material is to be furnished for larger diameter disc diffusers to limit the maximum tensile stress and to resist stretching

1.15 Surface aerator

1.15.1 General

Surface aerator is used in a variety of wastewater treatment applications. Powerful pumping action transfers oxygen by breaking up the wastewater into a spray of particles, creating more surface area for atmospheric pressure to drive oxygen into the wastewater. At the same time, the oxygen-enriched water is dispersed and mixed. The result: Effective wastewater treatment. aerator represents over four decades of accumulated research and field testing in a broad range of municipal and industrial applications throughout the world. Mechanical aerator combines outstanding efficiency and versatility in a rugged design. It provides excellent oxygen transfer, low operating costs, trouble-free performance and outstanding resistance to environmental extremes to which aerators are continually exposed. The aerator shall be tested in accordance with IS 13166.

1.15.2 Motor

• Totally enclosed, fan-cooled

• Heavy gauge cast iron fan shield

• Class F insulation

• Standard or premium efficiency available

• Double-row bearings on the drive end

• Heavy-duty L-10, 100,000-hour bearings

• Dynamically balanced and vibration tested

• Designed to meet the most demanding operational requirements

• Moto Junction Box: The Opening in the motor housing for winding leads is completely potted with epoxy filler.

1.15.3 Motor shaft

• One piece continuous from the upper bearings to the propeller

• 17-4 PH stainless steel in the 1150°F heat treated condition

• 135,000 PSI minimum yield strength

• Largest diameter shaft

• Threaded and keyed on the drive end for simple propeller installation

1.15.4 Seal Guard

Positioned below the bottom motor bearing to prevent moisture from migrating up the shaft into the lower bearing.

1.15.5 Discharge Cone

• Heavy-duty casting

• Large integral webs for rigid stability and increased lateral strength

• Designed for minimum head loss

• 304 stainless steel, or cast nickel-iron, epoxy-coated

• Provides for lowest vibration levels

• Produces maximum diffusion of water particles

• 100% contact with the volute, which distributes both static and dynamic loads

1.15.6 Float

• Large one-piece float for superior performance

• Engineered to provide stability and better buoyancy

• Fiberglass reinforced polyester (FRP), or 14-gauge, 304 stainless steel.

• Filled with closed-cell polyurethane foam that adds structural stability and prevents the possibility of sinking if damage occurs to the float exterior.

1.15.7 Deflector bearing

• Shaft runs free under normal operating conditions

• Provides support only when under load

1.15.8 Debris deflector

• Machined Delrin® for smooth fluid passage over the surface

• Attached with two recessed stainless steel set screws

• Double engagement provides an extra measure of preventing water migration up the shaft.

1.15.9 Propeller and Key

• Precision investment casting

• 316 stainless steel.

• Dynamically balanced

• Keyed to mate to the motor shaft in the proper position

• Secured to the shaft by a stainless-steel locking nut

• Simple installation or removal

• Anti-fouling, non-cavitating for greater operational efficiency

1.15.10 Locking Nut

• Stainless steel

• Firmly and securely locks the propeller to the shaft

• Just two tools required to install or remove the propeller

1.15.11 Volute

• 304 stainless steel.

• All sizes have a bottom flange for simple bolt-on attachment of the standard intake cone or optional anti-erosion assembly or draft tube

• Gussets at the top and bottom flanges add strength

1.15.12 Intake Cone

• 304 stainless steel

• Hydraulically designed for proper loading on the propeller

• Sufficiently sturdy to support assembled aerator on a hard, flat surface

• (Optional) Anti-erosion assembly

• (Optional) Draft Tube

1.16 Grit Removal System

1.16.1 General

This specification cover the general requirement of the performance, design and construction of the mechanical Grit Classify in used water (waste water) application with all relevant statutory regulations and the latest edition of all relevant international, harmonized European and British Standard and Indian standard and code of practices.

This specification shall also comply with:-

(a) The specific data sheet.

(b) The relevant process specification.

(c) The relevant Electrical specification

(d) The relevant Instrumentation Control and Automation (ICA) specification

1.16.2 Layout

The Contractor shall propose that layout area together with the manufacturer's layout drawings, and installation requirements to ensure fully functional and operation plant been installed satisfactory and meet the requirement and subject to the approval of the engineer.

1.16.3 Submittals

(a) The Contractor shall provide complete fabrication and assembly drawings, together with detailed specifications and data covering materials, power drive, assemblies, and accessories forming a part of the equipment supplied. The data and specifications for each unit shall include, but shall not be limited to, the following:

(i) Outline and assembly drawings of all furnished equipment. These drawings shall include:

1) Outline and general arrangement drawing of the equipment indicating the designation overall dimension /foot print and typical layout of key components / system;
2) Diameter, number and location of anchor bolts, thickness of metal through which bolts must pass and torque data;
3) Identification, size, rating, and location of all instrument and electrical connections;
4) Overall dimensions and estimated weights of all furnished equipment; and
5) Components drawings showing all details of construction

(ii) The wash water and pressure requirement.

(iii) Structural design calculations related to the screen structural integrity and any modification work related to the screens installation shall be provided if requested by engineer.

(iv) The Energy consumption and electrical drive loadings list.

(v) Wiring diagrams which show internal wiring, external connection wiring and interconnection wiring requirements. Manufacturer shall indicate the power supply and control power supply requirements.

(vi) List of all instruments and controls, along with function, included with the screen.

(vii) A typical control philosophy.

(viii) A typical commissioning plan (Including timescale for completion).

1.16.4 Grit Classifiers

(a) General Design

(i) The equipment and associated plant and instrumentation shall be suitable for the site location, environment, and the operation condition.

(ii) The equipment shall be effectively handle the grits from the influent flow and shall be capable of automatic operation for long periods without operation personnel attention under all-weather conditions. The plant shall be robust and reliable in operation.

(iii) The equipment shall be capable of withstand high quantities of grit without excessive wear.

(iv) The grit classifier shall be designed to receive pumped concentrated grit from the grit removal plant.

(v) The grit classifier shall be sited as close as reasonably practicable to the grit removal tank and the girt transfer pumps.

(vi) The complete classifier unit shall be self-supporting and suitable for bolting to prepared foundations.

(vii) Adequate and sufficient lift lugs shall be provided.

(viii) The complete drive assembly, screw conveyor, and lower bearing assembly shall be designed so that the screw can be raised for inspection without the need to disassemble any components, or to drain the classifier tank.

(ix) The complete drive assembly shall be pivoted at the shaft centerline so that the screw assembly can be raised for periodic inspection.

(x) The safety guard shall be provided to prevent objects from coming into contact with moving parts while the classifier is in operation.

(b) Grit Classifier Tank

(i) Classifier shall consist of a 316 stainless steel grit settling tank with a screw-type grit conveyor.

(ii) The grit settling tank shall be mounted on a 316 stainless steel supports.

(iii) The tank shall be designed to provide a settling compartment where grit separation takes place, with a minimum full water depth of 150% of the screw diameter, unless otherwise specified.

(iv) The classifier tank shall be design to prevent the build-up of grit and to aid in drainage.

(v) Each classifier tank shall be fitted with a grit discharge opening, located such that accumulated grit at the top (dry) end of the screw conveyor shall exit the tank in a vertical down direction through the grit discharge opening.

(vi) Each classifier tank shall be supplied complete with 316 stainless steel fabricated feed box(es) to facilitate the introduction of underflow from the hydro cyclone into the classifier.

(vii) The water and organic material shall be returned to the main flow via a flanged pipe.

(viii) The dewatered grit shall be discharged at high level from a chute.

(ix) Flange connections shall be provided for inlet and return water and organics.

(c) Feed Box

(i) The feed box shall be fitted with a wear protector, coated with neoprene to protect against abrasion, and to function as a splashguard. The wear protector and splashguard shall be internal to the feed box such that no splashing will be allowed outside the feed box. Radial flow diffusers shall not be acceptable.

(ii) The feed boxes shall have hinged covers, to provide for inspection of the hydro cyclone without disturbing the cyclone piping or alignment. The quick release security clips (316L stainless steel) shall be provided for the hinged covers.

(iii) The feed boxes shall be designed and located to minimize short-circuiting to the overflow weir of the classifier, and to handle maximum hydro cyclone underflow discharge.

(iv) The feed boxes shall be designed to dissipate energy generated from the hydro cyclone underflow.

(d) Screw Type conveyor

(i) The grit shall be removed from the bottom of the settling compartment and discharged by means of screw-type conveyor.

(ii) The screw shall be made from pre-formed heavy 316 stainless steel flight sections welded to the shaft and fitted with replaceable wearing shoes.

(iii) The screw shall be supported at the top by a combined radial and thrust bearing, and at the bottom by a radial bearing.

(iv) The bottom bearing shall be of a proven design for the application and sealed to prevent the ingress of grit and water.

(v) The screw shaft of the conveyor shall be designed with a maximum stress, and reliability of 20 years minimum.

(vi) The screw conveyor shall be rigidly supported at both the upper and lower ends, so that the screw conveyor is mounted above, and does not contact, the classifier tank. Sufficient clearance shall provide between the screw conveyor and the tank bottom, to eliminate tank wear, and providing a drainage area for the conveyed grit.

(vii) The upper end of the screw conveyor shall be connected to a cycloidal motion speed reducer. The cycloidal speed reducer shall be designed so that all torque is transmitted by rollers, and shall be capable of withstanding shock loads of 500% of rated loading.

(e) Washwater system

(i) A high pressure water wash system shall be provided to facilitate grit washing within the grit collection hopper. The high pressure water wash system shall be fitted with isolation valve and motorized valves. Provision of the pressure booster set shall be included if the wash water supply via the existing wash water supply facility which may not have insufficient pressure to be provided.

(ii) Washwater delivery pipework shall incorporate screwed connections at an accessible level.

(f) Drive Mechanism

(i) The screw classifier shall be driven by a direct coupled shaft mounted geared motor.

(ii) The screw shall be driven by a squirrel cage induction motor through a reduction gearbox and shall accordance with Electrical Specification.

(iii) A rotation detection device suitable for control and monitoring, shall be fitted to the screw.

(iv) The classifier spiral guard shall be provided in two pieces for ease of removal and to minimize the weight of any single piece.

1.16.5 Hydro Cyclone

(i) Each cyclone shall consist of a heavy-duty cast iron volute feed chamber with one fabricated steel cylindrical section with conical sections as minimum.

(ii) Each section of the cyclone shall be individually lined and protected from the high velocity grit by a neoprene liner. The cyclone shall be constructed so that any section of the liner can be replaced independently.

(iii) A hinge and quick disconnect clamp shall be provided between the apex assembly and lower cone section to allow removal of material which may clog the apex, without disconnecting any piping on the cyclone itself.

(iv) The inlet feed to the cyclone shall be PN 16 flanged.

(v) The cyclone vortex shall be made of Ni-Hard with a minimum hardness of 500 Brinell.

(vi) Suitable tapped for pressure gauge connection shall be provided for each cyclone inlet feed. A diaphragm-protected pressure gauge shall be provided.

(vii) The cyclone underflow shall feed into the classifier for washing and dewatering, and be sized so that the proper hydraulic loading is provided to the classifier.

(viii) Adequately vented to prevent siphoning shall be provided for the overflow.

(ix) Suitable and adequate lifting lugs shall be provided.

(x) Mounting for the cyclones shall be made by 316 stainless steel.

(xi) 316 stainless steel mounting plate shall be provided and shall be oriented such that the cyclone underflow discharges directly into the classifier feedbox

1.16.6 Vortex grit removal system

(a) Basin

(i) The Vortex Grit Basin equipment shall be installed in concrete basins. The equipment to be supplied shall be suitable for installation in these basins. The grit chamber shall be designed to operate on the vortex principle. Drives, bearings, and support equipment for grit mechanism shall be supported by and readily accessible from a concrete walkway above the water surface.

(b) Vortex Grit Mechanism

The grit chambers shall conform to the following construction, operation guidelines and have the accessories as indicated below:

(i) Vortex Type Grit removal chamber with low head loss systems. The grit removal unit shall have low head loss and shall be capable of removing grit from raw waste or process water and depositing the grit in a storage hopper. An integral grit transporting means shall be provided to transport the grit from the storage hopper to the disposal means.

(ii) Each grit chamber shall be complete with the minimum equipment but not limited to gear motor, gear head, axial flow propeller, grit removal pump and auxiliary equipment required for operation.

(iii) To minimize the possibility of clogging, all internal openings in the piping to the grit pumping device as well as the grit pumping device shall be large enough to pass a 100 mm sphere. No bends or elbows will be allowed in the piping on the suction side of the grit pump.

(iv) All drives, lubrication and bearings shall be readily accessible from walkways above the operating water level.

(v) To minimize the possibility of organic capture, the floor of the grit separation chamber shall be flat and there shall be no greater than an 80 mm opening for grit to pass through to the storage hopper.

(vi) Sloping floors in the upper chamber will not be allowed due to reduced grit removal efficiency and extra construction costs.

(vii) To ensure the efficient transport of the grit and simultaneous lifting and discharge of the organic material, the bottom of the upper chamber covering the storage hopper shall be constructed suitable corrosion proof / or thick steel plate , free from rotation, and shall be flat.

(viii) The grit moving across the bottom of the chamber shall be hydraulically scoured by an air lift pump or a propeller pump. The grit shall pass from the removal chamber through an opening in the transition plate and drop into a grit storage hopper.

(ix) The flow in the removal chamber shall travel between the inlet and the outlet should be 360 degree, providing maximum travel of the liquid for effective grit removal.

(x) The influent flume, transporting the liquid waste to the grit chamber, shall be of the size and shape shown on the contract drawings to assure that grit does not settle in the inlet flume and to provide for proper operation of the grit chamber.

(xi) A grit storage hopper with a 60° sloped bottom shall be provided with effective grit storage for the designed flow, grit pump will be either an air lift educator pump or a turbo grit pump close-coupled, vacuum primed type with curved multi vane impeller. Grit Classifier / Washer shall be rake or Shaft less screw type.

(xii) The material of construction of all wetted parts shall be in SS 316.

(c) Operating Condition

(i) The grit chamber shall operate on the vortex principle. To maximize grit removal efficiency, the grit chamber hydraulics shall incorporate a toroidal flow path enhanced by a slow vortex.

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

1) 95% of the grit greater than 150 microns in size,

2) 75-85% of the grit greater than 100 but less than 150 microns in size,

(iii) The displacement type blower shall have the capacity to provide sufficient quantities of air at the required pressure to ensure efficient operation of the air wash/airlift system.

(d) Grit Trap

Item Description	MOC
Air Lift Pump	Stainless Steel
Geared Motor Assembly	STD
3 Way Valve	Stainless Steel

Screw Classifier	SS 316

1.17 Clarifier Scraper System

1.17.1 General

This specification cover the general requirement of the performance , design and construction of the Sedimentation tank Scraper Bridge equipment in wastewater application with all relevant statutory regulations and the latest edition of all relevant international , British Standard and Indian standard and code of practices.

The clarifier mechanisms shall be suitable for installation in a circular concrete tank having an inward slopping hopper floor with 1 vertical to 12 horizontal slopes. The mechanism shall be of the center drive type with adequate torque rating and shall be supported on an RCC influent column with the flow entering the bottom of the influent column and flowing upward to the inlet openings near the water level. The equipment shall include center assembly with drive unit, feed well, center cage, sludge removal rake arms with sweeper blades and squeegees, two scum skimmers with respective scum boxes, weirs, baffles, walkway with handrails, anchor bolts and such other fittings, devices or appurtenances as necessary for a complete operating installation.

This specification shall also comply with:

- The relevant process specification;
- The relevant Electrical specification; and
- The relevant Instrumentation Control and Automation (ICA) specification.

1.17.2 Submittals

The Contractor shall provide complete fabrication and assembly drawings, together with detailed specifications and data covering materials, power drive, assemblies, and accessories forming a part of the equipment supplied. The data and specifications for each unit shall include, but shall not be limited to, the following:

1) Outline and general arrangement drawing of the equipment indicating the designation overall dimension /foot print and typical layout of key components / system;
2) Overall dimensions and estimated weights of all furnished equipment;
3) Component drawings showing all details of construction;
4) Weight schedule for each major equipment component and the heaviest individual maintenance and erection lifts;
5) A typical control philosophy;
6) A typical commissioning plan (Inc timescale for completion);
7) A lubrication schedule detailing parts requiring lubrication, and method and type and manufacturer of lubricants;
8) Identification, size, rating and location of all instrument and electrical connections;
9) The Energy consumption and electrical drive loadings list;

10) Wiring diagrams which show internal wiring, external connection wiring and interconnection wiring requirements. Manufacturer shall indicate the power supply and control power supply requirements; and

11) List of all instruments and controls, along with function**.**

1.17.3 Design Specification- General

(a) Sedimentation sludge scraper equipment shall be designed to suit process requirements for rectangular or circular tanks as appropriate

(b) The performance, design, construction and testing of the equipment shall comply with all relevant statutory regulations and the latest edition of all relevant international and Indian Standards.

(c) The equipment and associated plant and instrumentation shall be suitable for the site location and environment and shall fit for the operation condition.

(d) The equipment shall be designed to collect sludge from the tank floor and scum from the tank surface and transfer it to a hopper or channel for disposal unless specified otherwise.

(e) The equipment shall be designed for continuous automatic operation in an exposed environment. Maintenance requirements shall be minimised by the use of sealed for life bearings. Where lubrication is required lubrication points shall be readily accessible

(f) The equipment shall provide permanent safe access for operation and maintenance. Where tanks are elevated, stairs or access ladders from ground level shall be provided.

(g) The weight of the individual components over 25Kg, that are likely to be removed for maintenance shall either:-

(i) Incorporate clearly identified, permanent lifting points located to give a safe balanced lift; and

(ii) Be designed in such a way that standard lifting accessories (e.g. slings) can easily be attached.

With respected to item (i) above, if lifting points are not designed for lifting the complete component, they shall be clearly marked accordingly.

(h) Materials

(i) The material of the plant and equipment and its associated components shall be suitable for the site location and operation environment. Corrosion Protection system shall be provided if required and necessary and shall submit to engineer for approval

(ii) All Handrails, anchor bolts, nuts and washer shall be of 316 stainless steel.

(iii) All sealant used shall be suitable for the purpose.

(i) Support structure

(i) The structure shall be constructed in steel. All welds shall be continuous. The height from the top of the tank wall to the bridge walkway shall not exceed 450mm.

(ii) Support structure shall be of a robust design and be adequately braced to ensure rigidity under all operating conditions.

(iii) The bridge structure shall have two parallel beams of steel channel section, positioned to present a flat surface at the outside edge of the bridge.

(iv) For all the structural calculations including the design of handrails and floor plates shall be design and submitted to engineer for approval, if asked for.

(v) Support structures shall be protected against corrosion by the application of paints or protective coatings.

(vi) Support frames shall be fabricated to withstand equipment and material loads.

(vii) All metal fabrications (i.e. frames, support structure etc.) shall be designed to prevent moister traps and prevent the collection of liquids and debris and, if appropriate, facilitate the application of paint system and protective coatings.

(viii) The end of all steel sections shall be sealed, to prevent ingress of liquids, after corrosion resistant coatings have been applied.

(ix) All galvanizing shall comply with BS EN ISO 1461ig required and necessary.

(x) All metallic items (such as fixing and fixtures etc.), which are routinely wetted or submerged or immersed in by wastewater shall be made of stainless steel 316 L unless otherwise specified.

(j) Scraper Bridges

(i) The steel bridge shall be designed in accordance the relevant codes and standards. Bridge support beams shall be channels, with their flanges facing inwards or I section beams. Unless otherwise specified, the bridge support beams shall be continuous (i.e. no joins positioned at mid-span or locations of high stress/moments). The structure shall be design and submit to engineer for approval, if asked for.

(ii) The bridge structure shall not be constructed from any type of hollow steel section. Steel section thickness shall not be less than 8 mm.

(iii) Joints shall not be positioned at mid-span or at locations of high moments.

(iv) Bridges shall be designed to support a combined loading made up of the following components:

1) Loads associated with self-weight, walkway flooring, the sludge and scum collecting mechanism's, sludge loading on the blades, raise/lower drive, bridge travel drive, pump and pipework shall be taken into design calculation;

2) Maximum vertical defection of beams no more than $1/360^{th}$ of span.

(v) The structure shall absorb the reactive torque of the complete drive unit together with a maximum loading created when the tank is either full or empty. The structure shall be able to withstand any imposed loads occurring during start up after a prolonged shut down.

(vi) Internal cross bracing shall be provided to stiffen the structure and give additional resistance to twisting movements generated from the scraper blades and any peripheral drive forces.

(k) Walkways and hand railing

(i) A bridge walkway shall provide access from the tank periphery to the centre of the tank. The walkway shall have a minimum clear width of 1200 mm between hand railings. A full bridge/half bridge shall have access to the centre of the tank from either end.

(ii) The walkway and Hand railing shall comply with this specification.

(iii) The flooring shall form a continuous walkway for access to carry out routine servicing and maintenance.

(iv) Flooring shall be sectional with each floor section individually secured to the bridge main beams.

(v) Removable sections panel shall be provided as necessary to allow access to plant below the walkway for inspection and maintenance

(vi) The maximum deflection of an unfixed flooring section shall be 1/200th of its longest length.

(vii) Guide rail shall comply with BES EN ISO 14122-3 or equivalent.

(viii) Access ladders shall be completely integrated with the hand railing on each side. The ladder shall be permanently fixed to the bridge and shall overhang the tank wall.

(ix) All bridge mounted equipment shall be located within the main bridge structural members at or above walkway level to allow ready and safe access from the walkway to all items of plant requiring maintenance.

(l) Scraper Mechanisms

(i) Scrapers shall operate at speeds which shall not disturb the settlement of solids in the tanks.

(ii) The blade shape shall cause the minimum disturbance to settled sludge when in the raised position during the return travel.

(iii) The scrapers shall be constructed so that they can be operated when the tank is empty without detriment to the equipment.

(iv) Renewable wearing strips may be neoprene, rubber or brushes, depending upon application and shall be fitted to the blade to provide a continuous contact surface which shall be adjustable.

(v) Where rubber is used, backing strips shall be fitted to give support to the fixing of the rubber wearing strips. The backing strips shall not project beyond the tip of the scraper blade and the rubber wearing strips shall not project by more than three times their thickness.

(vi) The assembly shall be secured by means of stainless steel fasteners with PTFE washer as a minimum or equal and better compatible materials.

(vii) Chain and flight type scrapers shall provide a continuous sweep of the tank floor and shall be able to operate with the tank full or empty. Two pairs of endless chains wall mounted on sprockets at low level inside the tank shall carry the buoyant scrapers. The drive unit shall include a motor driven speed reducing gearbox comprising primary and secondary gears within a common housing such that lubrication arrangements are common to both sets of gears. The drive unit shall be mounted adjacent to the tank wall and shall have an endless chain arranged to drive the submerged transmission shaft which shall drive both wall mounted chains. The primary drive chain, the twin immersed chains carrying the scrapers, and the associated sprockets shall be manufactured from nylon or a similar non-corrosive, wear resistant material. Continuously or intermittently submerged metallic parts shall be non-corrosive stainless steel or material suitable for the application.

(viii) Mechanisms for fixed bridge scrapers shall be equipped with sufficient number of scraper flights, arranged in echelon formation, to deflect sludge progressively towards the draw off point.

(ix) Chain and flight type scrapers shall have multiple flights mounted on endless chains. There shall be at least one pair, but the number provided shall depend on the size of the process tank. Each scraper shall be arranged to scrape the tank floor and convey the sludge into the sludge hopper at one end of the tank. The ends of the tubular boom shall be securely fixed to the scraper chains with stainless steel bolts.

(m) Scum Removal System

(i) Scum removal system for fixed bridge scraper, if specified, shall have a scum sweep blade attached to the scraper bridge and shall sweep the entire surface of the tank. The blade shall be shaped to induce the surface scum towards the tank periphery.

(ii) Scum removal systems for travelling bridge scrapers shall sweep the surface of the tank and shall discharge the scum into a collection trough. The blade shall be raised / lowered in conjunction with the scraper blade and the relative position will depend on the direction of travel.

(iii) Scum board, if specified, shall be fitted across the outlet end of the tank. Dimensions and fixing details shall correspond with those for circular tanks.

(iv) Chain and flight scrapers shall effect scum removal by using flights attached, or part of the scraper blades skimming the surface during the return journey.

(n) Weir plate

(i) The weir, if specified, shall be 316L stainless steel, minimum thickness 6mm.

(ii) The weir plates shall be security fixed to the wall of the tank outlet channel. Thee fixings (anchor bolts) shall be made of stainless steel and have high pull out load and high shear load characteristics. Fixings shall allow adjustment of the weir level by +/-25mm

(iii) The type of the weir plates shall be according to particular specification.

(iv) Twin sealing strips shall be provided between the weir plates and the wall of the tank outlet channel. These shall be sufficiently thick to accommodate minor irregularities in the wall and be made of a material that will not deteriorate due to contact with the influent.

(o) Bearings and Lubrication

(i) Equipment component combinations that are likely to come into contact and be subject to relative motion shall be adequately lubricated or manufactured from materials with self-lubricating properties.

(ii) Bearings shall conform to the standards of the Anti-Friction Bearing Manufacturers Association, Inc. (AFBMA).

(iii) Rolling element bearing shall be rated for a minimum L 10 life expectancy of 50,000 hours while operating at maximum load.

(iv) Bearing housings or assemblies shall be provided with seals and self-aligning features, if appropriate, to prevent the ingress of dirt and water and/or accommodate misalignment.

(v) Lubrication points on bearing housing containing sealed for life bearing shall be fitted with caps to prevent inadvertent bearing re-grease.

(vi) Where sealed for life bearings are not provided, Automatic grease dispensers shall provide a clear indication of grease contents. The minimum capacity/life of the automatic grease dispensers shall be as specified in the tender.

(vii) Lubrication points on bearing housing shall be readily accessible without the need to remove guards or covers. If lubrication points are not readily and safety accessible, they shall be connected via lubrication pipework which are readily accessible lubrication points, installed on a common battery plate. The spacing of the lubrication points on the battery plate shall allow the retrofitting of automatic grease dispensers if required.

(viii) Automatic grease dispensers shall provide clear indication of grease contents, the supplier shall provide the first fill of lubricants to all components / system requiring lubrication. All bears and lubrication pipework shall be fully charged with grease.

(ix) Fixed bridge scrapers shall include a flanged motor driven helical worm gearbox. The secondary output shaft will be connected to the scraper mechanism. An adjustable overload device shall be incorporated in the secondary gear train to protect the equipment and this shall be complete with a torque limiter and safety cut-out switch for connecting directly to the control circuit of the motor starter.

(p) Gears and Gear Drives

(i) Unless otherwise specified, gears shall be of the helical or spiral-bevel type, designed and manufactured in accordance with AGMA Standards, with a minimum service factor (thermal and mechanical) of 1.7, a minimum L 10 bearing life of 100,000 hours and a minimum efficiency of 94 %.

(ii) Gears and gear drives as part of an equipment assembly shall be shipped fully assembled for field installation.

(iii) Gearboxes and motors shall have an ingress protection rating conforming to BS 5420: IP 55 classification.

(iv) Material selections shall comply with AGMA values and the manufacturer's recommendations. Input and output shafts shall be properly designed for the service and load requirements. Gears shall be computer-matched for minimum tolerance variation. The output shall have two positive seals to prevent oil leakage.

(v) Oil lubricated gearbox shall be fitted with oil filling and drain points and where appropriate, an oil breather and /oil level indicator. Oil level and drain location shall be readily accessible.

(vi) The oil filling and drain points shall be designed so that oil can be easily drained and replaced without spillage.

(vii) Where gear drive output shafts connect to couplings or sprockets, the gear drive manufacturer shall supply matching key.

(viii) The gearbox type, number of stages, manufacturer, and service factor ad final drive ratio shall be stated in the submitted date sheet.

(ix) All gears shall run in oil, and oil pans shall have means for fillings and draining the oil without dismantling any of the screen components. Bearings:

1) Bearings shall conform to the standards of the Anti-Friction Bearing Manufacturers Association, Inc. (AFBMA).

2) Except where otherwise indicated, bearings of process equipment shall have a minimum L-10 life expectancy of 100,000 hours.

(q) Drive Units and Control panel

(i) All drive system components (e.g. motors, gearbox, drive shafts etc.) shall be adequate supported.

(ii) The drive shall be maintainable from either the walkway or from outside the tank. If the drive is maintainable from outside the tank, portable access equipment shall be provided if necessary.

(iii) All drive shaft assemblies shall be designed for ease of maintenance.

(iv) Protection system shall be provided to protect against jamming and other mechanical overloads. The motor shall be automatically tripped in the evet of an overloaded.

(v) All drive components shall be adequately supported so that fatigue or under stress does not occur.

(vi) The control panel shall be provided and shall fully complied with the Electrical and ICA specification.

(vii) Loss of motion protection shall be provided and shall be proposed to ENGINEER for approval.

(viii) The speed of the bridge at the periphery of the tank shall be 1.5, /min to 2.1m/min.

(ix) All control devices shall be readily accessible for maintenance. Sensors, limit switches etc.

(x) Effective guards shall be fitted to all revolving shafts, couplings, end carriage wheels and sprockets in accordance with BS 5304.

1.17.4 Components

(a) The fixed/half bridge sludge scraper shall meet the following additional requirement:

(i) Central bearings

1) The central bearing and pivot arrangement shall be provided between the tripod and the bridge comprising a grease lubricated slewing ring bearing (ball or roller type) to allow rotational movement and a stainless steel axle, supported in self-lubricating plain bearings, to allow the bridge to pivot in the vertical plane.

2) All bearing shall capable of accommodating the deflection of the bridge and any irregularities in the bridge support structure and /or undulations in the running track.

3) The bearing support plate shall be fixed above the tripod top plate. Fixing holes shall be slotted at 90 ° to those in the tripod top plate, to allow a minimum of +/- 25, universal adjustment for centralising the bearing assembly.

(ii) Diffuser

1) The system shall have a diffuser drum, supported from the bridge and concentric about the centre of the tank. The depth shall be 1500mm with 200mm freeboard.

2) The drum shall be manufactured from glass reinforced plastic (GRP), with wall and flange thicknesses not less than 6mm. All surfaces shall be smooth and crevice free and all cut edges shall be sealed.

3) Two diametrically opposed cut-outs shall be provided in the diffuser drum wall, complete with scoops to assist continuous scum removal from inside the drum. Each cut-out shall be 150mm minimum width x 75mm minimum height above and below normal top water level.

4) To ensure a rigid construction the drum shall have stiffening flanges at top and bottom edges, and at intermediate points, if necessary. Diffuser drums with segmented construction shall have externally bolted flanged joints. Sufficient fasteners shall prevent joint separation. All bracings shall be external to the drum. The internal area of the drum shall be clear of any obstructions other than picket fence supports, and these shall be without flat surfaces that would prevent solids settling into the hopper.

5) The drum assembly, when in an empty tank, shall withstand wind loads of up to 40m/sec.

(iii) Central Tripod Support (if applicable)

1) The tripod support shall be arranged such that the centre of rotation ensures the bridge wheels follow a route, as far as practical, in the centre of the wall.

2) The tripod support shall be fabricated from tubular mild steel and galvanised after manufacture and designed to withstand all forces imposed by thrust and vertical loadings. The structural design shall be in accordance with BS 499. Designed stresses shall be less than the permissible stresses by a minimum safety factor of 2.0. Notwithstanding the above the minimum thickness of the tripod members shall be 10 mm. Wherever practical the legs of the tripod shall be positioned inside the sludge hopper to enable the tank floor to be scraped into the hopper.

3) A central riser pipe and bend terminating in a bell mouth or diffuser at top water level shall be provided. Pipework feeding the central riser (under tank base) shall be supplied and installed by the civil contractor unless specified otherwise.

4) The centre bearing shall be fixed to the tripod support structure and shall incorporate a ball or roller type slewing ring of minimum diameter 500 mm with heavy duty distribution ring, having pivot bearing connections to the bridge structure to accommodate any vertical movement of the bridge due to uneven wheel track levels.

(iv) Center assembly with drive unit

1) The drive assembly for each clarifier shall consist of a drive motor, helical gear box, steel roller chain drive, Intermediate worm gear assembly, turntable type internal spur gear, visual torque indicator, overload alarm and cut-off actuating **system.**

2) The drive motor shall 3 phase, 50 cycle, 415 volts supply with its variations in voltage and / or frequency.

3) The power transmission between the first reducer and the intermediate worm gear assembly shall be through a chain and sprocket drive, which shall be enclosed in a fiberglass chain guard.

4) The intermediate worm gear assembly shall consist of a case hardened and ground alloy steel worm (EN353/equivalent hardness 50-52 Rc) and cast iron worm wheel (IS: 210 grade FG260), all placed within a graded cast iron housing (IS: 210 grade FG260) complete with oil fill, level and drain fittings.

5) The main pinion and pinion shaft shall be keyed to the worm gear and made as an integral unit from forged alloy steel (AISI 4142/Equivalent 43-44 Rc).

6) The main internal spur gear assembly shall be of a turntable type construction and with an internal spur gear. The turntable base shall be made of cast Iron (IS: 210 grade FG200) and the main spur gear shall be of cast high tensile alloy steel (IS: 2644 –Gr2 240-250 BHN final hardness).

7) The turntable will be mounted on top of the center column and will have positive leveling features.

8) The spur gear shall be running on a built-up large diameter precision bearing assembly consisting of high chrome alloy steel bearing balls (AFBMA Gr 500, 62-65 Rc) and four replaceable hardened alloy steel inserts (AISI 4140/equivalent 36- 38 Rc final Hardness) pressed into the annular grooves in the gear and turntable base all running in an oil bath. The base will have a provision for a dust seal complete with oil fill, level and drain fittings.

9) All gears and bearings shall run in an oil bath. Readily accessible lubricant fill and drainpipes with necessary fittings shall be provided.

10) The drive worm shaft shall be free to move horizontally within the limits afforded by a calibrated compression spring at the thrust end. The worm shaft movement shall be transmitted to the drive control by a pin contacting the cam support and camshaft, thereby actuating the pointer. The pointer shall indicate the relative torque load on a 0 to 100% graduated scale. Four cams and limit switches shall be included. Cams shall be independently adjustable over the full torque range. Two limit switches shall be shop-adjusted to sound an alarm and stop the drive motor at predetermined torque settings.

11) Switches and cams shall be mounted in a weatherproof steel box having conduit terminal strips.

12) The drive shall be designed for a adequate torque rating with the main gear and pinion set designed for a yield torque of at least four times the duty rated torque. The drive main bearing shall be designed for a B10 bearing life of minimum 20 years with continuous operation and full total rotating mechanism weight.

(v) Feed Well

There shall be a rotating feed well surrounding the inlet RCC column. It shall be integrally attached to the scraper drive assembly and the scum scraper assembly for uniform movement. The diameter of the feed well shall be 22% to 25% of the diameter of the clarifier so as to limit the downward velocity below 1.5 m / sec as calculated on the full plan area of the feed well at peak flow. The immersed depth of the feed well shall be 55 % to 65 % of the side water depth of the clarifier. The material of the feed well and all fixtures either partly or wholly exposed to the atmosphere or fully submerged shall all be of SS 316. In any case, the thickness of sheet used for fabrication of the feed well shall not be less than 5 mm.

(vi) Center Cage

The center cage shall be of steel box truss construction and shall be provided with connections for the sludge rake arms and feed well supports. It shall be bolted to the main gear, which shall rotate the cage with the attached rake arms, and feed well. The main gear attachment to the cage shall have provision for adjustment to ensure leveling of the cage. Structural members as well as non structural members shall all be spliced 30 cm on both sides of the wastewater interface with SS 316 members to prevent corrosion from the waterline that may propagate to the whole assembly.

(vii) Walkway and Handrails

The effective width of the central walkway within the bridge shall be minimum 1m wide. Handrails shall be provided for the full length of the width of the walkway. The walkway shall be supported by the drive platform at the center and the tank walls at its outer end and shall be designed to withstand all normal operating loads. It shall consist beams of welded steel construction, with the walkway of galvanized grating floor plate supported by the cross members. A toe plate of 150mm height made of

5mm thick shall be provided on both the running edges. The height of protective hand railing & piping shall be 1000 mm from walkway up to the top row of piping and the steel member supporting this piping shall not project for more than 10 cm above this level and shall be finished with beveled edges. The piping shall be in two rows of aluminum thick-walled and equally spaced vertically. The horizontal spacing of the steel members supporting these pipes shall not exceed 1.5m center to center. These shall be integrally welded to the steel tensile members of the bridge.

(viii) Sludge removal rake arms with sweeper blades and squeegees.

The sludge rake mechanism shall be a full diameter installation of either the parabolic or radial alignment of the scraper in plan. In either case, the assembly shall be dynamically balanced in design and erection. The material shall be of SS 316 truss construction with steel raking blades and adjustable neoprene squeegees. The blades shall be spaced to insure complete raking of the tank bottom twice per each revolution and pushing the sludge to the sludge pit at the center. The rake arms shall be attached to the cage with provision for adjusting their slope. The rake arm truss and blades shall be fabricated from rolled / formed steel sections having a minimum thickness of 6 mm and designed to meet the full torque capacity of the central drive. All the structural members and the clarifier scraper mechanism shall be in SS 316. The tip speed of the arms shall be not more than 3.5 m per minute.

(ix) Overflow Weirs

The weirs shall be of masonry construction finished true to level with pilasters at about 50 cm centers.

(x) Skimmer and Scum box Assembly

There shall be 2 radial scum skimmers aligned along a diameter equipped with dedicated scum boxes. The scraper assembly shall consist of a vertical SS316 plate supported from one rake arm and extending from the feed well to a recessed adjustable pivoted scum scraper with neoprene wipers at the tank periphery. The material of construction of scum scraper shall be SS 316. The scum box shall be supported from the tank wall and connected to the scum sump through a 150 NB diameter scum pipe and shall be made of minimum 5 mm thick welded SS316 plate to serve as an integral section of the tanks scum baffle. The assembly shall have a scum trough, vertical sides and a sloping ramp. A flexible connector shall be provided for the scum outlet piping in the tank wall. The scum scraper shall maintain contact with the scum baffle as it travels around the tank periphery. Upon approaching the scum box ramp, it shall trip the scum in an enclosure consisting of the scum box ramp at the bottom and the baffle and scum scraper as three sides. The trapped scum shall be carried up the ramp and into the scum trough. The scum baffles shall be curved with minimum 3 mm thick SS 316 plates.

(xi) Fasteners

All fasteners in contact with sewage/waste water shall be SS 316 and others of hot dipped galvanized steel.

(b) Travelling Scraper– Chain and Flight Type

The flight and chain type scraper shall meet the following additional requirement:

(i) End carriages and rails

1) The bridge shall be provided with two end support carriage assemblies each of which shall house the runner wheels and drive arrangement.

2) The carriages shall be fabricated from carbon steel adequately braced to withstand all imposed loads. A continuous skirt and covers shall be provided all-round the carriage to protect against operator injury. Sections of the skirt and covers shall be removable to permit inspection and maintenance.

3) The drive arrangement shall ensure that the bridge not tilt or crab due to uneven wind and sludge loadings. A positive drive arrangement (e.g. rack and pinion) shall be provided in addition to the running rails.

4) The rails shall form the track for the runner wheels. If the drive system is of the "rack and pinion" type, this may be integral with the guide rails or be a separate rail. The rails and/or drive rack shall be designed such that water cannot be trapped. The drive pinion should be readily accessible for replacement and should be designed to wear in preference to the drive rail.

5) Limit switches and end stops shall be fitted to all running rails.

(ii) Drive System

1) The motor/gearbox unit shall be suitable for a two-speed operation. The drive motor shall incorporate an electro-mechanical brake designed to operate when the motor is stopped.

2) The output of the gearbox shall be transmitted to the drive wheels located in each end carriage via drive shafting. Auto-resetting torque limiting protection devices shall be provided between the gearbox and the drive shafting.

3) Gears shall be oil lubricated and the gear housing shall incorporate oil filling point, oil breather, and oil level sight glass, drain plug and drip tray sized to accommodate one oil change.

(iii) Scraper and skimmers blades arrangement

1) The scraper mechanism shall scrape sludge, scum and grease into the specific outlet located at the inlet end of the tank.

2) The scum skimmer blade arrangement shall be bridge mounted to move floating material towards the appropriate end of the tank. The arrangement shall be designed to ensure the minimum unskimmed dead area at each end of the tank.

3) The blades shall be fixed to provide continuous rigid support. The scum blade shall be capable of being raised clear of top water level.

4) Each end of the scum skimmer blade shall be provided with a renewable side wall scraper.

5) All blades shall have renewable reversible abrasion resistant wearing squeegee strips. The length of each squeegee strip shall not exceed a third of the blade length.

1.18 Gravity Belt Thickeners

1.18.1 General

Belt thickeners shall be used to thicken sludge. The sludge to be processed shall be pre-conditioned by dosing with polyelectrolyte. The thickening performance may be provided by a combination thickener, equipped with additional rollers which press the thickened sludge to achieve higher dry solids (DS) content.

1.18.2 Sludge conditioning chamber and mixing

Mixed sludge and polyelectrolyte shall pass to a bifurcated upwardly diverging conditioning tank which shall be suitably sized to enable good floc formation to occur. The outlet of the tank shall be designed such that the flocculated sludge distributes gently and evenly across the full width of the filter belt.

1.18.3 Sludge feed and distribution system

The belt thickener shall be provided with a sludge feed and distribution system which shall receive conditioned sludge and distribute it evenly across the full usable width of the belt.

The sludge feed shall be with variable speed progressive cavity pumps. Each gravity belt thickener shall be provided with a dedicated feed pump.

The sludge distribution system shall include a spreader blade to limit the depth of the sludge layer applied to the belt and a series of drainage fingers or ploughs to produce clear areas of belt through which to encourage drainage of the filtrate.

1.18.4 Belt thickener frame

The machine frame shall comprise structural steel channel and angle sections welded and bolted to form a rigid framework. The frame shall incorporate fabricated steel stops to allow operators to view the horizontal section of belt.

Filtrate troughs, filtrate tanks, conditioning tanks, etc., shall be constructed of steel plate or shall be of glass reinforced plastic.

The sides of the machine shall be enclosed within easily removable GRP or PVC panels. Guards and splash plates shall be of steel or uPVC materials. Guards shall be placed over moving parts of the machine.

Scraper, thickening and furrow blades shall be of high density plastic, to avoid damage to the filter belt.

The equipment shall be self-contained, hydraulic power packs, actuating mechanisms and drive units shall be mounted on the structural framework.

The equipment shall be completely factory assembled and shall include pipework, a control centre and an electrical installation between the various component parts.

1.18.5 Filter belt system

The filter belt system shall comprise a single continuous filter belt carried by a series of rollers around which it is driven by a variable speed motor and gearbox. The upper surface of the belt shall provide the gravity drainage section of the thickener.

The rollers shall be supported on a stainless steel framework, and the tension of the belt around the rollers shall be maintained by an automatic tensioning and tracking system controlled by signals from a PLC in response to signals from belt sensors. Alarms shall be provided to indicate belt slippage due to loss of tension or tracking out of limits.

1.18.6 Rollers and bearings

The machine shall be equipped with the following rollers:-

- A manually adjustable tension roller to allow pre-set belt tensioning. The roller shall be mounted on the top frame member in plummer blocks fitted to manually adjustable slides;
- A hydraulically slewed belt alignment roller. The alignment system shall be automatic. The belt shall be maintained central to the roller system. Should the alignment system fail or lose pressure excessive wander shall be detected by limit switches and the drive shall stop;
- A drive roller mounted on the top frame member in plummer blocks.

Plummer blocks shall be fitted with heavy duty bearings. Bearings shall have a guaranteed life in excess of 100,000 hours. Auxiliary seals shall be fitted to bearings to prevent the ingress of water.

Rollers shall be easily removable from the side of the machine.

1.18.7 Hydraulic power pack

A hydraulic power pack shall be supplied for each belt thickener. This shall be floor mounted adjacent to the thickener.

The hydraulic power pack shall comprise:

A hydraulic fluid tank fitted with filler cap, strainer, fluid level gauge and fluid temperature gauge.

An electric motor driven hydraulic pump. The pump speed shall not exceed 1800 rpm.

Hydraulic accumulator, filter, pressure regulators and control valves.

1.18.8 Washwater system

The belt wash system shall consist of a high pressure spray pipe fitted with an integral cleaning device for cleaning nozzles without dismantling or interrupting operation. Where suitable, final effluent shall be used as washwater. The whole belt wash area shall be totally enclosed to prevent release of spray to the atmosphere surrounding the thickener. A washwater tank shall be provided complete with overflow and drainage facilities.

The belt shall be washed automatically using final effluent, and be arranged for ease of threading, alignment and tensioning.

1.18.9 Sludge discharge system

Sludge reaching the end of the thickening section shall be removed from the belt by a scraper mechanism and discharged to thickened sludge hopper. The hopper shall be equipped with a positive displacement pump or screw conveyor to transfer the thickened sludge to subsequent treatment or disposal.

An easily replaceable sludge blade shall be positioned at an angle to the drive roller to ensure that sludge is effectively removed from the filter belt.

An easily replaceable sludge lift blade shall be positioned on the horizontal section of the filter belt immediately prior to the drive roller. The blade shall be capable of being locked in or out of position as the process requires. The blade height shall be adjustable and shall exert a back pressure on the advancing sludge to cause it to back up over the blade and dewater by self-weight.

Sludge shall fall down a grade 316 stainless steel chute directly to the inlet of a sludge belt press.

1.18.10 Control

The control system shall include the thickener assembly, and associated equipment comprising sludge feed, polyelectrolyte makeup and dosing system, flocculation tank, and thickened sludge transfer system. Operation of the thickener shall be initiated, together with its supporting systems, by the Operator. Feed of sludge shall be controlled by level sensors in the raw sludge pump sump. The feed pumps shall be inhibited by a failure of the thickened sludge transfer system resulting in an accumulation of sludge in the collection hopper.

Operation of the belt thickener shall be fully automated and linked to the SCADA system.

1.19 Filter Belt Press

1.19.1 General

Continuous belt filter press sludge dewatering equipment consists of two seamed woven, porous media belt (or belt material should be as specified by the manufacture) which converge in wedge form and are led over rollers whilst pressed together. Dewatering is accomplished by continually increasing pressure applied to sludge before discharge.

Components include sludge conditioning chamber and mixing device, seamed woven belts, rollers, belt tensioning and tracking devices and compressors, variable-speed belt and conditioner drives, control and starting equipment, belt washwater pumps, and all necessary appurtenant items.

The manufacturer of sludge dewatering unit shall be responsible for satisfactory operation of the dewatering system and associated equipment.

All equipment and components shall be furnished as complete assemblies with all internal wiring, piping, valving, and control devices.

1.19.2 Sludge conditioning chamber and mixing device

a) Chamber

The sludge conditioning chamber shall be either a horizontal rotating drum type or vertical type, sized to provide optimum mixing and flocculation of sludge and conditioning chemicals.

Type 316 stainless steel constructions, furnished with flanged sludge inlet connection, two-polymer feed connections, and flanged drain connection. Drains shall be equipped with 2-inch stainless steel ball valve and hose coupling.

Gravity flow from conditioning tank to belt thickener.

Readily accessible parts for cleaning, maintenance, or operational adjustment with no seals or bearings in contact with liquid.

b) Mixing devices

In-line sludge conditioning with Type 316L stainless steel non-clog mixing valve or venturi mixing devices sized to provide optimum mixing and flocculation of sludge and conditioning chemicals.

Provide one in-line mixing device per press, each device to be provided with a weighted adjustable mixing device and flanged.

Provide each mixing device with a polymer injection ring with four tangentially mounted polymer injectors.

Elbows, bends, or special pipe sections shall not be allowed.

The equipment supplier shall be responsible for the proper location and layout of the conditioning system.

1.19.3 Sludge feed and distribution system

Refer to this section under gravity belt thickeners.

1.19.4 Filter belt press frame

The filter belt press frame shall;

- Be designed to assure easy disassembly of all filter press components, including removal of all rollers, for maintenance and replacement within the space provided in the dewatering area;
- Have a minimum clearance of 2 m around all sides of the belt filter press and its drainage channels. Where the existing sludge buildings are used, there shall be sufficient clearance for operation and maintenance requirements, the Engineer may agree to a reduced clearance;
- Be designed to assure easy lubrication, adjustment, or replacement of all parts;
- Include platforms to provide access for maintenance, operation, and inspection of press and auxiliary components and as specified herein. The equipment manufacturer shall design the platform details and configuration;
- Ensure that multiple units shall have interchangeable parts;
- Ensure that the that the press frame, rollers, and bearings are capable of withstanding all applied forces, with a factor of safety not less than 5.0, without exceeding structural/mechanical limit actions of components and without exceeding roller deflection limitations specified hereinafter;

- The maximum stress with both belts at 0.91 kg per linear mm shall not to exceed 1/5 of the yield strength at the most critical point;
- Structure designed for installation on prepared concrete foundation and secured using threaded type concrete anchors and bolts. Bolting to the foundation shall not be required for frame rigidity;
- Easy access and visual contact with all internal components;
- It should be possible to remove rollers without dismantling the frame;
- Filtration collection pans under all drainage surfaces to be of minimum 14 gauge Type 316 stainless steel;
- After fabricating carbon steel parts, frame to be hot-dip galvanised or thermal-sprayed zinc and then coated with epoxy primer.

1.19.5 Rollers and bearings

a) Rollers

- All rollers shall be of continuous shaft or double-separated, plate stub end-shaft type construction. The stub end shafts and the roller heads must be welded in place. Bolted in place stub end roller shafts are unacceptable. Shaft deflection, with both belts at 0.91 kg per linear mm, shall not exceed 1.27 mm. Deflection under normal operating loads shall not exceed 0.305 mm;
- All perforated rollers shall be of Type 316 stainless steel construction;
- All rollers except when specified otherwise shall be constructed of corrosion-resistant material;
- All rollers shall have a minimum thickness of 5 mm of Buna-N with a hardness of 55-65 Shore "A" and be suitable for the intended services;
- There shall be a minimum of eight decreasing-diameter rollers in the high-pressure zone. First rollers, as a minimum, shall be perforated.

b) Bearings

- Provide shafts of all rollers with heavy-duty, greasable-type, self-aligning, roller bearings in sealed, splash proof, split case housings. The housing shall allow the changing of bearings without any changes in the factory alignment of the roller. The roller side of the housing shall be triple-sealed, and the roller shaft shall have a splash deflector designed to provide adequate sealing from moisture and grime. The outer side of the housing shall be cap-sealed and moisture proof;
- All bearings shall be a minimum of 125 mm outboard of the belt edge (externally mounted) and be greasable whilst the unit is in full operation. Grease fittings shall be extended to the face of the belt filter frame or up, or both, beyond platforms, as required for accessibility;
- All bearings shall have a minimum L-10 bearing life of 100,000 hours based on ANSI B3.16. The L-10 bearing life of 100,000 hours shall be based on 0.91 kg per linear mm tension of both belts with a belt speed of 3 m/min and the maximum summation of all forces applied to the bearings including, but not limited to, the forces exerted by the tension of the belts from the belt drive and belt tensioning devices, friction forces, roller mass forces, assembly misalignments, and the elasticity forces of the belts caused by the inner belt having shorter

travel distance than the outer belt, as the belt and sludge sandwich travels around the roller. A certified statement stating that all bearings comply with the specified requirements for minimum L-10 bearing life based on maximum loading to be submitted to the Engineer as part of the shop drawing submittal.

c) Belt filter press drives

- Filter belt drive rollers driven by separate gear motors with variable frequency drives;
- Drive service factor: 1.50, based on motor nameplate;
- Drive motors totally enclosed and of sufficient horsepower to meet all requirements of equipment. Service factor: 1.15.

1.19.6 Filter belt press system

a) Belts

The Contractors shall;

- Provide wear-resistant monofilament polyester or combination polyester and stainless steel with weave selected for optimum dewatering of processed sludge and minimum blinding of belt;
- Based upon the manufacturer's experience at other installations with dewatering of similar sludge with similar conditioning chemicals, shall sample and test sludge prior to final belt selection;
- Ensure the minimum tensile strength of the belt and connecting splice shall be equal to five times maximum tension to which belt is subjected;
- Provide a minimum life guarantee shall be 3,000 hours under rated conditions of service;
- Design the system to allow belts to be removed easily without disassembly of the frame.

b) Belt alignment and tensioning system

The Contractor shall;

- Provide a hydraulic or pneumatic system with each press; the system shall include pumps, compressors, storage reservoirs, and all controls, piping, and tubing necessary for a complete installation;
- Size each pneumatic pressure system to provide sufficient air to operate two belt filter presses. Include duplex air-cooled, single-stage air compressors, American Society of Mechanical Engineers (ASME) code receiver, pressure switches, and solenoids for control and alarm of all required functions and equipment. Provide compressor with gauges, a safety valve, and a valved outlet. Provide inlet with a combination filter regulator lubricator;
- Size each hydraulic pressure system to provide sufficient air to operate two belt filter presses. Include duplex oil pumps, ASME code receiver with cleanout ports at each end, hydraulic control valves, float and pressure switches, pressure reducing valve, oil level and pressure gages, supply and return lines, return line filter, and oil/water heat exchanger. Provide a simplex air compressor or bottled nitrogen system for maintaining receiver level balance;
- Provide hydraulic or pneumatic tubing pre-plumbed to a single Type 316L stainless steel junction box mounted on the press. All tubing crossing the frame shall be mounted in a stainless steel sleeve extending the full length of the unit;

- Provide NEMA 4X Type 316L stainless steel panel to house all controls and regulators and mount on a press frame;
- Provide belt automatic sensing aligning devices for each belt. Devices shall be live, continuous, and infinitely adjustable to assure proper alignment of belts;
- Provide 'align devices' which are hydraulically or pneumatically operated and are designed to align each belt and locate it centrally on roller by means of a sensing arm which detects position of belt edge. An arm operates a pilot valve which, in turn, affects the position of a hydraulic or pneumatic actuator connected to a pivoted belt alignment roller, causing the roller to skew from the transverse position. Continuous automatic belt guidance system is an integral part of the press. Incremental or threshold systems are not acceptable;
- Provide hermetically sealed limit switches, in stainless steel NEMA 4X enclosures, on machines with sufficient contacts to de-energise all drives and sound an alarm in case of belt over-travel;
- Provide each dewatering belt with a variable belt tensioning system. The tensioning system shall be live, continuous, and infinitely adjustable and either hydraulically or pneumatically actuated. Dewatering pressure shall be directly proportional to belt tension, and adjustments in tension shall result in immediate changes in dewatering pressure;
- Furnish the system with individual control stations with independent adjustments for each belt. Calibrate control stations to indicate dewatering pressure at various readings of hydraulic or pneumatic pressure;
- Assure parallel movement of tensioning rollers with tension adjustments made without shutdown of the machine. Tensioning shall be applied with two actuating cylinders or bellows mechanically interconnected;
- Furnish sensing devices for each belt with sufficient electrical contacts to de-energise all drives and sound an alarm in the event of system failure.

1.19.7 Washwater system and pumps

a) Washwater system

The Contractor shall;

- Provide a belt wash station, located inside each dewatering belt loop, for each belt. House wash water supply pipe and nozzle assemble to limit spray pattern. There shall be separate collection and discharge of wash water and filtrate streams;
- Fabricate housing from Type 316 stainless steel;
- Provide a minimum of one Type 316L stainless steel spray pipe fitted with non-clog nozzles for each station. Nozzle spacing and spray pattern shall have sprays from adjacent nozzles overlapping one another at the belt surface. Furnish the spray nozzle manifold with a removable strainer to prevent clogging of nozzles. Provide Type 316 stainless steel valves and spray nozzles of Type 316L stainless steel;
- Furnish each station with an external hand wheel. A half-turn of the hand wheel causes stainless steel brush bristles to enter each spray nozzle and dislodge any solid particles which have accumulated. Extend hand wheels to a convenient operating location beyond platforms;
- Cleaning of jet spray nozzles with brush mechanism shall be accomplished without disassembly, shutdown, or interrupting operation of the unit;

- Position each station so that washing is performed after cake discharges from the belt. The stations shall extend over the full width of filter belt and wash the belt from the side opposite the operating face;
- Materials of construction suitable for hot water flush: 82°C;
- Provide pressure gauges in wash water lines ahead of each wash station;
- Provide a pressure switch on the belt wash system to alarm low pressure to the control panel and to shut down the system due to insufficient pressure build-up during the start-up sequence;
- Provide a solenoid valve on the belt wash system to automatically open and close during start-up and shutdown sequencing. The wash water solenoid valve shall to be full port, normally closed, internal pilot operated globe pattern, and cast from high-pressure bronze with renewable resilient disc. Provide a stainless steel pilot valve, bronze main operating piston, and watertight enclosure. Valves requiring removal from line for inspection and servicing are not acceptable;
- Provide all hoses of sufficient length to drain wash water and filtrate to containment curbing and drains to prevent splashing.

b) Washwater pumps

In addition to the following requirements, all pumps shall comply with details in the Standard Mechanical Specification.

The Contractor;

- Shall provide evidence of approval by the manufacturer of the sludge dewatering unit for pump washwater to belt wash stations;
- Use non-overloading, volute centrifugal pumps direct-coupled to the driving motor by all-metal flexible coupling. Shop-test pump casings under hydrostatic pressure of at least 150 percent of rated shutoff or 10 bar, whichever is greater;
- Air vent-cock fitted to high point of each casing. Lower portion of each casing provided with drain plug. Type 316 stainless steel vent-cock, plugs, and fittings;
- Cast-iron impellers dynamically balanced, and key-seated and with lock nuts that permit easy removal of impellers. Impellers shall be the hydraulically and dynamically balanced and fully enclosed type;
- High-grade open hearth or acceptable alloy forged steel pump shafts finished and polished on all sections not covered by sleeves. All parts of shafts in contact with water or passing through stuffing boxes shall be protected by easily removable stainless steel sleeves. Extend sleeves through stuffing boxes;
- Bearings, at least one set to be a combination radial and thrust bearing. Bearings shall be mounted in dustproof and moisture-proof enclosures, be grease-lubricated, provide removable plugs in bearing cases or equivalent, and be located diametrically opposite grease fittings to prevent excessive greasing of bearings;
- Extra-deep stuffing boxes with mechanical seals;
- Provide a drain in the mainframe to collect leakage from stuffing box;

- Provide a Y-strainer on the belt wash system, with mesh selected to help minimise spray nozzle clogging. The strainer shall be sized one pipe size larger than the pump suction or as shown in the drawings;
- Provide a pressure switch on the pump discharge to alarm low pressure to the control panel.

1.19.8 Sludge discharge system

Blades shall scrape dewatered sludge at the discharge end of each belt and prevent clogging. Wear-resistant construction shall be compatible with belts, with retractable features so that stringy material is readily removed from blades.

Secure blade holders in place by dead weight or mechanical fastening. Spring tension type fasteners not allowed.

Blade setting shall be adjustable by means of external screw adjustment.

Each dewatering unit shall have a dedicated sludge discharge auger, feeding a separate auger discharging into a skip on the hard standing area outside the dewatering building.

1.19.9 Filtrate Collection System

The filtrate from the belt and the wash water shall be collected and delivered to the main filtrate sump for recycling or for transfer to subsequent treatment and disposal.

Filtrate pumps shall be provided in each sludge thickening or sludge dewatering building. Refer to the Employers Requirements for more details.

1.19.10 Control

Operation of the sludge process equipment shall be automatic.

The controls and instrumentation that are provided for the equipment shall interface directly with the plant SCADA via a PLC system, such that remote monitoring and operation is possible. PLC digital I/O will operate at 24 VDC and analogue I/O on a 4-20 mA signal.

All instruments shall be fully described on Instrument Data Sheets to, or equivalent to the format published by the Instrument Society of America (ISA). The data sheets shall contain all process, mechanical and electrical data. A functional specification shall be provided by the Contractor for all equipment supplied under this Contract to allow PLC/SCADA programming.

For the instrumentation and control requirements please refer to “ICA specification”.

The control equipment shall be housed in an MCC located in a separate room to the thickeners.

The control systems shall be similar to that for the existing thickners and shall be fully interegrated to any existing thickener or refurbished thickener.

1.20Sludge Dewatering Centrifuge

Sludge dewatering shall be done by mechanical sludge dewatering units such as Solid Bowl Centrifuge. The dewatering units shall include but not limited to the following equipment:

- Automatic Polyelectrolyte Solution Preparation System
- Polymer metering pumps
- Supply line & flush line

- Sludge feeding pumps
- Dewatering unit
- Belt conveyor
- Cake hopper
- Flow meters for feeding Sludge, and for feeding chemical solution
- Control valves on sludge feeding line, and on Chemical feeding line
- Drain system

Dewatered cake shall be conveyed by a belt conveyor to cake hopper for carrying out for reuse.

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

The dewatered sludge should be truck-able & be suitable for disposal by open body truck and should have a minimum solid concentration of 25% or more (measured as dry solids w/w basis).

The dewatering unit should have a 95% solid recovery.

The centrifuge centrate should not contain more than 1000 mg/l solids.

The centrifuge should be capable of being operated at lower solid feed concentration in case of maintenance.

Dewatering units shall be provided in a separate Sludge Dewatering Building. Feed pump station shall be provided at lower level/floor and dewatering units shall be provided at upper level/ floor. Solid Bowl Centrifuge

The centrifuge shall comprise a conical cylindrical bowl and scroll feed horizontally mounted in bearings on a frame. The centrifuge bowl and scroll support frame shall be mounted on a fabricated steel sub-frame.

The bowl and scroll shall be made from stainless steel SS316 material. The leading faces of the scroll shall be protected against abrasive wear by the application of a suitable hard-coated material.

The whole rotating assembly shall be enclosed by a carbon steel fabricated casing incorporating a Centrate discharge hopper and outlet pipe, and a rectangular solids hopper which shall discharge the dewatered sludge into the disposal system.

The rotor shall consist of a solid bowl which is conical-cylindrical in shape and which rotates about a central shaft. An inner scroll shall be provided to convey separated sludge from the periphery of the cylindrical bowl to the beach at the conical end of the rotor.

The main scroll bearings shall be arranged for lubrication by an external lubrication system. Wherever practicable greasing nipples shall be arranged together as a battery. The complete rotating assembly shall be dynamically balanced and test certificates provided.

Sludge shall be fed into one end of the rotor through a centrally positioned feed tube and dispersed to the bowl through an inlet chamber.

The bowl shall be provided with an adjustable 360o peripheral weir at its cylindrical end to control the depth of the Centrate in the rotor.

The fixed outlet castings of the rotor shall be designed to collect the centrate and dewatered sludge from the rotor. Baffles within the casing shall direct the separate phases to the relevant discharge points and prevent cross-contamination.

The centrifuge shall be mounted on heavy-duty vibration isolators, located between the machine and the supporting steelwork or foundations, to damp vibrations and prevent vibration transmission. Two

axis vibration monitors shall be provided to stop the centrifuge automatically when excessive vibration is detected.

Flexible connections shall be provided on the sludge fed system and the Centrate system at the centrifuge. The dewatered sludge discharge system shall incorporate flexible chutes.

Variable Speed Drive

A variable speed drive shall be provided to accelerate the rotor to operational speed and maintain that speed during the centrifuge's duty period. The bowl drive shall be electric or hydraulic and shall be coupled to the drive shaft by a multiple 'V' notch belt drive.

Differential Scroll Drive

The scroll drive shall be provided with a separate drive mechanism to control its rotation in the same direction but at a different speed to the outer bowl. The differential speed shall be adjustable.

The drive shall be linked to the main bowl drive by an epicyclic gearbox. The differential speed of the scroll shall be automatically and manually adjustable so that the moisture content of the dewatered sludge can be controlled as required.

For safe operation, contractor shall provide control panel showing proper Sequence of operation with interlocking.

Chutes and interconnecting piping shall be provided with flexible joint (minimum 10 mm flexible in all direction) to avoid vibration.

1.21 Air Compressor

1.21.1 General requirements

1. Air supply plant shall be designed and configured according to the application(s) which are classified into the following groups:
    A. Motive power source for operating valve actuators, air motors, reverse jet filters, silo arch breaking pads and pneumatically operated machines;
    B. Motive power source for starting diesel generating sets (if specified);
    C. Instrument air supply;
    D. Air scour of membrane filters (if specified); and
    E. Air feed to operations such as dissolved air flotation and pumping surge suppression (if specified);
2. Unless otherwise specified and with the exception of group (B) applications, air supply plant shall include at least one duty and one standby compressor set which shall be electrically driven by cage induction motors.
3. Air shall be filtered to remove dust in order to protect the compressors from undue wear and to suit the needs of the application. Filtration shall take place on the intake side of the compressors and in the case of group (C) at point of use of the air.
4. Oil lubricated compressors may be used for group (A), (B) and (C) applications provided that oil eliminating filters are installed on the delivery side of the compressors.
5. Where oil mist lubrication is recommended for certain types of valve actuator, the lubricators shall be installed at each point of use of the air. Oil-free compressors shall be used for group (D) and (E) applications.

6. Air shall be cooled by means of after-coolers except generally in the case of group (D) applications.
7. Air receivers shall be provided for group (A), (B), (C) and (E) applications to balance supply and demand or to provide a reserve to operate a prime mover.
8. Air dryers shall be provided for group (A) and (C) applications and when recommended for group (D) to suit the membrane filters.
9. Parts of the air supply plant other than the compressor sets and drivers where the surface temperature routinely exceeds 65°C shall be insulated and clad with aluminium.
10. Water-cooled components subject to condensation shall also be insulated and clad in the same way.

1.21.2 Air intake

1. Air intakes shall be positioned in a manner, which avoids collection of contaminants such as engine exhaust fumes and excessive dust and always away from any extractor fan discharge points.
2. Air may be admitted to the room, which houses the compressors either through an external wall or, where this is not possible, via an intake duct. Where air is delivered to processes on a continuous basis, the compressors may be connected to the intake duct in order to draw air from outside the building and not from the room itself.
3. A louvered panel or panels shall be installed at the air inlet point together with filters. The filters shall comprise removable panels with convoluted elements mounted in frames. The elements shall be of the washable type and a spare set shall be provided to facilitate substitution for this purpose.
4. Intake ducting shall be in galvanised steel and of adequate proportions to minimise pressure drop and vibration. Where necessary to suppress low frequency noise, a silencer of the multiple aerofoil or `beam splitter' type shall be installed within the duct close to the inlet point.
5. Where air is drawn by the compressors directly from the room, appropriate provision shall be made to protect equipment and pipework from low ambient temperatures. Where air is drawn from outside the building, then heat from the machines must be dissipated effectively at times of high ambient temperatures.
6. The room shall be properly ventilated.

1.21.3 Reciprocating Compressors

1. Reciprocating compressors of the oil-lubricated type shall be employed only for application groups (A), (B) and (C) as defined above.
2. Oil-free reciprocating compressors may be employed for other low capacity applications.
3. Unless otherwise specified each compressor shall be rated for continuous operation at twice the maximum air demand or to recharge the receiver from empty in one hour whichever is greater.
4. They shall be suitable for intermittent operation and shall maintain the associated air receiver pressure between pre-set limits irrespective of actual air demand up to the maximum demand.
5. Cylinder heads shall be readily removable for inspection.
6. Each compressor shall be driven via a Vee-belt drive arrangement by a cage induction motor, which shall be rated to allow the compressor to operate at the safety valve setting without overloading.

7. The compressor and motor shall be mounted on a combination baseplate with slide rails for belt tension adjustment. A sheet steel guard shall be bolted to the baseplate.
8. Where necessary, each compressor shall have an automatic solenoid operated unloading system to facilitate starting.
9. This system shall be initiated by auxiliary contacts on the compressor motor starter and shall be subject to an adjustable time delay.
10. Oil-lubricated machines shall have an automatic oil lubricator fitted with indication of oil level and feed rate. The delivery side of each machine shall have an oil-eliminating filter with provision for draining into a portable container.

12. Each compressor shall have an inlet air filter and silencer, a pressure safety valve, fusible plug, check valve and isolating valve.
13. Compressors shall be tested in accordance with BS ISO 1217 and BS1571 Part 2.
14. Safety valves shall comply with BS EN ISO 4126-1. The installation of safety valves, gauges and fusible plugs shall comply with BS1123 Part 1.

1.21.4 Rotary compressors

Rotary compressors shall be selected from the following types unless otherwise specified:

1. Rotary lobe (Roots) compressors;
2. Liquid ring compressors;
3. Screw compressors.

1. Rotary lobe compressors

    a) Generally, rotary lobe machines shall be sized to deliver directly the necessary flow rate of air at the pressure required by the process. Due allowance shall be made for operating a pressure safety valve set at a higher pressure without overloading the compressor or its driver.

    b) Under no circumstances shall a compressor be selected to operate at or above the continuous maximum temperature or discharge pressure specified by the compressor manufacturer.

    c) A clear safety margin shall be allowed, preferably of at least 0.2 bar.

    d) The sealing arrangement between the timing gearbox and compression chamber shall ensure that leakage of oil cannot take place during operation or shutdown.

    e) Where necessary to facilitate starting of the compressor (e.g. at reduced voltage), an unloading arrangement shall be incorporated in the compressor delivery system and shall include a motorised valve operated via auxiliary contacts on the compressor motor starter.

    f) Each compressor shall be driven via a Vee-belt drive arrangement by a cage induction motor.

    g) The motor may be arranged for variable speed or two speed operation where this suits the requirements of the application. The compressor and motor shall be mounted on a combination baseplate with slide rails for belt tension adjustment.

    h) A sheet steel guard shall be bolted to the baseplate.

    i) Each compressor shall have an inlet air filter, inlet and discharge silencers, a pressure safety valve, pressure gauge, check valve and isolating valve. In process applications where the discharge pressure may approach the maximum permitted, the machine shall be arranged to shut down on high discharge temperature and a suitable switch and thermometer shall be provided.

    j) Where appropriate, the compressor and its accessories may be pre-assembled on a steel frame.

    k) Compressors shall be tested in accordance with BS ISO 1217 and BS 1571 Part 2.

    l) Safety valves shall comply with BS EN ISO 4126-1. The installation of safety valves, gauges and fusible plugs shall comply with BS 1123 Part 1.

2. Liquid ring compressors

a) Liquid ring compressors may be used for, in special circumstances only, for group (D) and if specified in process specification.

b) Generally, liquid ring machines for process use shall be sized to deliver directly the flow rate of air at the pressure required by the process. Due allowance shall be made for operating a pressure safety valve set at a higher pressure without overloading the compressor or its driver.

c) Each compressor shall have a seal water supply system, which shall include an isolating valve, in-line strainer, solenoid-operated valve, flow switches, regulating valve and check valve. The solenoid-operated valve shall be operated by auxiliary contacts on the compressor motor starter. The flow switches shall initiate a shutdown of the compressor if following start-up the seal water flow goes outside high or low limits.

d) The compressor materials shall be compatible with the seal water quality. Generally, a cast iron casing and grade 316 stainless steel rotor and shaft shall be used unless otherwise specified. Bearings shall be of the outboard type and shaft sealing shall be effected by packed glands.

e) Each compressor shall be driven via a V-belt drive arrangement by a cage induction motor normally arranged for fixed speed operation.

f) The compressor and motor shall be mounted on a combination baseplate with slide rails for belt tension adjustment. A sheet steel guard shall be bolted to the baseplate.

g) The delivery side of each compressor shall be connected to a dedicated water separation vessel. The vessel shall be of welded carbon steel construction to BS5500 and equipped with supporting feet, access manway, sight glass with safety enclosure, float operated drain valve, manual drain valve, pressure gauge and pressure safety valve.

h) The vessel shall be designed to maximise dis-entrainment of water and where necessary shall be fitted with suitable baffles.

i) Level switches shall be provided to initiate shutdown of the compressor if the water level in the separation vessel goes outside high or low limits.

j) The used seal water shall be piped to an approved discharge point.

k) Each compressor shall have an inlet silencer, inlet check valve discharge check valve and isolating valve in addition to the features detailed above.

l) Compressors shall be tested in accordance with BS ISO 1217 and BS 1571 Part 2.

m) Safety valves shall comply with BS EN ISO 4126-1. The installation of safety valves, gauges and fusible plugs shall comply with BS 1123 Part 1.

3. Screw compressors

    a) Screw compressors of the oil-free type may be used for application group (E) and if specified in process specification.

    b) Generally, screw compressors for intermittent duty shall be rated for continuous operation at twice the maximum air demand and shall be suitable for intermittent operation to maintain the associated air receiver pressure between pre-set limits irrespective of air demand up to the maximum value.

    c) Screw compressors for continuous duty shall be sized to deliver directly the flow rate of air at the pressure required by the process. Due allowance shall be made for operating a pressure safety valve set at a higher pressure without overloading the compressor or its driver.

    d) Under no circumstances shall a compressor be selected to operate at or above the continuous maximum temperature or discharge pressure specified by the compressor manufacturer. A clear safety margin shall be allowed.

    e) The sealing arrangement between the timing gearbox and compression chamber shall ensure that leakage of oil cannot take place during operation or shutdown.

    f) Each compressor shall be driven via a V-belt drive arrangement by a cage induction motor.

    g) The motor may be arranged for variable speed operation where this suits the requirements of the application. The compressor and motor shall be mounted on a combination baseplate with slide rails for belt tension adjustment. A sheet steel guard shall be bolted to the baseplate.

    h) Each compressor shall have an inlet air filter, inlet and discharge silencers, a pressure safety valve, pressure gauge, check valve and isolating valve. The machine shall be arranged to shut down on high discharge temperature and a suitable switch and thermometer shall be provided.

    i) Compressors shall be tested in accordance with BS ISO 1217 and BS 1571 Part 2.

    j) Safety valves shall comply with BS EN ISO 4126-1. The installation of safety valves, gauges and fusible plugs shall comply with BS 1123 Part 1.

1.21.5 Centrifugal compressors

1. Centrifugal compressors shall be the single stage centrifugal type driven through speed increasing gear unit by an electric motor, and shall be factory mounted on a common base plate with all accessories required for a complete system. Each system shall include a discharge check valve.
2. Single stage compressors shall be horizontally split, single stage units with overhung shaft design or impellers mounted between bearings, integral suction and tangential discharge. Motor shall be 1500 rpm (fixed speed) totally enclosed fan cooled (TEFC) squirrel cage induction type.
3. Each compressor shall develop a discharge pressure at least 0.05 bar above the specified discharge pressure when the capacity is reduced to 70% of the capacity at the specified discharge pressure.
4. Compressors shall operate satisfactory without surging at any point between 60 and 100% of the specified capacity.

5. Casings shall be cast iron made in sections with joints between sections accurately machined. Sections shall be held together by means of steel tie rods.
6. Seals shall be provided where the shaft passes through the ends of the casing. Suitable seals shall also be provided to prevent bearing contamination and to prevent loss of bearing lubricant.
7. Suction and discharge nozzles shall be flanged. Flanges shall be flat faced with diameter and drilling to BS EN 1092.
8. Each section of the casing shall be equipped with a casing drain. Casing drains shall be piped together and the common drain line piped to the edge of the baseplate. A drain valve shall be provided.
9. Impellers may be of either fabricated or cast construction. Fabricated impellers shall be made of aluminium or grade 316 stainless steel and shall be riveted to cast hubs.
10. Cast impellers shall be accurately formed and machined on all exterior surfaces. Each impeller shall have uniform sections, smooth surfaces, shall be free from cracks and porosity and shall be dynamically balanced.
11. Each shaft shall be of solid design and shall be fully machined or ground to size and polished. Each shaft shall be of ample size to transmit the maximum applied power and to carry all applied radial loads without excessive deflection.
12. Each rotor assembly shall be supported at each end by one or more oil or grease lubricated antifriction bearings.
13. All points where oil leakage may occur shall be suitably trapped to prevent oil contamination of air.
14. Bearings shall have a L10 life rating of 100,000 hours.
15. Shaft speed shall not exceed the bearing manufacturer's recommendations. Bearings shall be mounted in housings outboard of the casing heads.
16. Bearing housings shall be arranged to permit inspection and replacement of the bearings without disconnecting the piping or disassembling the blower.
17. Each compressors shall be directly connected to the drive motor by means of a flexible coupling. Each coupling shall have a power rating of not less than 1.25 times the motor nameplate power when the misalignment is within the coupling manufacturer's tolerance limit. A suitable coupling guard shall be provided.
18. Each compressor shall be equipped with a dry type air filter located upstream of the suction inlet and silencers both in the suction and delivery.

1.21.6 Aftercoolers

1. All air supply plant other than group (D) applications and where liquid ring compressors are used shall incorporate after-cooling.
2. Unless otherwise specified, a single aftercooler with isolating and bypass arrangement shall be provided for applications (A), (B) and (C) only as defined above. In other applications, standby capacity is required.
3. Aftercoolers shall either be of the air-cooled type with finned-tubes and electrically driven cooling fan or the water-cooled shell and tube heat exchanger type.

4. Materials in contact with cooling water shall be resistant to corrosion. All heat exchange surfaces shall be accessible for cleaning.
5. Aftercoolers of the shell and tube heat exchanger type with air on the tube side and water on the shell shall be designed to BS 3274 and shall be type 2.
6. The heat exchanger shell shall be in carbon steel 151 360 A to BS EN 10028 Parts 1 to 3 and BS EN 10029 and the corrosion allowance shall be not less than 2mm.
7. The shell shall be blast cleaned and coated internally and externally as set out in Part 3 of the Specification. The epoxy system shall be used for internal parts of the shell and may be used for external surfaces also. The heat exchanger tubes shall be copper designation C106 to BS EN 12451 or, where specified, 70/30 cupronickel designation CN107 to BS EN 12451.
8. The shell and tube side classifications shall be not less than Class 150.
9. Pipe connection flanges shall be drilled to BS EN 1092 with the appropriate pressure designations but not less than PN10. Provision shall be made for removal of condensate.
10. The heat exchanger shall be thermally insulated and clad with aluminium.
11. The air outlet pipework shall be fitted with a thermometer and a temperature switch with voltage free changeover contacts to initiate a high temperature alarm. The water supply pipework shall be fitted with a flow meter.
12. Generally, the air outlet temperature shall approach the cooling medium temperature to within 10 deg. C at maximum air throughput or as otherwise specified.

1.21.7 Condensate separators

1. Condensate separators shall be installed downstream of air aftercoolers.
2. The separators shall comprise pressure vessels and fabricated from carbon steel. The internal trim shall be designed to remove moisture from the air in droplet and mist form.
3. The separator shall be equipped with an automatic drain valve with isolating valve and separate manual drain valve and voltage-free contact for high level alarm. The drain connections shall discharge to an approved point.
4. The air outlet from the separator shall be fitted with a thermometer and temperature switches with voltage free changeover contacts to initiate high and low temperature alarms.

1.21.8 Air receivers

1. Air receivers shall be installed wherever it is necessary to balance a variable rate of air consumption with a fixed rate of supply which includes applications in groups (A), (C), (E) or where an air reserve is needed to operate a prime mover such as in group (B) and sometimes in group (A) as defined in Section 1.21.1.
2. The capacity shall be sufficient to limit the number of compressor starts to no more than 10 per hour. In group (B) applications, the capacity shall be sufficient for the specified number and duration of engine start attempts.
3. Air receivers shall be of welded steel construction with a corrosion allowance of 2 mm and may be either vertically or horizontally mounted according to capacity. The vessels shall have suitable supporting feet or cradles as appropriate.
4. Air receivers supplied under this contract shall comply with the requirements of local regulating authorities.

5. The fittings shall include a pressure gauge, pressure safety valve, automatic drain valve with isolating valve and separate manual drain valve. The drain connections shall discharge to an approved point.
6. Safety valves shall comply with BS EN ISO 4126-1. The installation of safety valves, gauges and fusible plugs shall comply with BS 1123 Part 1.
7. Pressure switches with voltage-free contacts shall be installed on the receiver to control the associated compressors and to initiate a low pressure alarm. The control relays shall normally be mounted in the same panel as the compressor motor starters. Both the cut-in and cut-out pressure settings of the standby machine(s) shall be set lower than the corresponding settings of the duty machine(s).
8. The Contractor shall be responsible for conducting all the required tests and meeting other requirements to achieve this.

1.21.9 Air dryers

1. Air dryers shall be of the automatic twin cell desiccant type designed to produce an outlet dew point better than -40 deg. C for applications in groups (A) and (C) and, when required, for group (B) as defined in Section 1.21.1.
2. The dryer shall be of the floor mounting or wall-mounting type with twin carbon steel adsorbed vessels packed with silica gel beads.
3. Dryers shall be designed and tested to BS ISO 7183 as applicable.
4. The vessels shall each have an electric immersion heater designed for a 230 V AC supply unless otherwise specified, air inlet and outlet connections and drying media filling and emptying pads.
5. The dryer shall incorporate an automatic adsorbed changeover and reactivation system comprising solenoid-operated valves and a control panel. The air for reactivation purposes shall be taken from the dry air outlet side and passed through the absorber to be reactivated at a rate controlled by an orifice plate.
6. The dryer shall be thermally insulated and clad with aluminium sheet.
7. Each adsorbed shall be sized for 8 hours drying duty when operating at pressures between 4.5 and 7 bar g.
8. The reactivation cycle shall include a period of air purge with the heater deactivated in order to cool the reactivated adsorbed to operating temperature prior to changeover.
9. The control panel shall incorporate the following features:
    a) Isolating switch for 230 V AC supply;
    b) Circuit protection for 230 V AC and 24 V DC circuits;
    c) Cycle timer;
    d) Heating timer;
    e) Heater contactors;
    f) Control relays;
    g) Control transformer;
    h) Indicator lamps for CELL No 1 DUTY, CELL No 2 DUTY, HEATER No 1 ON, HEATER No 2 ON;

i) Indicator lamp for DRYER FAULT, voltage-free contacts for remote transmission of same shall be connected to the SCADA system.

j) RESET push-button;

k) LAMP TEST push-button.

1.21.10 Particle Filters

1. Particle filters on process gas streams shall be designed to remove dust with the efficiency of greater than 99.9 at particle size of 1.0 micron, 99.5% at a particle size of 0.5 micron and 98% at a particle size of 0.1 micron.
2. The pressure drop through the filter at the maximum gas flow rate shall not be greater than 0.03 bar when the filter is clean and not greater than 0.1 bar when the filter is dirty.
3. The filters shall comprise carbon steel bodies with flanged inlet and outlet connections and removable top cover providing access to replaceable cartridge elements.
4. Sufficient elements shall be installed so that replacement will be needed not more frequently that once every six months.
5. Where specified, a duplex arrangement of filters with inlet and outlet isolating valves shall be provided to permit element replacement without interruption to the operating plant.
6. The filters shall be equipped with a differential pressure indicator and switch with voltage free changeover contacts, which shall be connected to the SCADA system to initiate a high pressure drop alarm.
7. A manual sampling and purge valve shall be provided downstream of the filter to permit testing with or without gas feed to the downstream process.

1.21.11 Air pipework

1. Pipework up to and including 50 mm N.B. shall be in steel to BS EN 10255 with heavy fittings in malleable iron to BS143 screwed to BS EN 10226-1. Threaded joints shall be made with a temperature resistant jointing compound. PTFE tape shall not be used.
2. Pipework over 50 mm N.B. shall be in steel to BS EN 10216 grade 360 or 430 with flanged joints drilled to BS4504 PN16 or higher rating where applicable.
3. Carbon steel pipework shall be hot dip galvanised in accordance with Painting and Protective Coatings General Specification. No other internal coating is required.
4. Pipework shall be arranged to minimise the transmission of vibration and where necessary, connections shall be made with anti-vibration couplings.
5. Particular care shall be taken at points where condensation is likely to form or to accumulate such as following compression or cooling of ambient air or discharge of reactivation air from dryers.
6. Appropriate traps and automatic drain valves discharging to approve points shall be installed.
7. Thermal insulation and cladding where fitted shall be arranged in a manner which provides access to valves and other components for maintenance purposes.

1.21.12 Air isolating valves

1. Air isolating valves shall be generally of the cast iron gate type to BS EN 1171 or butterfly type to BS EN 593 and complying with the requirements of the General Specification of Valves, Penstocks and Stoplogs.
2. Air isolating valves up to 50 mm N.B. may alternatively be in copper alloy to BS EN 12288 where compatible with the required temperature and pressure rating.
3. All isolating valves shall be tested in accordance with BS EN 12266.
4. Electric actuators for valves and solenoid-operated valves shall comply with the requirements of General Specification of Valves, Penstocks and Stoplogs.

1.21.13 Air flow control valves

Air flow regulating valves shall be globe type constructed of stainless steel 316C16 to BS EN 10213. Valve spindle shall be stainless steel type 316S16 to PD 970. Gland packing and seating ring shall be PTFE. Valves shall be sized in accordance with BS EN 60534 – 2. Flanged valves shall have integral flanges drilled to BS EN 1092 with pressure designation to match the pipework system. The flow control range of the valves shall be 10:1 or greater.

1.21.14 Air filters and silencers

Air filters on the inlet to compressors shall be of the dry element two stage, high volume, and pleated type and shall have differential pressure gauge to determine when cleaning or element replacement is required. The efficiency of the filter shall be greater than 99% removal for particles 5 microns and larger. The intake silencer shall be located downstream of the filter and it shall be acoustical absorption type with fibre glass packing.

1.21.15 Control of Instrument Air Compressors

1. The control system shall be designed so that either compressor may be selected as the duty unit and the other compressor as the stand-by unit. This selection shall be made locally and indicated on the SCADA system.
2. The compressor shall be controlled automatically by the pressure-unloading valve associated with it to maintain the pressure in the air receivers within the limits necessary for the satisfactory operation of all associated plant.
3. Compressors shall be fully controlled from a local panel with only monitoring provided on the SCADA system. An available signal shall be provided for each air compressor and these shall be connected to the SCADA system for indication and alarming.

The stand-by compressor shall start automatically and deliver air to the air receivers if the pressure in the air receiver falls to a preset value, which shall be above the minimum value necessary for the satisfactory operation of all associated plant. The stand-by compressor delivery shall be controlled automatically by its own pressure unloading valve.

1.22 Lifting Equipment

1.22.1 General

1. All lifting equipment shall be provided complete with drive units, access platforms, ladders, runway beam, supports, plinths, painting, labelling, field control panel, emergency stop button,

cabling, etc., with all necessary instruments required to control the operation of system/ equipment and all other necessary accessories and ancillaries required to form a completer and functional system.

2. All lifting equipment provided shall bear a permanent inscription on each side legible from ground floor level stating the safe working load and the registration number assigned by the Factory Inspectorate.
3. The Contractor shall provide the test loads, any instrumentation required and the level of supervision as required by the concerned authorities. The test load shall be removed from site by the Contractor after successful tests have been carried out.
4. The Contractor shall make his own assessment, by calculation or approved load testing equipment, of the weight of main components to be lifted and, prior to lifting, shall satisfy the safe working loads (SWL) of lifting equipment are not exceeded.
5. All relevant drawings and calculations of the lifting equipment shall be submitted for approval before any fabrication and installation is carried out.
6. Lifting gear shall be designed to allow a straight lift to be achieved.
7. The “Safe Working Load” shall be marked conspicuously and clearly on all lifting equipment

1.22.2 Reference Standards

(a) The following is a list of standards referenced but not limited to, in this Section:

(i) American National Standards Institute (ANSI):

1) B30.2, Overhead and Gantry Cranes (Top Running, Single or Multiple Girder).
2) B30.10, Hooks.
3) B30.11, Monorails and Underhung Cranes.
4) B30.16, Overhead Hoists (Underhung).
5) B30.17, Overhead and Gantry Cranes (Top Running, Single Girder).
6) HST 1M, Performance Standard for Electric Chain Hoists.
7) HST 2M, Performance Standard for Hand Chain Manually Operated Chain Hoists.
8) HST 4M, Performance Standard for Overhead Electric Wire Rope Hoists.
9) MH27.1, Underhung Cranes and Monorail Systems.

(ii) British Standards Institute (BSI):

1) BS 466, Specification for power driven overhead travelling cranes, Semi-Goliath and Goliath cranes for general use**.**

(iii) Crane Manufacturer’s Association of America (CMAA):

1) 70, Electric Overhead Travelling Cranes.
2) 74, Top Running & Under Running Single Girder. Electric Overhead Travelling Cranes.

(iv) Indian Standards.

1) IS 807 Codes of Practice for Design, Manufacture, Erection and Testing (Structural Portion) of cranes and hoists

2) IS 3177 Code of Practice for Design of Overhead Travelling Cranes and Gantry Cranes other than steel work cranes.

3) IS: 2266 Specification for steel wire ropes for general Engineering purposes.

4) IS: 15560 Steel hooks for standard shank design

5) IS: 3443 Specification for crane rail section.

6) IS 325 - Specification for three-phase induction motors

6) IS: 3938 Electric Wire Rope Hoists.

(v) International Electro technical Commission (IEC): 60529, Degrees of Protection Provided by Enclosures (IP Code).

(vi) National Electrical Manufacturer's Association (NEMA): MG 1, Motors and Generators.

1.22.3 Electric overhead travelling cranes

(a) General

(i) Cranes shall be designed in accordance with IS-3177, IS-807 or BS 2573 Part 1 & 2 and shall comply with the requirements of BS 466 for Class 2 medium duty operation.

(ii) The term crane shall be deemed to include gantry rails, platform with hand rails for maintenance purposes, access ladder, down shop conductors, end stops, holding down bolts and all other items required for complete installation.

(iii) Operation shall be from ground floor level by bridge-mounted pendant push-button controls.

(iv) Controls shall be mechanically and electrically interlocked to prevent inadvertent operation of opposing motions. The pendant control voltage shall not exceed 50 V AC.

(v) The pendant shall be supported independently of the electric cable and shall be arranged for extending when necessary.

(vi) The crane shall be fitted with limit switches to prevent excess travel, over-hoisting and over-lowering of the crane hook.

(vii) Electro-mechanical fail safe brakes shall be incorporated on all power-operated motions.

(viii) The crane shall be fitted with a load-limiting device to stop the lifting operation when the load exceeds the pre-set limit.

(ix) The load sensor shall be of the strain gauge bridge transducer type calibrated at the factory.

(x) Crane hooks shall be fitted with safety catches and the hook block shall incorporate fully guarded rope sheaves.

(xi) Down shop conductors shall be of the fully insulated shrouded bus bar type. The current collectors shall have renewable contact pieces. Festoon cables may be used for the cross travel.

(xii) A crane power supply isolating switch, lockable in the off position and incorporating a supply on indicator light, shall be provided at the bottom of the access ladder.

(xiii) A second isolating switch shall be provided at the control cubicle located on the crane platform.

(xiv) All motors shall be of the quick reversing type.

(xv) All movements shall be electrically operated and shall function 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.

(xvi) Sufficient slings, ropes, shackles and lifting beams shall be supplied to handle all items of plant served by the crane. They shall be labelled or marked with the Safe Working Load (SWL) and the purpose for which they are intended.

(xvii) 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 shall be provided.

(xviii) All electrical equipment shall be fully tropicalized where necessary. Motors and switchgear shall be provided with anti-condensation heaters which shall be energized when the crane is at rest and suitable warning labels shall be fitted.

(b) Crane accessories

(i) Hoisting Unit

1) The hoisting unit shall be of an electric driven wire rope type. It shall be capable of safe operation with optimum acceleration characteristics. Importance shall be given to minimum maintenance.

2) The design shall incorporate a normal hoisting speed and a much slower creeping speed. Adequate interlocking and control shall be provided to prevent over travel both upwards and downwards.

(i) Cross travel unit

1) The above unit, namely the hoist trolley, shall have an electric drive. Safe operation and optimum acceleration characteristics of the cross travel unit shall be ensured through the use of individual drive units incorporating self-braking motors.

2) Importance shall be given to the presence of features allowing for minimum maintenance.

(i) Long travel

1) The long travel unit shall have an electric drive. Safe operation and optimum acceleration characteristics of the long travel unit shall be ensured through the use of individual drive units incorporating self-braking motors.

2) Importance shall be given to the presence of features allowing for minimum maintenance.

3) The drive shall be of the direct torque transmission type. Transmission to the travel wheel shall be by splines through reduction gears and with the gear wheels running in oil-bath and with all shafts on anti-friction bearings.

4) The long travelling wheels shall be of double flange special spheroidal-graphite cast iron type.

(ii) Hoisting rope

1) The rope shall be of the best plough steel, of twist-free type and shall comply with IS 2266 or BS 302.

2) Its breaking strength shall be not less than six times the safe working load (SWL). Sufficient length of this rope shall be provided.

(iii) Rope drum

1) The rope drum shall be rolled, welded and precision machined from high grade steel and shall be flanged at both ends. It shall be driven through an internal gear rim and supported by large diameter bearings. The drum shall have specially machined grooves.

2) The size of the drum grooves shall be such as to accommodate within 1 layer the length of rope required for the specified lift. Furthermore, it should have no fewer than 3 dosed turns at each anchored and a spare groove at the other end.

(iv) Rope guide: The rope guide shall consist of a pressure ring and a threaded ring smoothly guiding the rope off the drum and operating the limit switch in the event of hook over travel.

(v) Hook Block: The hook block shall be of the fully-enclosed type conforming to IS:15560 or BS EN 1677 Part 5. The material of the hook shall be forged steel. The hook shall be fully swivelling and shall be mounted on a ball or roller bearing. A protective skirt shall be provided to enclose the bearing. A safety catch shall also be provided. The block must be arranged for lowering down to the floor level. The shape of the block shall be designed to avoid the catching of the block when lifting through floors and openings.

(vi) Hoist rope pulleys: The above pulleys are to be of cast steel fitted with roller bearings and arranged for grease lubrication.

(vii) Brakes

1) All motors shall be equipped with conical rotor electric mechanical brakes. The springs for the brakes shall be of the compressive type and shall not be stressed in excess of 80% of the torsional elastic limit of the material.

2) All brake linings shall be effectively and permanently secured. Provisions shall be made for simple and easily accessible means of adjustment due to wearing of the lining.

3) All brakes shall be protected from oil, grease, dust and any other adverse effects.

4) The brake for the hoisting unit shall be the automatic type. When the circuit is cut-off or fails, it shall be able to arrest the motion and hold at rest any load up to and including the test load at any position of the lift. It shall be able to control with safety the lowering of any up to and including the test load. The brake torque shall not be less than 250% of the rated motor torque.

5) The brakes for the traversing and travelling units shall be able to bring the crane safely to rest at any load up to and including the test load and shall be of the automatic type.

(viii) Gears, bearings and lubrication

1) All gears are to be mounted on anti-friction bearings and totally enclosed within an oil tight housing. They are to be of high quality gear steel and are to possess accurately machined teeth. The gear teeth are in addition required to be hardened and highly resistant to wear and fracture.

2) The bearings are to be of the anti-friction type and required to be permanently lubricated. The bearings shall be designed for a minimum service life of 5 years.

3) Re-lubrication, if necessary, shall be made possible through easily accessible grease nipples. The latter shall be of uniform type and readily accessible. Special attention is to be given to the lubricating of points not readily accessible.

(ix) Crane runway rails

1) Contractor shall design, supply and install the crane runway rails. Rails shall be constructed from the steel universal I-beam.

2) The sizing of the steel universal I-beam shall take into account of the total load of the overhead travelling crane and the rated working load with the appropriate safety factor for an efficient operation of the overhead travelling crane.

3) The rails for the portal cranes shall be constructed of square bar of steel suitable for the portal crane application. The rails shall be welded to the levelling plates which extend throughout the whole length of the rails.

(x) Transverse crane beam

1) Transverse Crane Bridge shall be a single box girder mounted on the top of double channel end carriages for crane with a safe working load of less than 10 tons.

2) Transverse Crane Bridge shall be a double box girder of double rail crab for crane with a safe working load of 10 tons and above.

3) The box section shall comprise two rolled steel joints with the flanges butting and continuously welded to provide a horizontally stiff girder.

(xi) Crane rail Support Joints

1) The rolled steel support members to which the crane rails are to be fixed shall be provided. The joints are to be of approved dimensions and type capable of adequately supporting the fully loaded crane at all points and during travel without significant deflection.

2) The members are to be securely fixed to the supporting corbels from reinforced concrete columns provided by the main contractors, by purpose made shoes and deep stainless anchor bolts. The fixings shall be of an approved design such that the members are simply supported on the columns and impart no fixing moments.

3) End stops shall be installed to arrest the crane

(xii) Crane Rails

1) The crane rails complete with fish plates, holding down bolts and stops etc. are to be supplied and fixed complete. The rails and fittings are to be of heavy gauge flat bottom type.

(xiii) Bolts, Nuts and Washers

1) Bolts, nuts and washers shall be of stainless steel and shall conform to BS 6105:1981 - Specification for corrosion-resistant stainless steel fasteners.

(c) Control of crane

(i) General

1) The crane shall be controlled by low voltage operation via reversing magnetic contactors from a pendant push-button station. The control voltage, preferably 42V, shall be supplied by a transformer, the primary and secondary windings of which are to be protected by special fuse links.

2) Adequate control will be levied through the use of suitably placed limit switches and brake mechanisms. Sufficient interlocking will also be provided to ensure a fail-safe unit.

(ii) Pendant push-button system

1) The crane shall be controlled from a push-button station of a modern, practical and handy design and suitable for floor operation.

2) The push-button station shall be suspended from the Crane Bridge and mobile along one side of the bridge through the use of trailing cables supported by ball bearings trolleys or sliders running smoothly on a rigid light aluminium track adjacent to the bridge.

3) The control pendant shall be lockable to prevent misuse and shall be provided with a special flexible hose to protect the control cable against tensile stresses and possible mechanical damage.

4) The weight of the control pendant shall be supported independently of the electric cable. If the control pendant is of metal, it shall be effectively earthed.

5) The push-buttons shall be housed in a sturdy, dust-proof box of approved material so designed as to give the required mechanical or electrical protection to all operating parts.

6) The control pendant shall be capable of withstanding damage.

7) Each crane motor will be operated by two (2) push-buttons, one for each direction of motion. Each push-button is to be of the double pressure type for dual speed operation.

8) The push-button station for the portal crane shall be of weatherproof construction with a protection of IP 65.

(iii) Limit switches

1) Long travel and cross travel limit switches with over-riding facilities shall be incorporated and suitably arranged in the crane unit.

2) Limit switches required to cut-off the raising and lowering motions when the hook block reaches its top and bottom maximum limits shall be provided.

3) Position limited switch shall be provided where more than one trolley is operated on the same bridge to prevent the overshoot of the crane and collision.

(iv) Load Limiting Device

1) Each crane shall be equipped with a load limiting device which can measure the mechanical load being hoisted and can cease lifting operation (and maintain the load in place) when the load exceeds the pre-set limit. The load sensor shall be of the strain gauge bridge transducer type calibrated at the factory.

(d) Electrical works

(i) General

1) Contractor shall supply and install all the electrical works necessary for the proper functioning of the electric overhead and portal crane systems.

2) All the electrical works shall comply with the specifications of the distribution system in G5 Electrical Works.

(ii) MCC

1) All the switchboard shall comply with the Electrical Specification.

2) MCC shall be complete with the following components:-

- Motor starters
- MCCBs/ MCBs

- Main isolator
- Name plate

(iii) Power supply and Crane wiring

The crane shall operate on a 3 phase, 415 Volts, 50 Hz supply. Supply shall be 60 volts fed from a transformer with an earthed centre tap secondary.

1) Generally, the power supply to the cranes shall be through totally enclosed copper bus-ducts suitable for safe mobile power feeding to the cranes except the portal crane.

2) The supply across the gantry beams shall be made by means of multi core cable running along a collector channel and loading onto a spring loaded drum. The supply along the length of the station must be completely insulated in a PVC housing and protected against any accidental contact similar or equivalent to the VAHLE type power rail. The wiring collector and pick-up gear must be arranged for ease of maintenance from the crane gantry.

3) A red warning lamp shall be provided at each end of the track and shall be illuminated when the power is on.

4) The controller shall be fixed to the crane and arrange for easy maintenance.

(iv) Motors

1) The motors shall be squirrel cage induction motors with adequate surface ventilation for intermittent duty.

2) The motor ratings shall conform to the relevant FEM design rules. Duty times shall be assumed to be at least 25%. Insulation shall be fully tropicalized and be preferably categorised in Class F.

3) The type of enclosure for the motor will be required to be in conformity with the appropriate IEC rules and the requirements as specified in Section G 5.0 of the Specification.

(v) Earthing

1) The crane structure, motor frames and metal cases of all electrical equipment including metal conduit or cables guards shall be effectively earthed.

1.22.4 Manually operated overhead cranes

(e) Cranes shall be designed in accordance with BS 2573 and shall comply with the requirements of BS 466 for Class 2 medium duty operation.

(f) The term crane shall be deemed to include gantry rails, end stops, holding down bolts and all other items required for complete installation. All access ladders and platforms necessary to carry out maintenance and repairs shall also be provided.

(g) Sufficient slings, ropes, shackles, and lifting beams shall be supplied to handle all items of Plant served by the crane. They shall be labelled or marked with their safe working load and with the purpose for which they are intended.

(h) The Contractor shall supply the test load. The test load shall be removed from site by the Contractor after successful tests have been carried out.

1.22.5 Jib Crane

(i) The jib cranes lifting capacity shall be according to the Process Specifications.

(j) Each unit shall complete with the base plate, mast, boom, hoist, anchor bolts, provision for manually moving the hoist, lifting the load and rotating the boom as required to make it a complete system.

(k) All the jib cranes are manually operated.

(l) All materials shall be properly selected for the stresses to which they will be subjected. Jib crane assembly shall be fabricated in accordance with latest standard and regulations

(m) The Jib crane mast, boom, trolley, hoist and other components shall be fabricated using established procedures and welding shall be carried out by qualified welders.

(n) Lifting Lugs shall be provide for equipment and components weighing 40kg.

(o) All Anchor Bolts shall be Type 316 stainless steel, sized by equipment manufacturer,

(p) Free-standing Jib crane

(i) Crane mast shall be base plate mounted. The crane will have full web gusset plates, welded to the mast and base plate for stability and reinforcement. Insert or sleeve mounted cranes shall not be accepted.

(ii) The crane mast shall be of adequate section size for the specified loading conditions.

(iii) The mast height should be selected to have enough head room to facilitate lifting of the equipment as indicated in the data sheets at the end of this section.

(iv) The material of construction shall be carbon steel or any other suitable material of manufacturers' standard.

(v) The top end of the mast should be finished to attach the crane boom.

(vi) The boom will consist of a standard I-beam or wide flange, and may be reinforced with a cap channel for lateral stability.

(vii) Trolley stops will be utilised to prevent the hoist trolley from falling off the boom or contacting any obstruction.

(viii) The boom will be level and horizontal, and will permit a hoist and trolley to ride upon its flat flange track.

(ix) The crane's deflection at the end of the boom should not exceed 1/150 of the crane's span.

(x) One end of the boom should be attached to the mast and should be able to rotate about this connection point.

(xi) Bearings shall be heavy-duty roller type, prelubricated and sealed. The bearing shall have a L-10 life of 50,000 hours.

(xii) All apparatus supplied under this Section shall be constructed with due regard to safety of operation, accessibility, interchangeability and durability of parts.

1.22.6 Monorail Hoists Block and chain block

(q) Load chain wheel driven through gear reductions, a hand chain wheel, load blocks, sheaves, chain, hook, and hoist braking

(r) Chain shall be Non-jamming alloy type. Hand chain wheel deep pocket for reception of chain. Hand wheel shall have a guard that prevents chain slipping or jumping. Chain hoists shall have chain storage adequate for storing full lift length of chain and shall be designed and located to avoid interference while hoisting.

(s) The hook shall be constructed with sufficient ductility to open noticeably before hook failure, equipped with safety latch, free to rotate 360 degrees with rated load, and positively held in place with locknuts, collars or other devices

(t) The brakes shall be accordance with ANSI HST 1M and 2M, adjustable to compensate for wear. Positive action, Weston type mechanical load brake, with uniform composition lining and forged steel alloy latch pawl.

(u) The chain block shall be provided with geared hand travel four wheel trolley suitable for running from a rolled steel joist.

(v) The lifting chain shall be set quality corrosion resistant steel alloy, of such length to allow a lift to be made from the ground level to loading level without re-slinging.

(w) Electric hoist

(i) The lifting wire rope of the electric hoists shall be of best plough and of such length to allow a lift to be made at ground floor level without re-slinging. The hoist mechanism shall be controlled from a hold on push button pendant.

(ii) Hoists which are rated at 2 tonne and above, shall be fitted with load limited devices as specified for overhead travelling cranes.

(iii) The pendant shall be suspended independently of the electric cable 1300mm above ground floor level. A stainless steel pendant holder shall be installed on site. Control supply shall be not more than 60V fed from a two winding transformer with an earthed centre-tap.

(iv) Cables feeding the electric hoist unit and down shop cables shall be flexible cables suspended from carriers sliding on taut wires.

(v) The electric drive motors shall be fitted with electro-magnetic brakes to prevent over travel on release of the control button.

(vi) Limit switches shall be installed to prevent over travel, over lowering and over coiling of the lift rope. End stops and limit switches shall be provided to arrest the hoist block.

(x) The lifting equipment shall include a triple leg chain sling with hooks; a suitable wire rope sling; a nylon rope sling. The slings shall be of suitable length and strength to enable a safe lift to be made of all items of equipment intended as indicated in the drawings.

1.22.7 Crane Access

(y) Fixed aluminium ladders and catwalks complete with toe boards etc. as required for the full and proper access to the crane and appurtenant equipment for maintenance purposes shall be provided.

(z) An aluminium alloy catwalk shall be provided on the crane, complete with handrails and toe boards to enable ease of maintenance of the crane unless otherwise stated.

1.22.8 Trolley

(i) Frame: Welded steel, cast steel, or ductile iron construction, or a combination thereof. Construct to control deflection of trolley assembly while transmitting the carrying load to running surface.

(ii) Drive shall consist of chain sprocket mounted on shaft. Furnish chain to within 5 feet of operating floor level. Drive shaft shall drive the trolley wheels through a gear and pinion or spur gear arrangement.

(iii) Furnish roller assembly stabilizers on single-girder trolley units to prevent tipping during load pickup.

(iv) Wheels: Rolled or forged steel, accurately machined and ground to receive inner bearing races. Furnish alloy steel axles. Rotating axles with wheels mounted press fit and keys, or with keys alone. Minimum tread hardness 210 Brinell.

(v) Drive Gears: Helical, spur or herringbone type, rolled or cast steel, with machine cut teeth.

(vi) Bearings: Combination radial and thrust type, double row, angular contact ball bearings or single-row tapered roller bearings. Bearings prelubricated and sealed, or fitted for pressure lubrication. Locate pressure lubrication fittings for accessibility during maintenance.

(vii) Brakes: Suitable for service class and rated torque capacities as specified in ANSI B30.11.

1.22.9 Testing

(aa) In every event the crane shall be tested in the presence of the employer engineer to demonstrate the safe condition of the crane.

(bb) In the event the power supply is not available when the crane been installed, temporary power supply or a hand operated hoist shall be arranged temporarily.

(cc) After all the equipment have been installed the entire crane assembly included the hoist chain shall be completely tested for all functions in the presence of the employer engineer and a licensed tester. The contractor will be responsible for obtaining a certified test certificate for the crane, a copy of which must be handed to the employer engineer.

(dd) Test complete assemblies for proper alignment and connection, and quiet operation

(ee) The full load test to be conducted shall require that weights equalling the maximum capacity of the bridge cranes and hoists be carried by the units, while the bridge cranes and hoists are operated as follows:

(i) Hoists operated through the entire lifting height for each of the units at various positions of the crane and trolley for each crane, as directed by the engineer.

(ii) If the equipment fails the test all necessary changes shall be made and the equipment shall be re-tested. If the equipment again fails to meet the test requirements to the satisfaction of the engineer, it shall be removed and replaced with satisfactory equipment.

1.23 Mixer and Flocculators

1.23.1 Mixers

(a) General

(i) Chemical mixing shall use either hydraulic or mechanical energy and shall provide uniform mixing of the chemical in the main flow of water at all times over the entire range of chemical doses applied and flows through the works. A high degree of local turbulence is considered necessary for satisfactory mixing.

(ii) Mixing energy shall be defined either by the 'mean velocity gradient', G, in the expression water power (W) per unit flow (m^3/s) is equal to the product of the viscosity (Pa-s), mean residence time (s) and square of the velocity gradient (s^{-1}) or any other method approved by the engineer.

(iii) Unless otherwise specified, power supply to the equipment shall be 415Volt, 50 Hz, 3 Phase and shall in accordance with Electrical specification.

(iv) The impeller-to-water power requirements, gear losses and an allowance for build-up on the impeller for each mixer shall be included in determination of the power requirements.

(v) The electrical power or head loss requirements to achieve efficient mixing shall be optimized to ensure minimum energy consumption at each mixing location.

(vi) The drive unit shall consists of a foot mounted electric motor and a gear reducer, with flexible coupling provided between the motor and gear reducer, Drive unit.

(b) Static Mixers

(i) Static mixers shall be inline mixers where dosed chemicals are mixed by energy of water flow alone, employing stationary mixing elements which forces water and chemicals to mix through a progression of divisions, expansion and redistribution of the flow. They shall have no moving parts and have minimal maintenance requirements.

(ii) The mixer shall comprise fixed elements installed in a housing of diameter same as the pipe diameter and shall be provided with raised face P16 flanged end connections to BS EN 1092, unless otherwise specified. The chemical injection pipes or lances shall form an integral part of the mixer unit. Any section of empty pipe between the outlet of the mixer and the sampling point shall not be considered as part of the mixer.

(iii) The mixer housing shall be designed and tested in accordance with ANSI B31.3 and constructed of SS316.

(iv) Mixing elements shall be compatible with the chemicals to be dosed at the maximum concentrations likely to be in contact with the mixer and shall be of SS 316.

(v) The supply and location of the chemical injection point shall be the responsibility of the static mixer supplier. Each static mixer shall be provided with two injection points (one duty, one standby) for each chemical. Injection points shall be fitted with 25mm stainless steel injection boss for each injection point. Injection tubes shall be of the withdrawable under pressure type. The material of construction of the injection tubes shall be compatible with the chemical dosed at its maximum dosing solution concentration and shall be SS 316 and shall be adequately supported and designed to withstand the flow velocity at the point of application and any flow or turbulence induced vibrations. The injection tubes shall be supplied complete with cooperation cocks and non-return and isolating valves.

(vi) Each mixer unit shall have a flow direction arrow and lifting lugs.

(vii) The mixer shall be designed to achieve a 95% minimum degree of mixing or to give a coefficient of variation (Cov) not greater than 0.05 for the mixer over the range of water flows in the pipe at a head loss less than the head loss specified.

(viii) For sampling point required, it shall be located three pipe diameters downstream of the outlet end of the mixer. Facilities shall be provided for taking representative samples of the water from the pipe cross section for testing purposes. The tests shall demonstrate that 95% of all concentration measurements taken from the pipe shall be within plus or minus 10% of the mean concentration over the specified flow range in the pipe and the specified dose range.

(c) Mechanical mixers

(i) Mechanical mixers shall be of the mixed flow type with the concentration of the additive chemical in the exit flow being the same as that in the mixing tank. The mixing tank shall be equipped with a mixer of the top-entry three bladed axial flow type with an equivalent pumping capacity to give a turnover rate greater than six times the tank volume per minute.

(ii) Mixer drive units shall be suitable for 24 hours a day continuous operation. Each drive unit shall consist of a foot-mounted electric motor and a gear reducer with a flexible coupling provided between the motor and the gear reducer. Unless otherwise specified the motor shall be fixed speed. Lifting lugs shall be provided to permit lifting the complete mixer and drive unit. Gearing shall be helical or spiral bevel and shall be totally enclosed. The output shaft shall be enclosed in a drywell which provides positive leak proof sealing. The mixer shaft shall be rigidly coupled to the output shaft.

(iii) The coupling to the mixer shaft shall be readily accessible so that the gearbox may be easily removed and replaced without entry of personnel into the mixing chamber or shutdown of the stream flow.

(iv) Gear reducer and motor bearings shall be oil or grease lubricated, antifriction type. All points where oil leakage may occur shall be suitably trapped to prevent oil contamination of water. The bearings life shall have a minimum -10 rating of 100,000 hours.

(v) Each mixer shall be mounted on structural steel beam or channel supports with chequered plate access platform complete with hand railing. The opening in the platform shall be large enough to permit the removal of the mixer and the shaft after the removal of the impeller.

(vi) The impeller diameter and tip speed shall be of a design to provide efficient mixing of the applied chemicals. The rotational speed of the mixer shall not be greater than 40 percent of the critical speed of the shaft. Mixers shall not be provided with bottom steady bearings. The height of the impeller above the floor of the tank shall be as recommended by the manufacturer, subject to the approval by the Engineer. Provision shall be made in the design of the shaft to allow vertical adjustment of the impeller at least ±150 mm from the recommended position in order to optimise performance.

(vii) Vertical shafting of the impeller shall be designed and supported to eliminate shaft whip and vibration. The shaft diameter shall be greater than the diameter of the output shaft of the gear reduction unit. The mixer shaft, impeller assemblies, and couplings shall be constructed from stainless steel type 316.

(viii) Mixers shall be suitable for installation in concrete tanks. The residence time in the tanks shall be as specified in the Process Specifications. In general the size of a mixing tank shall be limited to about 25 m^3 and several tanks may be provided in parallel. Water shall be distributed equally between the tanks by weirs and shall enter the tanks at the bottom and overflow out into a common channel. Entry to the mixing tank shall be designed to distribute the water uniformly in the tank. If necessary baffles shall be installed in the tanks to prevent formation of vortices. The tank shall be designed to minimise short circuiting. An allowance shall be made in the mean residence time (volume of tank ÷ flow) to accommodate short circuiting.

(ix) For chemical mixing application, the location of the chemical feed point with respect to the mixer shall be determined by the Contractor and the mixer shall be designed to achieve a high degree of homogeneity of the chemical in the water flow. The ratio of the minimum concentration to the maximum concentration of the chemical dosed measured along the central 80 percent of the mixer outlet weir shall not be less than 0.9.

(d) Hyperboloid Mixers

(i) The mixer shall be vertical mounted. Where applicable, design and construction of support, drive, shaft and bearing and gear box shall comply with the requirements of mechanical mixer and the as stated above.

(ii) The mixer shall be provided with a single impeller of semi open hyperboloid design. Impellers shall be of a design, arrangement, and diameter and shall operate at a speed that will provide efficient and proper mixing of the wastewater at the design flow of the process treatment unit as specified.

(iii) The rotational speed shall not exceed 65% of the critical speed of the shaft (including impellers and appurtenances). Bottom steady bearings will not be acceptable.

(iv) Impeller shall be provided with removable arms to permit the impellers to be removed through the access hatches in the cover slab.

(v) The impeller shall have hyperboloid shaped to ensure that oxygen concentration is uniformly distribute throughout the tank with minimum energy consumption. The mixing flow pattern shall ensure there is no sedimentation at the bottom of the tank.

(e) Submersible mixer- propeller type

(i) The mixing unit shall be closed couple direct driven or integral gear driven submersible type. All components of the mixer, including motor and gear box shall be designed to suit the operation environment and condition. All components of the mixer including the motor and gear box shall be capable of continuous operation in air, completely unsubmerged.

(ii) A sliding guide brackets shall be provided. The mixer shall be guided by a single bracket which shall be capable of handling all thrust created by the mixer.

(iii) The proper blades shall be dynamically balanced and of non-clogging backward curve, the number of blades or the propeller shall be proposed and submitted for Client / Client's Engineer approval.

(iv) The seal shall be mechanical seal and maintenance free and easy to check and replace. Shaft seals lacking positively driven rotating members or conventional double mechanical sealed which use a common single or double spring and required a pressure differential to offer external pressure and effect sealing will not be acceptable.

(v) All mating surfaces shall be machined and fitted with nitrile rubber O ring where watertight sealing is necessary.

(vi) The upper mast bracket shall be constructed with a position locking plate on conjunction with a lock pin to positively lock the mast in place at various operating angles and allow of 180 degree of the hoist and mast about a pivot point.

(vii) The mast shall be constructed structural tubing and the size of the tubing shall be recommended by the manufacturer.

(viii) The lower mast bracket shall support the entire weight of the mixer mast, mixer and hoist assembly, shall connect the mixer mast to the floor and shall include a mast pivot pin.

(ix) The mast assembly shall include a stainless steel 304 lifting cable, of same size specified for the hoist cable, which will connect to the hoist lifting cable using the quick disconnect as specified above.

(x) The power cord shall be tethered to the lifting cable using stainless steel hardware. The tether hardware shall include heavy duty rubber hose to protect the power cord and siding carabiner that allows power cord to slide freely on the lifting cable.

(xi) The lifting cable shall be attached to the mixer with a lifting bracket or bridle chain which will allow the lifting cable to be centred over the mixer. A stainless steel bridle chain shackle shall be provided to connect the lifting cable to the lifting bracket or bridle chain.

(xii) A retaining chain shall extend from the top of the mixer mast to the mixer and shall allow the mixer to be located at any intermediate point on the mast. The bridle chain shackle shall connect the retaining chain to the mixer.

1.23.2 Flocculators

(a) Flocculators shall be slow speed vertical shaft top entry type with four-blade gate paddles or other proven paddle arrangement subject to the approval of the engineer.

(b) The degree of agitation shall be defined by the `mean velocity gradient', G (s-1) in the expression water power (W) per unit flow (m^3/s) is equal to the product of viscosity (Pa x s), mean residence time (s) and square of the velocity gradient (s-1). The flocculation condition shall be defined by the product of velocity gradient and mean residence time (volume of tank ÷ flow).

(c) The drive unit shall be suitable for 24 hours a day continuous operation. The drive unit shall consist of an electric motor and gear reduction unit with a flexible coupling provided between the motor and the gear reduction unit. The motor shall be provided with a variable speed control system to allow control of the rotational speed of the flocculator over the operating range. The speed adjustment shall be by manual operation of a `knob' or `lever' with a pointer moving against a scale calibrated in the flocculator speed units.

(d) Lifting lugs shall be provided to permit lifting the complete drive unit. The motors shall be readily separated from the gear reduction unit. All gearing shall be helical or spiral bevel and shall be totally enclosed. Output shaft shall be enclosed in a drywell which provides positive leak proof sealing. The flocculator shaft shall be rigidly coupled to the output shaft.

(e) The coupling to the flocculator shaft shall be readily accessible so that the gearbox may be easily removed and replaced without entry of personnel into the mixing chamber or shutdown of the flow.

(f) Gear reduction units and motor bearings shall be oil or grease lubricated. All points where oil leakage may occur shall be suitably trapped to prevent oil contamination of water. The bearings shall have an L-10 rating of 100,000 hours.

(g) Each flocculator shall be mounted on structural steel beam or channel supports with chequered plate access platform complete with hand railing. The opening in the platform shall be large enough to permit removal of flocculator and the shaft after the removal of the paddles.

(h) The arrangement of the paddles, their dimensions and the tip speed shall be of a design to provide efficient flocculation of the chemically treated water.

(i) Flocculator paddles and paddle shaft shall be constructed of stainless steel type 316.

(j) Flocculators shall be suitable for installation in concrete tanks. The mean residence time in the tanks and the velocity gradient shall be as specified in the Particular Requirements. The flocculation tank shall consist of one, two or three equal-size compartments in series depending on the downstream process flocculation requirements. Tanks shall be provided with baffles arranged in such a way to eliminate short-circuiting. If necessary an allowance shall be made in the residence time for short-circuiting. The number of flocculation tanks to be provided in parallel shall be dictated by the maximum tank size acceptable to the Contractor. Where tanks are provided in parallel the water flow shall be divided equally between the tanks by weirs and flocculated water shall overflow out into a common outlet channel.

(k) The flocculators and the tanks shall be designed to achieve uniform mixing of chemically dosed water to produce flocs of characteristics suitable for the downstream solid-liquid separation process.

1.24 Membrane Filtration system (Membrane Bioreactor)

GLOSSARY OF TERMINOLOGY

Backwash or Back pulse	Any instance a membrane train is taken offline and water, and/or chemical solution is pumped through the membranes in the reverse direction of the filtrate flow.
Days	Defined as Calendar Days.
Design Flow	Equivalent to “Net Flow”.
Instantaneous Flux Rate	Equals the filtrate flow rate, in m^3 per hr, produced during the service cycle divided by the total membrane outside surface area in square meter. Service cycle is defined as the period of continuous filtration between the membrane relaxation, backwash or back pulse, where the membrane manufacturer’s equipment uses relaxation or backwash/back pulse as a permeability maintenance method. Units of “Instantaneous Flux Rate” are litre per square meter per hour (lmh)
Large Membrane Sub-unit	A group of small membrane sub-units sharing a common air and filtrate connection. Depending on the Membrane Manufacturer, this may be referred to as a “cassette,” “rack,” “unit,” or by other terms.
Maintenance Clean	Any instance a membrane train is taken offline for application of a chemical solution that is not considered part of the normal backwash cycle or recovery clean.
Membrane Tank	One isolatable unit of the overall membrane facility that may contain one or more parallel rows of large membrane sub-units. The parallel rows may be separated by a partial wall. The Membrane Tank shall be capable of draining and filling as a single entity.
Membrane Technology Provider	The company / entity that designs, manufactures and supplies the membranes and systems associated with membranes. Where a responsibility or activity is referenced to the “Membrane Technology Provider” it shall be carried out by representatives of that company / entity with specific experience and expertise in that area / function.
Membrane Train	One of multiple functional units of the membrane system that operates in parallel, and distinctly, from other trains, and that includes: a grouping of large membrane sub-units located within a single tank, one or more common membrane filtrate headers and with one membrane filtrate pump per membrane train, and a common air supply header. A train operates as a single entity for filtration, backwash/back pulsing, relaxing, maintenance, cleaning, or recovery cleaning. Each Membrane Train is contained in one Membrane Tank

Net Flow	Equals the net flow rate of treated effluent (filtrate), in million litres per day (MLD), over a 24-hour period of continuous operation, calculated as flow produced minus backwash and cleaning water, and accounting for periods of relaxation, backwashing, and cleaning.
Net Flux Rate	Equals the total amount of filtrate produced by the membrane system over a representative period that is available for downstream discharge (after deduction of backwash and cleaning water) divided by the total membrane outside surface area in square meter. Units of "Net Flux Rate" are lmh. Representative period includes relaxation, back pulsing, chemical cleaning, etc., as appropriate for flow duration being considered.
Permeability	Measure of the ability of flow to pass through the membrane. Measured as flux divided by TMP.
Production Capacity	Equivalent to "Net Flow".
RAS	Recycled Activated Sludge
Recovery Clean	Any manual, automated or semi-automated procedure occurring less than once per month that uses one or more cleaning chemicals to reverse the effects of membrane fouling. This involves isolating a membrane train and filling membrane tank or filtrate side of membrane unit fully or partially with cleaning chemicals. The membranes/process components are soaked for a period of time then the spent chemical solution is removed from the train. This process may also be termed "clean-in-place (CIP)".
Relaxation	Any instance a membrane train is taken offline by temporarily stopping the filtrate pump.
Small Membrane Sub-unit	Basic unit of membrane production. The small membrane sub-unit is the smallest assembled unit of a delivered system that is designed to be removed from a large membrane sub-unit and replaced as a complete unit. Depending on the membrane manufacturer, this may be a single assemblage of fibres in a common potting or flat sheets attached to a support structure and may be referred to as a "module," "cartridge," or other terms.
Temperature Corrected Permeability	Equals permeability multiplied by membrane manufacturers Temperature Correction Factor (TCF) expressed in the following form: $P_{20} = P_t \times TCF_{(20-t)}$ Where: P_{20} = permeability at 20 degrees C (Celsius) P_t = permeability at measured temperature in degrees C Unless otherwise provided by Membrane Technology Provider, TCF shall be assumed as 1.024.

Transmembrane pressure (TMP)	The pressure differential across the membrane. TMP shall be adjusted for losses from membrane discharge to pressure gauge. Units of TMP are Pascal (Pa).

1.24.1 General Requirements

(b) Quality Assurance

(i) The following minimum requirements shall be met:

1) The membrane manufacturer shall have in place a dedicated quality control program that complies with ISO-9000/9001.

2) Additional requirements as per the particular specifications.

(c) Membrane Material and Structure

(i) Membrane fibres shall have wide pH tolerance and good resistance to oxidants. They shall be suitable for intermittent exposure to those concentrations of chlorine and pH values used in solution for maintenance cleans and recovery cleans. The limiting values for chlorine concentration shall be at least 1000 mg/l. The range for pH shall be at least 2 to 12 for temperatures below 30 ^{0}C and pH 2 to 9 for temperatures greater than 30 ^{0}C respectively.

(ii) Membrane material shall be designed to operate for the life as specified with any stated reductions in performance with time due to chemical, physical and mechanical ageing, when operated within the parameters set by the membrane supplier.

(iii) The physical strength of the membrane material shall be sufficient to allow them to be backwashed and chemically cleaned without damage to the membranes.

(iv) Hollow fibres having a nominal pore size of 0.05 micron or less shall be used.

(v) The membrane shall be designed for the flow from outside to the inside of the fibre or sheet.

(vi) Membranes shall be physically strong enough to withstand the operating conditions associated with continuous operation in an aerated tank of mixed liquor at concentrations up to 12,000 mg/l. It shall also be accepted that this mixed liquor will contain foreign materials such as small solids and fibres that may pass through the 2mm hole aperture fine screens installed upstream of the Bioreactor.

(vii) For systems which use back pulsing, membranes shall be able to withstand backwash flow (from inside to outside) without any indication of damage

(d) Cleanability

Membrane filters shall be suitable for cleaning by maintenance clean and recovery cleans and subsequent soaking using aggressive chemicals such as oxidants (e.g. chlorine) acids, alkalis or detergents at high concentrations required to remove fouling. Backwashing and cleaning operations shall return the membrane filters to the initial permeability and trans-membrane pressure less a stated value as specified.

1.24.2 Membrane Design Considerations

(a) The system shall be suitable for installation in an environment at temperatures 15 to 45^{o}C.

(b) The system shall be divided into identical trains with large membrane sub-units as necessary.

(c) Small Membrane Sub-units

(i) The membranes shall be assembled into a housing called a small membrane sub-unit.

(ii) The small membrane sub-unit shall be constructed such that the membranes are held vertically and bonded firmly at the top and/or bottom of the sub-unit.

(iii) For hollow-fibre type membranes, the internal lumens of the membrane fibres shall connect into a common area at the top and/or bottom of each small sub-unit.

(iv) The materials used to hold the membrane fibres in-place shall be chemically resistant to high concentrations of chlorine (minimum 1,000 mg/L), and low pH (range 2 to 3) and high pH wash solutions (range 10 to 11).

(v) The top and bottom sections of the small membrane sub-unit shall be connected with corrosion resistant materials and allow permeate to be withdrawn from one or both ends of each small membrane sub-unit.

(vi) The base of each small membrane sub-unit shall contain diffusers to allow scour air to escape and travel upwards past and between the membrane fibres or sheets, creating an agitation effect.

(vii) All non-steel components of the small membrane sub-units shall be UV resistant and have a chemical resistance at least equal to that of the membranes.

(d) Large Membrane Sub-units

(i) The small membrane sub-units shall be assembled into large membrane sub-units.

(ii) Each large membrane sub-unit shall be supported within a frame or support rails manufactured of chemically resistant Type 316L stainless steel materials or other materials provide the proposed assembly has been successfully used by the Supplier for at least 2 years.

(iii) A complete support system for installation in concrete basin, consisting of beams, frames, and brackets shall be provided. Anchor bolts shall be furnished by others.

(iv) Isolation valves shall be provided by Supplier on permeate and air scour, and any other process piping within limits of membrane basin to provide means of isolating and removing individual large membrane sub-units from the remainder of system, without draining the train, and to enable the system to produce permeate with one or more large sub-units out of service.

(v) Each frame shall be fitted with two lifting eyes (one at each end) to allow the entire large membrane sub-unit to be lifted into and out of the membrane train and transported away. A lifting bracket that connects to the frame at multiple points and is lifted at one point is also acceptable.

(vi) All fasteners, including nuts, bolts, screws, cables, washers and other appurtenances, associated with the large membrane sub-unit and housing shall be manufactured from Type 316 stainless steel. Supplier shall ensure that sufficient isolation is provided such that no galvanic corrosion occurs between fasteners and the frame/support rails.

(e) Immersed Membrane Filter Support Frames

(i) The materials of construction of parts submerged in water including the support frame shall be entirely suitable for intermittent exposure to chlorine of concentration up to 1000 mg/l and pH Values in the range 2 to 12 as would be experienced during recovery clean and soaking and maintenance clean. It shall be assumed that frames will be washed clean of chemicals after CIP. The materials of construction of submerged parts shall be stainless steel type 316S11 to BS EN 10088-3, if necessary plastic or powder coated.

(ii) The materials of construction of parts above top water level such as beams and hangers shall be suitable for exposure to vapours of acids, alkalis and moist chlorine used in CIP and maintenance cleans. It shall be assumed that these will deposit on parts exposed and will not be washed away. The materials of construction of hangers and beams shall be stainless type 316S11 to BS EN 10088-3 if necessary plastic or powder coated to minimise moist chlorine attack.

(f) Access for Maintenance

(i) Access shall be provided to all sections of the membrane filter required for maintenance. Where membrane sub-units need to be able to be removed, there shall be clear access provided to allow the module to be isolated and attached to a lifting device.

1.24.3 Ancillary Systems

(a) Pipework

(i) Membrane filtered water collection pipes from individual modules, membrane filtered water header pipes and the membrane train filtered water manifold shall be of stainless steel type 316S18 to BS EN 10216-5.

(ii) Air blower piping and air distribution pipes to membrane filter modules shall be stainless steel type 316 S18 to BS EN 10216-5.

(iii) Wash water supply pipework shall be stainless steel type 316S18 to. BS EN 10216-5

(iv) Chemical pipework shall be in accordance with the respective chemical as specified in the specification for piping and chemical plants.

(v) Plastic pipes shall not be exposed to direct sunlight and they shall not be painted as a means of protection against sunlight. They shall be shielded from sunlight.

(vi) Install true union fittings where future disconnection may be required.

(vii) Filtrate piping shall be designed to limit maximum flow velocities to 2.4 m/s. If unable to meet 2.4 m/s flow criteria, the Contractor shall indicate and describe locations where velocities exceed this limit and rationale as to why they cannot meet the flow criteria.

(viii) Process air piping shall be designed to limit maximum flow velocities to 15 m/s. If unable to meet 15 m/s flow criteria, the Contractor shall indicate and describe locations where velocities exceed this limit and rationale as to why they cannot meet the flow criteria

(b) Membrane Filter Plant Penstocks And Valves

(i) The scope of supply shall include valves within the limits of the membrane basin and isolation valves, check valves, control valves, and other required valves outside of the membrane basin for the filtrate pumping system, air extraction system (if required), air scour system, backwash or back pulse system, drain system, and sampling/monitoring system.

(ii) The Contractor shall provide all valves required on filtrate and air headers and on piping used to connect large membrane sub-units to the headers.

(iii) All Motorised / pneumatically actuated valves, including those used for flow control, shall be of the resilient seated butterfly type and shall be flanged or lugged wafer type. All Motorised/Pneumatic valves shall be of butterfly type; plastic pipe isolating valves shall be of the full-port ball type. All valves and penstocks shall be as specified in the general specification for Valves, Penstocks and Stoplogs. Materials of construction of penstocks and butterfly valves shall be selected to be resistant to short term exposure to chlorine concentration of at least 1000 mg/l and pH values at least in the range 2 to 12 as would be experienced during CIP and soaking and chemical backwashing. Butterfly valves shall have epoxy coated cast steel or cast iron body, stainless steel type 316C16 to BS EN 10213 or type 316S16 to PD 970 disc and stainless steel type 316S16 to PD 970 spindle. Seat materials shall be EPDM or Buna-N.

(iv) Motive power for valve actuation shall be pneumatic using single or double acting cylinders; where valves are required to fail-close in the event of a power failure, the actuators or pilot solenoid valves shall be spring loaded, for automatic valve closure on loss of power. Where valves fail open and / or close valves are double acting pneumatic a local air receiver shall be provided and sized to dive all valves to their fail safe positions when the air pressure is at the low alarm set point level.

(v) Valves shall be provided to isolate each large membrane sub-units

(c) Membrane Filtered Water Pumping System

(i) Each membrane train shall have a suction header for filtrate collection.

(ii) All large membrane sub-units in a membrane train shall be connected to the suction header.

(iii) The pipe connections between the large membrane sub-units and the manifold header pipe work shall be capable of operating at the positive and negative pressures expected for this system.

(iv) The pumps shall be horizontal end-suction centrifugal pumps in accordance with the general specification of Pumps.

(v)

(d) Permeate cum Back pulse Pumping System

(i) Pumps shall be horizontal end suction centrifugal type as specified in general specification for Pumps.

(ii) Backwash water source shall be from the filtrate water stored in the backpulse tank.

(e) Air Extraction System (if required)

(i) An air extraction system shall be provided to remove air bubbles generated during the permeate extraction process. Air extraction systems that rely upon vacuum pumping are unacceptable.

(ii) The system shall consist of an eductor mounted to the high point of permeate piping system, unless otherwise required by Supplier.

(f) Air Blowers

(i) Air blowers, which provide airflow to scour the membranes for control of fouling and to assist in keeping the mixed liquor in a membrane basin in suspension, shall be provided by the Contractor.

(ii) Unless otherwise specified Air blowers shall be positive displacement type in accordance with the general specification for Air Supply Systems.

(iii) Air cycling valves and actuators, if required for control and operation of the air scour to each membrane sub-unit, shall be provided by the Contractor.

(iv) Provide air distribution header(s) and diffusers for each membrane train within limits of the membrane basin.

(g) Maintenance and Recovery Cleaning Systems

(i) The contractor shall provide chemical metering pumps in accordance with the general specification of pumps and chemical plants

(h) Basin Drain Pumps:

(i) The Contractor shall provide basin drain pumps, isolation valves, check valves, flow meters, instrumentation and other components to provide an automated basin draining system, if required.

(ii) Drain pumps shall pump the basin contents to the head of the process basin.

1.24.4 Chemical Systems

(i) The Chemical Systems shall be provided in compliance to the general specifications for chemical systems.

1.25 Screen

1.25.1 Introduction

This specification cover the general requirement of the performance, design and construction of the mechanical screens in waste water application with all relevant statutory regulations and the latest edition of all relevant international, harmonized European and British Standard and Indian standard and code of practices.

This specification shall also comply with:-

(j) The specific data sheet.

(k) The relevant process specification.

(l) The relevant Electrical specification

(m) The relevant Instrumentation Control and Automation (ICA) specification

1.25.2 Layout

The Contractor shall propose that layout area together with the manufacturer's layout drawings, and installation requirements to ensure proper installation subject to the approval of the engineer.

1.25.3 Submittals

(a) The Contractor shall provide complete fabrication and assembly drawings, together with detailed specifications and data covering materials, power drive, assemblies, and accessories forming a part of the equipment supplied. The data and specifications for each unit shall include, but shall not be limited to, the following:

(i) Outline and assembly drawings of all furnished equipment. These drawings shall include:

1) Outline and general arrangement drawing of the equipment indicating the designation overall dimension /foot print and typical layout of key components / system.

2) Diameter, number and location of anchor bolts, thickness of metal through which bolts must pass and torque data.

3) Identification, size, rating and location of all instrument and electrical connections.

4) Overall dimensions and estimated weights of all furnished equipment.

5) Components drawings showing all details of construction

(ii) The wash water and pressure requirement

(iii) structural design calculations related to the screen structural integrity and any modification work related to the screens installation shall be provided if requested by engineer.

(iv) The Energy consumption and electrical drive loadings list

(v) Wiring diagrams which show internal wiring, external connection wiring and interconnection wiring requirements. Manufacturer shall indicate the power supply and control power supply requirements.

(vi) List of all instruments and controls, along with function, included with the screen

(vii) A typical control philosophy

(viii) A typical commissioning plan (Including timescale for completion)

1.25.4 Design Specification

General

(a) The screen shall come complete with, but not limited to the following:

(i) Electric motors, odour containment covers with provision for connection of odour control facility, gearing, drive bushing, limit/ torque switches, position indicator, integral starter, selector switch, supports, painting, labelling, field control panel, emergency stop button, cabling, etc. and all necessary instruments required to control the operation of equipment and all the other necessary accessories and ancillaries required to form complete and functional system of the plant.

(b) The screen shall be designed and suitable for mounting directly into the inlet channel as shown in the drawings and meet the performance required as stated in the specification.

(c) The design shall avoid the formation of areas of stagnation on the flow. Resilient sealing strips shall be provided to form an effective seal between the frame and the channel walls/floors and between fixed and moving parts of the screen.

(d) The classification of the screen and the size of the screening aperture shall be accordance with the particular specification. In general the classification of the screen as below tables:-

(i) Coarse screen - Screen with screen aperture of 20 mm , One dimension (1D). The function of this type of screen is either to protect the downstream processes from mechanical damage or to relieve process plant such as, grit removal plant from excess ragging**.**

(ii) Fine screen - Screen with screen aperture less than 6 mm, 2 dimension (2D). Unless otherwise stated Process Specification, the term 'Fine Screen' shall imply a 6mm 2D screen. The function of this type of screen is predominantly used for screening flow to full treatment (FFT).

(iii) Ultra-Fine screen - Screen with screen aperture less than 2 mm, 2 dimension (2D). Unless otherwise stated Process Specification, the term 'Ultra-Fine Screen' shall imply a 2 mm 2D screen. The function of this type of screen is predominantly used for screening flow to full treatment (FFT).

(e) The screen shall be suitable for the environment and operation conditions as specified in the process Specification.

(f) All electrical equipment shall have suitable rating for the ingress protection and enclosure classes according to location where equipment installed. The minimum rating shall be IP 65, unless otherwise specified.

(g) Power supply to motor shall be 415 V, 50 Hz, 3 Phase. The motor speed shall not exceed 1500 rpm. The motor shall be protected by thermal sensors fitted to it.

(h) The screen should be design that the equipment will not be damaged by periodically receiving material, such as grit, debris, which is contained in the influent.

(i) The screen design should employ minimum welding to ensure that heat affected zone is minimum.

(j) The system shall be designed to permit simple, easy disassembly and reassembly of any pieces which must be removed to service the screen. Such disassembly and reassembly shall not require any special tools or the removal of surrounding building / structure components.

(k) Unless specified otherwise in Particular Specification, the velocity through the screen shall be in the order of 0.3 – 1.2 m/s (min-max respectively) depending on the type/design of the screen. The actual design conditions shall be verified with the manufacturer and where inconsistent with the above requirement, it shall be approved by the engineer.

(l) Weight for each major heaviest component shall be submitted in the tender. The lifting strategy for maintenance and erection of these heaviest components shall be stated clearly in the tender. Components with weight over 25kg that are likely to be removed for maintenance shall either:-

(i) Incorporate clearly identified, permanent, lifting points located to give a safe balance lift or;

(ii) Be designed in such a way that standard lifting accessories (e.g. slings) can easily be attached.

(iii) If lifting points are not designed for lifting the complete component, they shall be clearly marked accordingly.

(iv) The complete unit shall include all necessary permanent safety device such as machinery guards, emergency stop and similar items required by local health and safety regulations.

(m) The major components of the screen shall be fitted with lifting eyes for removal.

(n) Screens shall be supplied with stainless steel or GRP covers. Security hinges for the removable sections shall be incorporated in the cover to allow easy access for maintenance but not compromise operator safety. Where necessary, grease lines shall be extended so that lubrication can be carried out with the covers in place.

(o) The screen shall be supplied with side baffles to divert incoming flow into the screen if required and necessary. The side baffle together with all angles, fitting, fasteners, etc. shall be Stainless steel 316L and fitted in between the screen and channel walls.

(p) All fasteners and anchor bolts shall be Type 316 stainless steel.

(q) All types of screens shall be capable of operating in manual or automatic mode.

(r) All types of screens shall be capable of handling high quantities of grit without excessive wear.

1.25.5 Structure supports / Frame structure

(a) The support structure for the screen curtain shall be robust design and be adequately braced to ensure rigidity under all operation conditions. Unless otherwise specified, all support structure shall be manufactured from stainless steel 316L and shall be not less than 3 mm thick.

(b) The support structure shall be locally reinforced around foundation bolt holes.

(c) Any internal cross bracings shall be arranged to minimize the formation of screenings collection traps within the assembly.

(d) The screen shall be designed to withstand the maximum possible head differential without incurring any structural damage (including permanent deformation of the structure and screen curtain) and to be capable of effective operation after this head differential has reduce to normal operation levels.

(e) All metal fabrications (i.e. frames, support structures etc.) shall be designed to prevent moisture traps and prevent the collection of liquids and debris.

(f) All galvanising shall comply with BS EN ISO 1461 if required and necessary.

(g) All metallic items (such as fixing and fixtures etc.), which are routinely wetted or submerged or immersed in by wastewater shall be made of stainless steel 316 L unless otherwise specified. If stainless steel is unsuitable for use, an alternative corrosion resistant materials shall be proposed and approved by engineer.

(h) Support frames shall be fabricated to withstand equipment and material loads.

(i) Support frames shall be fabricated to be installed on the concrete floor or where indicated on the structural steel.

(j) All anchor bolts shall be stainless steel 316 as minimum, sized by equipment manufacturer.

1.25.6 The Drive Mechanism

(a) Protection system shall be provided to protect against jamming and other mechanical overloads. The motor shall be automatically tripped in the event of an overload.

(b) All drive components shall be adequately supported so that fatigue or under stress does not occur.

(c) Local forward and reverse inching control facility shall be provided to release blockage.

(d) The screen drive system shall comprise a single, continuous duty, electric geared motor. The motor shall be located outside of the screen covers and above the top of the channel.

(e) The gear reducer shall be directly coupled to a heavy duty shaft machined from solid stainless steel round bar.

(f) The drive shaft shall be supported on both ends by grease filled roller bearings. Separate grease filled self-contained cartridge seals shall be mounted on drive shaft between bearings and frame to eliminate spray wash from entering bearings or gear reducer.

(g) Submerged sprocket shall not be acceptable.

1.25.7 Bearings and Lubrication

(a) Bearings shall conform to the standards of the Anti-Friction Bearing Manufacturers Association, Inc. (AFBMA).

(b) Except where otherwise specified, bearings of process equipment shall have a minimum L-10 life expectancy of 100,000 hours.

(c) Submerged bearing shall not be acceptable.

(d) Lubrication points on bearing housing containing sealed for life bearing shall be fitted with caps to prevent inadvertent bearing re-grease.

(e) Where sealed for life bearings are not provided, automatic grease dispensers shall provide a clear indication of grease contents. The minimum capacity/life of the automatic grease dispensers shall be as specified in the tender. The supplier shall provide the first fill of lubricants to all components / system requiring lubrication. All bearings and lubrication pipework shall be fully charged with grease. Lubrication points on bearing housing containing sealed for life bearing shall be fitted with caps to prevent inadvertent bearing re-greasing.

(f) Lubrication points on bearing housing shall be readily accessible without the need to remove guards or covers. If lubrication points are not readily and safety accessible, they shall be connected via lubrication pipework which are readily accessible lubrication points, installed on a common battery plate. The spacing of the lubrication points on the battery plate shall allow the retrofitting of automatic grease dispensers if required.

(g) The requirement for lubrication pipework shall be as follow as minimum:-

(i) It shall be 316 stainless steel or if greater flexibility is required, a suitable polymeric material shall be proposed to ENGINEER for approval

(ii) It shall be minimum bore of 6mm and maximum length of 2 m

(iii) It shall be adequately supported to prevent excessive sagging or distortion and if necessary, be protected against vibration (e.g. vibration loops)

(h) Alemite grease fittings shall be provided at locations accessible from the operating floor for the lubrication of all moving parts of the screen except the chains, which shall be water lubricated. All gears shall run in oil, and oil pans shall have means for fillings and draining the oil without dismantling any of the screen components.

1.25.8 Gears and Gear Drives

(i) Unless otherwise specified, gears shall be of the helical or spiral-bevel type, designed and manufactured in accordance with AGMA Standards, with a minimum

service factor (thermal and mechanical) of 1.7, a minimum L-10 bearing life of 100,000 hours and a minimum efficiency of 94 percent.

(j) Gear speed reducers or increasers shall be of the enclosed type, oil- or grease-lubricated and fully sealed, with a breather to allow air to escape but keep dust and dirt out. The casing shall be of cast iron or heavy-duty steel construction with lifting lugs and an inspection cover for each gear train. An oil level sight glass and an oil flow indicator shall be provided and installed for easy reading.

(k) Gears and gear drives as part of an equipment assembly shall be shipped fully assembled for field installation.

(l) Material selections shall comply with AGMA values and the manufacturer's recommendations. Input and output shafts shall be properly designed for the service and load requirements. Gears shall be computer-matched for minimum tolerance variation. The output shall have two positive seals to prevent oil leakage.

(m) Oil lubricated gearbox shall be fitted with oil filling and drain points and where appropriate, an oil breather and /oil level indicator. Oil level and drain location shall be readily accessible.

(n) The oil filling and drain points shall be designed so that oil can be easily drained and replaced without spillage.

(o) Where gear drive output shafts connect to couplings or sprockets, the gear drive manufacturer shall supply matching key.

(p) The gearbox type, number of stages, manufacturer, service factor and final drive ratio shall be stated in the submitted data sheet.

1.25.9 The Screenings discharge

(a) The height of the screenings discharge shall be compatible with the screenings handling system unless specified in the process specification.

(b) An enclosed, corrosion resistant screenings discharge chute to transfer screenings and wash water into the screenings handling equipment shall be provided.

(c) For cleaning and inspection purposes, the chute shall be provided with full width, easily removable cover panel(s). Effective seal (e. g. resilient seal) shall be provided between each cover plate and the discharge chute to prevent leakage.

(d) The discharge chute shall be:-

(i) The discharge chute shall be 316L stainless steel as minimum;

(ii) Designed to prevent the build-up of screenings on the surface;

(iii) Smooth and free from any other obstructions; and

(iv) Sized to take the maximum transferred to the discharge chute without spillage.

(e) Adequate access shall be provided in the sides of the screen enclosure to allow for maintenance and the removal of trapped screenings.

(f) Unless otherwise specified, the sheet steel components shall be stainless steel 316L as minimum.

(g) Drain / overflow shall be provided to prevent liquid from spilling from the chutes and hoppers in the event of malfunction. The drain / overflow must be piped to discharge into the screening channels.

(h) The washer / press and discharge chute shall be provided with the screen as a unit.

1.25.10 Screenings Transfer equipment

(a) Screw conveyors

It shall be fully accordance with the conveyor specification and process specification.

(b) Launder Trough (Sluice)

(i) Unless otherwise specified, the trough shall be manufactured from stainless steel 316 as minimum with minimum 2mm thickness.

(ii) The principle design features and the cross sectional shape of the trough shall be U section unless otherwise specified. The launder shall terminate in a suitable flange to allow connection to the screenings treatment equipment.

(iii) The maximum capacity of the launder trough shall exceed the combined peak screenings and carrier water flow rates which are specified in particular specification , otherwise manufacturer shall submitted the data to engineer for approval. A high water level sensor shall be provided to detect blockage with the trough. In case of high level the trough shall overflow by gravity to the screening channel or site drainage system.

(iv) All joints, including any junction, bends etc. along the trough shall be continuously seal welded inside and out so that launder are watertight. External stiffening ribs shall be provided as required limiting stresses and deformation in plates during shipping, installation and operation

(v) The launder / carrier water shall be injected into the launder trough at multiple points along the entire length of the trough.

(vi) The source and the quality of the launder/ carrier water as specified in the specification.

(vii) The launder trough shall be designed to prevent the build-up of screenings within the trough. Particular attention shall be paid to the trough design at points of flow division or bifurcation.

(viii) The trough shall not incorporate any protrusions or constrictions that are could cause ragging or blockage.

(ix) Unless specified otherwise, the trough shall be designed with minimum fall of 1 in 40 along its entire length. In the event this fall cannot be achieved due to site condition, proposal shall be submitted to ENGINEER for approval prior the manufacturing.

(x) Where specified, the launder trough shall incorporate a method of collecting grit and stones for removal and disposal. This shall be effective without taking the launder trough out of services. It shall be automatic (spiral or plug valve) as with manual bypass as per specified.

(xi) Removable hinged cover shall be provided along the launder system for inspection and maintenance. The hinged cover shall be air tight to contain any odorous air while screening system is in operation.

1.25.11 Screens and Screenings Washing system

(a) Effective cleaning system shall be provided for the screens cleaning.

(b) The screens shall be automatically and mechanically self-cleaning.

(c) The screen cleaning system shall be spray bar system.

(d) The minimum requirement for the spray bar system shall be as following:

(i) The screen washing system shall comprise with manual isolation valve, in-line strainer, pressure regulating valve, solenoid valves, spray bar and nozzles

(ii) The spray bars shall run the full width of the screen / screen curtain and shall ensure effective screenings cleaning and adequate coverage.

(iii) Wash water supply pipes with a suitable non-clogging stainless steel nozzles shall be provided for washing the screen / screen curtains. The nozzles shall be arranged to direct fan-shaped, over-lapping sprays across the full width of the screen to ensure full washing of the screen / screen curtain. Pipe and fittings shall be of 316 stainless steel.

(iv) Washwater shall be obtained from a source as specified in Specifications. Auto backwash strainer / filter shall be installed if necessary and required. Auto changeover basket filter shall not be used.

(v) Spray bar shall be adequately supported and shall be positioned to minimise the accumulation of screenings on their surface.

(vi) The nozzle diameter shall be sized adequately for the wash water supply to prevent blocking.

(vii) Spray bars shall be removable from the outside of the screen curtain support structure to permit maintenance. The spray nozzle shall be attached to the spray bar by quick removable Nation pipe Thread (NPT) connections for ease of cleaning and removal.

(viii) All pipework and nozzles shall 316 stainless steel as minimum, and sufficient unions shall be provided to allow easy dismantling for maintenance and replacement.

(ix) The wash water pipe shall be extended outside of the head housing and shall be fitted with a control valve. The control valve shall be of the tight shut-off type suitable for flanged connections and complete with weatherproof electric motor actuator or solenoid valve as appropriate.

1.25.12 Solenoid Valves

(a) Solenoid valves shall be provided to control the screens washing system. The valves shall be mounted on a combined delivery and return manifold in a manner to allow each valve to be hydraulically isolated for changing without interrupting the operation of the remaining valves.

(b) An open/shut indicator shall be provided on or immediately adjacent to each solenoid valve. Where necessary, adjustable flow regulators shall be provided adjacent to each solenoid valve.

1.25.13 Guarding and covers

(a) The screen shall be 316 stainless steel and shall be fitted with all necessary guarding and covers.

(b) Guarding shall comply BS EN ISO 12100 and BS EN 953 or equivalent.

(c) If access is required to components for process correction or maintenance, mobile guards shall be used if the foreseeable frequency of access is high. Movable guards shall be interlocked in accordance with BS EN 1088 or equivalent.

(d) Hinged doors shall be provided in the sides of the screen enclosure, located directly opposite each other, to allow maintenance of the mechanism and the removal of any screening materials that may be trapped within the screen assembly.

(e) Components that may require regular access of maintenance or condition monitoring shall be accessible without removing guards by mean of access door or access hatches with padlocking and stainless steel quick release fixings.

(f) All equipment shall be “lock out” to prevent automatic starting prior to any covers or guards being removed.

1.25.14 Odour Containment for screens

(a) Odour containment enclosure shall be provided for the screen located at the top of the channel wall or top water level if specified. The cover shall contain the “aerosol effect” created by the screen cleaning and removal system and also contain the egress of gases and odours. The cover shall be manufactured from 316 stainless steel so that they are maintenance free. Where required, connection shall be provided for odour control ductwork using flanged stub pipes moulded or built in to the covers.

(b) The enclosure shall include hinged covers to facilitate access for inspection and maintenance.

(c) Provide suitable flanged connection for odour control duct as specified in the Odour containment specification.

(d) Each cover shall include a limit switch that stop and/or inhibits screen operation when the cover is not closed.

(e) Odour containment cover shall extend from top of channel to top of screen. The cover shall have suitable cut outs opening which shall extend at least 1.5m upstream and downstream of the screens unless specified. Cover shall be removable and trafficable and shall be provided to ensure odorous air is fully contained while screens are in operation.

(f) The containment cover shall be fully comply with General specification Odour Containment Cover.

1.25.15 Accessories

(g) Equipment Identification Plates: Provide 2mm thick, Type 316 stainless steel identification plate securely mounted in a readily visible location on each separate equipment component and control panel(s). Plate shall bear 10m high engraved block type black enamel filled equipment identification numbers and letters. The nameplate shall state, as a minimum, the following:

(i) Manufacturer and date of manufacturer

(ii) Model No

(iii) Serial No

(iv) Power rating for the drive

(v) Pressure Rating of power Pack if applicable

(vi) Major Component Weights

(h) Lifting Lugs: Provide for equipment and components weighing over 40kgs.

1.25.16 Product

Additional to the general requirement stated in previous sections of this specification, each individual type of screen shall have the following additional requirement:

(a) Mechanical Inclined Raked Bar Screen

(i) Mechanical Inclined Raked bar screens shall be of the inclined bar type, with an inclination no greater than 15 degrees to the vertical, and designed to remove solids size as specified in the relevant specification.

(ii) This section shall cover the following rake screens:-

1) Continuous chain rake screens

2) Straight bar screens (front racked and back racked)

(iii) Each screen shall be fitted with a mechanical automatic bar raking mechanism, controlled in such a way to ensure the bar racks are cleaned intermittently and the screenings collected and deposited in an appropriate receptacle.

(iv) Equipment furnished shall be fabricated and assembled in full conformity with drawings, specifications, engineering data, instructions and recommendations of the equipment manufacturer, unless otherwise specified.

(v) General Design Requirements

1) The screen units shall be self-contained and complete with bar rack, side frames and pin rack, rake assembly, scraper assembly, screen washing system, electric drive motor, controls, gear reducer, anchor bolts and all accessories and appurtenances specified, indicated on the drawings or otherwise required for a complete and properly operating installation.

2) Any power actuators shall be kept above top water level at all times. The rake assembly shall be capable of being parked above top water level; when the screen is not in service.

(vi) Frame structure

1) Side frames shall be designed to support the required loads and to be anchored to the channel. A pin rack or cog rail constructed to accurately mesh with the cogwheels provided shall be mounted in each side frame. The pin racks shall consist of steel bolts fitted with bushings and rollers, roller chain or mechanical cog rail rigidly secured in place**.**

2) Guide rollers travelling in channel-shaped tracks attached to the side frames shall be arranged so that the rake will climb over and be free of any immovable debris lodged in the bar rack, and then return properly, mesh with and clear the bar rack. Anchor bolts, nuts, and washers shall be AISI Type 316L stainless steel.

3) Assembly fasteners such as bolts, nuts, washers, etc. except anchor bolts that are submerged or subject to contact with the liquid shall be 316L stainless steel.

4) Sharp projections of cut or sheared edges of ferrous metals, except stainless steel, which will be submerged in operation and are not to be welded, shall be ground to a radius as required to ensure satisfactory paint adherence.

5) All welded joints which will be fully or partially submerged shall be sealed watertight by continuous welds.

6) Unless otherwise specified or permitted, all items fabricated from stainless steel shall be thoroughly cleaned, degreased, and pickled following fabrication.

(vii) Screen curtain

1) The screen curtain shall comprise a fixed static assembly of bars and shall be 316 stainless steel as minimum.

2) The bars shall be parallel throughout their length.

3) The bar spacing shall be as specified in the particular specification

4) The gaps between the bars and the side frames/ panels shall not be greater than the bar spacing.

(viii) Rake Mechanism (Chain type)

1) The screens rake shall have multiplicity of raking combs carried by two endless revolving chains on upper and lower sprockets.

2) Screenings shall be positively removed from the screen curtain by the raking action of a number of rakes. The number of rakes and frequency of raking shall ensure continuous, effective removal of screenings from the screen curtain.

3) Each bar rack shall consist of individual bars and shall be securely anchored to the channel floor and to a dead plate at the top of the rack. Each bar rack shall span the full width of the channel and shall extend above the specified high liquid level. The bar shape shall be rectangular or wedge shaped.

4) A dead plate extending from the top of the bar rack to the discharge chute shall be provided. The space between the dead plate and the bar rack shall be sealed to prevent overtopping of the rack.

5) The rake assembly shall be guided over the discharge point and the accumulated debris shall be removed by a scraper assembly attached to the side frame and designed to pivot to achieve effective cleaning of the rake.

6) Each rake shall incorporate a number of easily replaceable rake bars / tine plates.

7) An adjustable scraper blade shall be provided to clean the rake, this shall return to its original position in a controlled manner after each cleaning cycle. The scraper blade shall incorporated a wear strip, attached to the blade by 316 stainless screws.

8) Once engaged, tines shall protrude a sufficient distance through the screen elements to prevent "packing" of the screenings between the screen elements.

9) For the front raked screens, a flat debris plate shall be fitted between the screen side frames/panels, above the screen curtain, to retain the screenings on the rake as they elevated to the discharge point. For back raked screens, a fail-safe and overtopping by-pass shall be provided and the flat debris plate shall not be required.

(ix) Screen washing Facilities

1) The screen shall be automatically and mechanically self-cleaning.

2) End of each rake shall be attached to drive chain to ensure that the tines remain perpendicular to the chains throughout the raking stroke.

3) The screen curtain cleaning mechanism shall be designed to prevent the trapping and compaction of screenings into the channel floor or against the sides of its support structure.

4) For the rake and chain assembly drive system, the side frame/panel shall incorporate replaceable roller tracks to support/guide the rake and chain assembly.

(x) Drive Mechanism

1) The rake and chain assembly drive system shall be designed so that the rake is positively driven during both its downward and upward raking stokes.

2) The position of the head shaft bearings shall be adjustable to main chain tension.

3) The discharge chute shall be fully shrouded and shall be manufactured from 316 L stainless steel.

4) Each bar screen shall be driven by an electric motor through a flexible coupling. Drive units shall be designed for 24 hours continuous service and shall be dual speed.

5) For the front and back raked type screen, during normal operation, the rake shall be held clear of the screen curtain during the downward raking stroke, but shall be positively engaged with it during the upward raking stroke.

6) The drive chains shall be provided with close fitting, shrouded sprockets and guide rails to prevent buckling during operation.

7) Limit/proximity switches shall be provided for setting the rake stroke length.

(xi) Materials of Construction

As a minimum, the material of construction shall be as follows:

Item	Material
Rake Arm, Rake Shelf	316L
Apron, Discharge Chute	316L
Wiper	316L
Pin Rack or Cog Rail	316L
Bar Rack, Side Frames, Dead Plate and Guides	316L
Pin Rack Bushings and Rollers	Carbon steel hardened and ground – Non lubricated type
Shafting	Carbon steel, cold rolled, solid
Cog Wheels or Drive Sprockets	Chrome molybdenum steel AISI 4142 hardened to Rockwell C50 / Stainless steel, AISI Type 304L
Bearings	Anti-friction, rolling element type, grease lubricated
Wiper Blade	UHMW polyethylene
Automatic Bearing Lubricators	Lubsite lubricators
Anti-Seize Thread Lubricant	Jet lube Nikal crane; Pure Nickel special or Permatex Nickel Anti-Seize

(b) **Band Screen (Centre Flow)**

(i) The screen shall be designed to operate in an open channel passing influent which is specified in the particular specification. The flow shall enter the inside of the continuous belt and exit through both sides and the bottom belt.

(ii) The screen shall be suitable to be installed in the channel as shown on the drawings.

(iii) The screen shall be of the continuous rotating band type and shall be of robust design, capable of withstanding the impact of floating and settled debris and suitable for continuous operation.

(iv) General Design Requirement

1) The head section of the screen shall incorporate a horizontal head shaft fitted with spray bars for the screen and screening washing. The head shaft shall be position behind the rotating belt and will backwash the solids into a stainless steel hopper.

2) The head section shall be rigidly attached to the main frame so that the entire screen can be removed as a unit. The screen frame shall be of robust design for easy transportation and installation on site.

3) The screen belt shall consist of individual panels with perforation of specified opening which are linked together by stainless steel shafts to form a continuous band. The screen belt shall rotate within a heavy duty stainless steel static support frame that shall be a rectangular box construction.

4) The screenings will be removed at the top of the screen within the head section and offloading into a screening handling system via a discharge sluice / chute.

5) A close fitting stainless steel enclosure complete with screenings discharge chute shall fully enclose the screen. The cover shall be lightweight and easily removable for maintenance.

(v) Screen Belts / Perforated Panel

1) The screen frame shall be fitted with replaceable roller tracks to guide the screening belt.

2) The continuous belt shall be supported and rotated around heavy duty stainless steel sprockets located on the drive shaft in the head space of the screen.

3) The perforated panels shall be sufficiently supported to prevent deflection of the panels. The support system shall support the screening grid and bear tension loads across the entire length and width of the screen belt.

4) The perforated panels shall be designed to have adequate thickness to prevent hair pinning of fibrous debris and hair. The design of the perforated panels shall minimise plugging and allow for easy cleaning with minimum backwash pressure and volume.

5) The perforated panels shall be connected to form a continuous belt that will rotate within the frame's guide system.

(vi) Frame Structure

1) The design shall ensure the support frame mesh with the closure seal on each guide link to prevent passage of screening material and grit particles.

2) Removable inspection panels shall be provided allow easy access to the grid drive sprockets, drive shaft, and screening collection.

3) The heavy duty guide links shall be protected against undue wear from grit and specially machined to form a closure seal between the rotating belt and the static frame.

4) The guide link system shall travel around a stainless steel guide wear track that is integral to the support frame. Top and bottom wear tracks shall be bolt in and field replaceable.

5) Guide systems that use rollers, stainless or hardened steel chains will not be acceptable.

6) Grid panel sealing systems that use neoprene seals or stainless steel hinges will not be acceptable.

7) Grid to frame sealing systems that use adjustable strips attached to the frame will not be acceptable.

8) Stainless steel protective covers shall be provided to prevent leakage and contain spray wash.

9) Unless specified otherwise, the belt shafts shall be of stainless steel and the outer chain shall consist of stainless steel link plates with stainless steel rollers.

10) The upper drive sprocket shall be of carbon steel and shall incorporate an outer wear ring component of stainless steel. The lower belt guide shall be of stainless steel.

11) Resilient seal or equivalent shall be provide to seal between the screening belt and main frame .The seal shall be continuous from grade level through the water flow forming an uninterrupted closure between the traveling screen grid and the stationary frame. The seal shall be heavy gauge stainless steel, fixed to the screen frame and be adjustable so it will remain in contact with the rotating screen belt at all times. There shall be no gap in the grid to frame seal larger than 0.5mm.

(vii) Screen washing facility

1) Screens washing facility shall be provided within the head section to wash the screens panels as it passes the discharge point above the discharge chute for the screening prior dropping into a screening handling system. The wash water shall be returned by gravity back to the headworks. Two stainless steel spray wash headers shall be located in the head section to offload the screenings from the continuous belt.

2) The spray bars shall be positioned behind the rotating belt and backwash the solids into an internal hopper manufactured from stainless steel. The wash water shall be used to continuously flush the screenings from the internal hopper into the compactor.

3) A rotating brush system shall be included as an option to aid in the offloading of screenings.

4) Removable access covers and splashguards shall be incorporating an inspection door provided and designed to reduce aerosol from the spray nozzles and odour to a minimum.

(viii) Drive mechanism

1) The band screen shall be driven by a top mounted motor and a chain drive linked to the upper rotating assembly. The chain drive shall be protected by a weatherproof guard.

2) A disc clutch or manual reset current sensing overload shall be fitted to protect the motor against overload in the event of obstruction of the screen.

3) The gear reducer shall be directly coupled to a heavy duty shaft machined from solid stainless steel round bar.

4) Unless otherwise specified, the belt shall be capable of raising and discharging objects up to 250mm in diameter and up to 200kg in weight. The belt shall not travel at a speed greater than 2m/min.

5) All components of the screens (including frame, grid, and drive components) shall be stainless steel unless specified otherwise. The guide link system shall travel around a stainless steel guide wear travel which is integral to the support frame.

6) All electrical terminations and control equipment shall be housed in a proprietary local control panel. The screen controls shall permit either continuous manual operation, automatic timed operation or automatic continuous operation based on ultrasonic level measurements in the channel.

(ix) Construction material

As a minimum, the material of construction shall be as follows:

Item	**Material**
Main Frame and Head Section	316 L
Roller Track	316 L
Bearing Housing	SS 316 L
Outer / Inner curved Roller Tracks	316 L
Main Chain Sprockets	BS 1452 Gr 260
Main chain link	Stainless steel
Main chain Rollers	Nylon 6
Screen panel	Ultra-High Molecular Weight Polyethylene(UHMWPE)
Main chain Sealing plate	Low Friction Plastic
Basket Frames	316 L
Spray bar and nozzles	316
Splash guard	316 L
Trough / discharge chute	316 L

(c) Drum Screen

(i) General Design Requirement

1) The automatic dram screen shall be composed of screen, screw conveyor, washing unit, dewatering unit and drive unit. etc.
2) The automatic dram screen shall have 2 mm opening and shall be used to block, scrape, wash, and dewater the suspended solid or scum in the influent or sludge.
3) This equipment shall be designed with sufficient safety factor in strength,
4) This equipment shall be of integrated type and shall be constructed such that it can be installed easily.
5) The difference of water level, the characteristics of suspended solid, and flow rate shall be considered in design.

(ii) Fabrication

1) Drive unit

Cycloidal reduction gear or worm reduction gear shall be used as drive unit. Drive unit shall transmit the power by means of gear transmission or direct connection with coupling.

Gear box shall be provided in case of gear transmission,

2) Screen

The screen shall be made of cylindrical stainless steel. The screen shall have a smooth finish in order to prevent the attachment of screenings and shall be arranged with equal spacing.

An electrical pole shall be installed in front of the screen in order to detect the overflow and control operation,

3) Rake

The rake shall be connected with the screw conveyor along the same axis and shall rotate with it. The raked screenings shall be scraped down into the screw conveyor by the scraper.

The rake shall be constructed such that the screenings never remain on the screen after raking,

4) Screw conveyor

The impeller and shaft of the screw shall be a welded structure of stainless steel and shall endure the inclined stress,

A dewatering device shall be provided at the upper portion of the screw conveyor, The dewatering device shall be sealed and shall have sufficient strength to endure the pressure of screenings and scum. The inspection hole and washing water pipe shall be provided for the dewatering device. The inspection hole shall permit easy inspection and the washing water pipe shall be used to wash the casing for filtrated liquid,

5) Shaft and bearing

The shaft of screw shall be made of stainless steel and shall have sufficient strength to endure the incurred stress.

The submerged bearing shall be an oil-less enclosed pneumatic type. For a bearing installed above the water level, an automatic oiling device shall be provided.

6) Washing unit

Washing nozzles shall be provided at the inlet of the screw conveyor in order to wash down the screening or scum with pressurized water.

7) Chute

A stainless steel chute shall be provided at the discharge part of the screw conveyor. The chute shall be constructed such that the screenings are blocked from being discharged.

(iii) Material of Construction

Screen	: Stainless Steel AISI316
Rake	: Stainless Steel AISI316
Screw conveyor	: Stainless Steel AISI316
Chute	: Stainless Steel AIS1316

(iv) Protection Equipment

1) Mechanical protection: For cyclodial reduction gear, a built-in torque limiter shall be provided,

2) Electrical protection: An over-current detector with instantaneous converter shall be provided in case the mechanical protection is not provided.

(d) Step Screen

(i) General Design Requirement

1) 6 mm step screens shall be supplied complete with all the necessary ancillary equipment and with screenings washing and compacting facilities.

2) The screen shall be designed to prevent blockage at the base by grit or stones and shall be constructed of stainless steel Grade 316 to BS 970-1 (partially replaced by BS EN 10084).

3) The screen and frame shall be designed to facilitate safe inspection, cleaning, lubrication and repair to ensure safe and satisfactory operation under all service conditions. The frame shall be of robust construction and be suitable for fixing to the top of the channel coping. No fixings shall be allowed below the coping level. Any concrete fixings shall not be less than 125 mm away from the edge of concrete.

4) Screen shall not be permanently secured to the screen channel walls. Location fixings shall be positioned at coping level for ease of access. Screen shall be housed in an enclosed structures and shall be manufactured in sections to facilitate removal from the channel, making due allowance for the maximum height available.

5) Each fine screen and the compactor shall be capable of handling the flow as detailed in the Employers Requirements, and shall be suitable for the climatic conditions stated in the Contract.

6) The screen shall consist of a series of self-cleaning screening bars in a staircase configuration. Every other bar shall be fixed in a rigid structure, and the remaining bars shall form a robust moveable framework that shall revolve in a reciprocating motion to lift the screenings step by step to the top for discharge.

7) A sealing plate shall be provided between the outer edge of the screen and the walls of the screening chamber. The plate shall enclose the drive mechanism on the upstream side of the screen to prevent fouling by debris. Chain drives, if used, shall incorporate means of adjustment to compensate for chain wear. Tension screws shall be provided and shall be manufactured from stainless steel.

8) The screens shall be fitted with an automatic cleaning mechanism, which shall remove the screenings adequately and positively into a screenings transfer system to the screenings washing equipment without risk of spillage. The transfer system shall be totally enclosed and be fitted with bolted removable access cover sections.

9) The screen framework and components shall be designed to resist both hydraulic and drive mechanism loads during normal running and all modes of failure. Screen mechanism shall be arranged such that the minimum number of moving parts will remain immersed when the screen is in the parked position.

10) The Contractor shall make his own assessment of the amount of screenings which will be produced by the equipment and the design of the screenings handling system shall be carried out accordingly.

11) The drive motor(s) shall be fully weatherproofed totally enclosed squirrel cage continuously rated IP55, class F, BS4999 Part 105 complete with anti-condensation heater. The motor shall be suitable for the climatic condition and shall be fitted with an adequately sized sun canopy.

12) Screen shall be provided with a limit switch which shall inhibit the start of the screen in case the covers are not completely close.

13) To minimise odours and nuisance insect populations, the screen transport system and compaction/dewatering system shall be completely enclosed.

14) The spray wash systems shall be completely enclosed to prevent spray, aerosols, and leakage from coming in contact with the operating floor.

15) A seal plate shall be provided to enclose the screen and the rectangular concrete channel. The seal plate shall be one piece fabricated of 11-gauge minimum stainless steel and shall bolted to the channel wall with an angle profile on each side. The sealing plate shall be of sufficient height to prevent bypassing of flow around the screen at the maximum screen hydraulic capacity.

16) The manufacturer should also note that the concrete structures shall be covered for odour control. The manufacturer shall advise of any structural modifications required for accommodating their equipment.

(ii) Washwater System

Washwater supply shall be taken from the site washwater system and shall be as required by the screens manufacturer. Details of the existing washwater network are detailed above.

(iii) Gear motor

1) The constant pitch screw shall be powered by a helical speed reducing gear motor. The motor shall be explosion proof type with normal starting torque and low starting current. The gear reducer shall have a minimum torque output of 1.4 when applied to the motor nominal horsepower.

2) The speed reducer shall include anti-friction bearings with high overhung load properties and oilseal, double-lip, high temperature synthetic type, riding on a precision ground shaft, to minimize leakage possibilities. Speed reducer shall be enclosed in a cast iron weatherproof casing. Gears shall be made of hardened and heat treated forged steel. The gear motor shall not be overloaded under any normal operating conditions and shall be designed for heavy-duty service. The gearing shall be oil lubricated.

3) Motors shall be sized so that under maximum continuous loading the nameplate horsepower is a minimum of 15% greater than the driven load.

(iv) Gear head

1) The gear motor shall drive a gear head consisting of gears manufactured from case hardened steel and hardened to 58-62 Rockwell C. All gear teeth shall be ground to ensure an accurate profile. The main bearing shall be sufficiently wear resistant to stand heavy-duty service. The axial load developed by the compacting screw shall be neutralized by a built-in spherical thrust bearing.

2) The gear head shall be mounted inside a totally enclosed oil filled gear box designed with a high cross-section module with stiffening webs for maximum rigidity with a service factor of 2.0. The gear box shall support the cantilever screw shaft and shall be protected from foreign matter entry by a set of 2 seals.

(v) Trough

1) The full length drainage trough shall be made of 316L stainless steel sheet. The trough shall be equipped with a 75 mm minimum diameter drain outlet. The drainage collecting trough shall be easily removable for occasional cleaning/flushing/maintenance purposes. The trough shall also be supplied with two lateral inspection ports having dimensions of approximately 100 mm by 500mm. A 25 mm pipe flushing connections shall be provided at each end of the drainage collecting trough to allow washing/cleaning of the trough, and also to prevent the over accumulation of compacted screenings material into the drainage slots.

2) The trough shall be provided with drainage holes to allow excess water to drain into a collecting tray, from where it shall be piped back to the channel upstream of the screen. An overflow pipe of 316L stainless steel construction shall also be provided and returned upstream of the screen.

3) Unless otherwise advised by the Engineer, the Launder Trough shall incorporate a 'Stone Trap' to collect grit to prevent it entering the compactor. The grit shall be disposed of downstream of the fine screens and upstream of the detritors.

(vi) Hopper & outlet

1) Hoppers shall be made of minimum 6mm thickness 316L stainless steel plate, flanged top and bottom. The hopper openings at the lower flange or screw housing level shall be approximately 600 mm x 300 mm. The sidewalls shall be inclined to allow preliminary screenings containment above the screw conveyor.

2) The screw shall deliver the screenings into a conical compacting and dewatering section and shall taper off to a point within this zone to allow the screw to position itself in the centre of the compacted screenings. The dewatering section shall drain into a collecting tray.

3) An outlet/friction tube shall be provided to convey the screenings from the compacting section to the discharge point, further compaction and dewatering taking place within the tube. The discharge tube shall be made of 316L stainless steel. The discharge tube shall be inclined and oriented to suit the screenings collection skip. The discharge tube shall use long-radius fittings designed to avoid any jamming of the partially dewatered/compacted screenings inside it. The discharge pipe shall be easily disassembled with stainless steel grooved couplings.

(vii) Spray watering system

1) Washwater shall be used for the spray system in the trough and the conical compacting chamber to clean the collected screenings of organic matter to produce a clean handleable final product. The inlet washwater connections shall include manually operated ball valves and all pipework shall be supported by purpose made brackets of 900mm centers.

2) The washing system shall be designed to clean the trough and also prevent the accumulation of compacted material into the drain holes. It shall be controlled by a solenoid actuated valve controlled by a timer and compactor stop / start controls.

(viii) Control

1) The controls and instrumentation that are provided for the equipment shall interface directly with the plant SCADA via a PLC system, such that remote monitoring and operation is possible. PLC digital I/O will operate at 24 VDC and analogue I/O on a 4-20 mA signal.

2) All instruments shall be fully described on Instrument Data Sheets to, or equivalent to the format published by the Instrument Society of America (ISA). The data sheets shall contain all process, mechanical and electrical data. A functional specification shall be provided by the Contractor for all equipment supplied under this Contract to allow PLC/SCADA programming.

1.25.17 Electrical Equipment and protection monitoring equipment

(a) Electrical equipment shall conform to the Electrical Specifications

(b) When equipment is located in a hazardous area, the equipment must be approved and certify for use in the applicable hazardous area classification.

(c) Provide all necessary electrical components and wiring for a complete, functional system. Electrical components shall be provided in accordance with the electrical requirements. Where required, all electrical components shall be rated for hazardous area. Hazardous Classification for Liquid Facilities. Component assemblies will include the following, but not limited to:

(i) Gear motor drives

(ii) Control panels

(iii) Non-fused disconnects

(iv) Electric valves

(d) Unless specified otherwise, each screen shall be supplied with the manufacturers proprietary local control panel incorporating stop/start/inching/reverse controls functions as appropriate and in accordance with the ICA Specification.

(e) Drive systems shall include a torque overload protection device, which will prevent mechanical damage in the event of the unit being jammed. The torque overload device shall auto-reset after the screen has stopped ready for manual restart of the drive. The torque overload device output shall be suitable for control and monitoring. Electronic shear pins or similar system can be proposed and shall be approved by engineer.

(f) Thermal protection shall be provided for the motor overheat / short circuiting / signal phasing.

(g) Limit switch shall be provide for screen mechanism over travel protection if necessary (i.e. Top travel limit stop out of flow switch/ bottom travel limit switch / over travel top limit switch).

(h) All electrical connections to control devices such as integral switches, solenoids and instrumentation shall be made to a single terminal box, housed on the screen structure. The terminal box shall be fully complied with Electrical and ICA specification.

1.25.18 Local Control panel

(i) Control panel and motor starters shall be provided as part of the package, in compliance with Electrical and ICA specifications.

(j) The system shall be robust and permit simple, easy disassembly and reassembly of any pieces which must be removed to service the screen, washer or compactor, such disassembly and reassembly shall not require any special tools or the removal of surrounding components.

(k) All wiring, cabling, conduit and electrical plant and equipment, motors and installation shall be in full compliance with Electrical Specification.

1.25.19 Instrumentation and Controls

(a) General

(i) All instrumentation and control components provided under this Section shall be in accordance with ICA Specification.

(ii) PLC and instruments shall conform to the relevant section of ICA specification PLC and instruments shall conform to the relevant section of electrical specification.

(iii) The equipment supplier shall provide all functions and associated equipment as necessary for proper operation of the systems

(iv) The sensor shall be capable of operating in temperatures from +10^{o}C to +60^{o}C and shall be impervious to submersion and shall have a high resistance to corrosive atmosphere.

(v) The screen shall be operated in conjunction with wash & compactor system, screenings conveyor, and penstocks as well as associated instruments. The integrated operation may be controlled with a plant PLC controller (by others) or the screen equipment package's PLC controller hosted in a Local Control Panel (LCP).

(b) The minimum requirement for the Local Control Panel (LCP) shall be as following:

(i) IP 65, Large Stainless Steel Box, enclosure with suitable protection for housing in the location.

(ii) Local-Off-Remote selector switch for each drive.

(iii) Front panel mounted indicator lights for power on, motor run and trip (for each motor).

(iv) Forward-Off-Reverse switches.

(v) All other relays, switches and wiring necessary for screens and washing compactor operation.

(c) Provide the following protection monitoring as minimum:-

(i) Provide forward/automatic/reverse switches on each drive to allow manual reversing.

(ii) Provide hard-wired overload relays to shut off drive in the event of jamming.

(iii) Provide hard-wired torque switches to shut of the drive in the event of jamming.

1.25.20 Condition Monitoring

(a) In addition to the condition monitoring requirement stated in the Electrical and ICA Specifications. The following shall also be provided:-

(i) Above pre-set high pressure differential.

(ii) Screen low wash water pressure.

(b) Indicating lights and switches shall be provided in LCP as follows:

(i) Screen in operation (locally and in LCP).

(ii) Power on-off light (local only).

(iii) Alarm conditions (locally and a common alarm to LCP).

(iv) Emergency stop push buttons at the screen's LCP.

1.25.21 Site Testing

(c) Prior to site testing, the Contractor shall provide the services of a qualified manufacturer's technical representative, who shall adequately inspect the installation and test the equipment furnished under this contract and instruct the Client's operating personnel in its maintenance and operation. Manufacturer's Certificate of Proper Installation Compliance report shall be submitted to engineer for approval prior any test commencement on site.

(d) The screens shall be site tested after erection in the presence of the engineer and manufacturer's representative to confirm and verify the structural and mechanical compliance to the requirements specified. The site acceptance test shall include demonstration that the screens operate continuously without vibration, jamming or overheating and perform their specified functions satisfactorily.

(e) All labour, materials and test apparatus necessary for conducting the field acceptance tests shall be furnished by the Contractor at no additional cost to the Employer.

(f) Test shall be conducted on each unit and shall include the following as minimum:-

(i) Prior to facility start-up, test complete assemblies for correct rotation, proper alignment, unobstructed movement and connection.

(ii) Electrical System shall be tested in accordance with Electrical Specification.

(iii) Leakage test for all pipework, joints and fittings and hydraulic power pack.

(iv) Measurements taken and recording the temperature rise of the hydraulic fluid remains and the power consumption of relevant plant and equipment.

(v) Verification of reliable and smooth operation of the screen and all associated ancillary equipment i.e. pressure relief valves, pressure gauges etc.

(vi) Test for continuous 3-hour period under actual or approved simulated operating conditions without malfunction. In the event failure occur, adjust, realign, and/or modify units as approved by ENGINEER and retest if necessary

(vii) Upon completion of test, test results shall be submitted to ENGINEER for approval.

1.25.22 Tests on Completion

The screen assembly shall be subject to a complete commissioning procedure with the following additional requirement as minimum:-

(i) 24 hour continuous operation prior to being put into operation.

(ii) Smooth operation of all rotating bars ensuring there are no signs of fouling or resistance local to the top/bottom bearings of the hydraulic drive motors.

(iii) Check for leakage from the hydraulic power pack and associated pipework, joints and fittings.

(iv) Check temperature/consumption according to the data sheets.

(v) Check the energy consumption provided by supplier.

(vi) All pipework restrained where necessary to avoid excess wear and tear leading to failure of flexible hoses caused by abrasion.

Verification of reliable and smooth operation of all ancillary equipment associated with the hydraulic power pack, i.e. pressure relief valves, pressure gauges etc.

1.26 Screening Conditioning System

This specification covers the general requirement of the performance, design and construction of the screening treatment equipment in used water (wastewater) application with all relevant statutory regulations and the latest edition of all relevant international , harmonized European and British Standard and Indian standard and codes of practice.

The specification cover the following type of compactor equipment:

- Dewatering Compactors; and
- Washing Compactors.

This specification shall also comply with the following:

- The specific data sheet (if applicable);
- The relevant process specification;
- The relevant Electrical specification; and
- The relevant Instrumentation Control and Automation (ICA) specification.

1.26.1 General Layout arrangement

The Contractor shall propose the general layout area taking consideration of the manufacturer's recommendation and the installation requirements to ensure full completed and functional system been installed. The layout shall be subject to the approval of the engineer

1.26.2 Submittals

The Contractor shall provide complete fabrication and assembly drawings, together with detailed specifications and data covering materials, power drive, assemblies, and accessories forming a part of the equipment supplied. The data and specifications for each unit shall include, but shall not be limited to, the following:

(a) Outline and general arrangement drawing of the equipment indicating the designation overall dimension /foot print and typical layout of key components / system.

(b) Overall dimensions and estimated weights of all furnished equipment.

(c) Component drawings showing all details of construction.

(d) Weight schedule for each major equipment component and the heaviest individual maintenance and erection lifts.

(e) A typical control philosophy

(f) A typical commissioning plan (Incl timescale for completion)

(g) A lubrication schedule detailing parts requiring lubrication, and method and type and manufacturer of lubricants

(h) Identification, size, rating and location of all instrument and electrical connections.

(i) The wash water consumption and pressure requirement

(j) The Energy consumption and electrical drive loadings list

(k) Wiring diagrams which show internal wiring, external connection wiring, and interconnection wiring requirements. Manufacturer shall indicate the power supply and control power supply requirements.

(l) List of all instruments and controls, along with function, included with the screen

1.26.3 Design Specification

(a) The performance, design, construction and testing of the equipment shall comply with all relevant statutory regulations and the latest edition of all relevant international and Indian Standards.

(b) The equipment and associated plant and instrumentation shall be suitable for the site location, environment, and the operation condition.

(c) The equipment shall be effectively handle the screenings from the influent flow and shall be capable of automatic operation for long periods without operation personnel attention under all-weather conditions. The plant shall be robust and reliable in operation.

(d) The equipment shall be capable of withstand high quantities of grit without excessive wear.

(e) Unless otherwise specified in the particular specification, the process performance of the equipment (i.e. screening quality) is measured in terms of the reduction in volume, moisture content and BOD of the treated screenings, compared to the raw input screenings.

(f) Manufacturer shall state the following performance criteria in their equipment datasheet:-

I. Screening volume reduction (%)

II. Screenings moisture content reduction (%)

III. Average %DS (treated screenings) (%)

IV. Average BOD (treated Screening) (Mg/l)

(g) The plant noise level shall not exceed 85 dB(A) at distance 1 meter from equipment centre line (based on the equipment being mounted in semi reverberant / free field conditions). Acoustic hood or cladding shall be provided if necessary to meet the noise level.

(h) The weight of the individual components over 25Kg, that are likely to be removed for maintenance, shall either:

I. Incorporate clearly identified, permanent lifting points located to give a safe balanced lift

II. Be designed in such a way that standard lifting accessories (e.g. slings) can easily be attached**.**

With respected to item (i) above, if lifting points are not designed for lifting the complete component, they shall be clearly marked accordingly.

(i) The compactor shall be fitted with lifting eyes for removal as a complete unit.

(j) The compactor shall design such that operations personnel do not have to remove screenings from the screens, unless otherwise specified.

(k) Compactor shall be supplied with stainless steel or GRP covers. Hinged or removable sections shall be incorporated in the cover to allow easy access for maintenance but not compromise operator safety.

(l) The ingress rating of all exposed components which may be subjected to be aggressively washed by hose from the wash water or cleaned from a steam cleaner with a degreaser additive shall be minimum rated at IP 65.

(m) All types of compactors shall be capable of operating in manual or automatic mode.

(n) Screenings washer/press and discharge chute shall be provided complete as a unit.

(o) Materials selection

I. The material of the plant and equipment and its associated components shall be suitable for the site location and operation environment. Corrosion Protection system shall be provided and submitted to ENGINEER for approval

II. All assembly and anchor bolts, nuts and washer shall be 316 stainless steel as minimum.

(p) Support structure

I. Support structure shall be of a robust design and be adequately braced to ensure rigidity under all operating conditions.

II. Support structures shall be constructed from corrosion resistant materials or protected against corrosion by the application of paints or protective coatings.

III. Support structures shall be locally reinforces around foundation bolt-holes.

IV. Support frames shall be fabricated to withstand equipment and material loads.

V. Support frames shall be fabricated to be installed on the concrete floor or where indicated on the structural steel.

VI. All sharp corner of all cut or edge shall be smoothed by a power grinder.

VII. All metal fabrications (i.e. frames, support structure etc.) shall be designed to prevent moister traps and collection of liquids and debris and, if appropriate, facilitate the application of paint system and protective coatings.

VIII. The end of all mild steel sections shall be sealed, to prevent ingress of liquids, after corrosion resistant coatings have been applied.

IX. All galvanising shall comply with BS EN ISO 1461.

X. All metallic items (such as fixing and fixtures etc.), which are routinely wetted or submerged or immersed in by wastewater shall be made of stainless steel 316 L unless otherwise specified. If stainless steel is unsuitable for use, an

alternative corrosion resistance materials shall be proposed and approved by engineer.

(q) Drive Systems

I. All drive system components (e.g. motors, gearbox, drive shafts etc.) shall be adequate supported.

II. All drive shaft assemblies shall be designed for ease of maintenance.

III. Protection system shall be provided to protect against jamming and other mechanical overloads. The motor shall be automatically tripped in the evet of an overloaded.

IV. All drive components shall be adequately supported so that fatigue or under stress does not occur.

V. The drive system shall be provided with a local inching facility to release blockages.

VI. All electrical switchgear emergency stop switch and local control station shall be fully accordance with Electrical specification and Instrumentation and control specification.

VII. The compactor-drive until mounted at the bottom of the inclined screw trough and shall be enclosed.

VIII. The compactor shall be directly driven by an electric motor coupled to a shaft mounted gearbox.

(r) Bearings and Lubrication

I. Equipment component combinations that are likely to come into contact and be subject to relative motion shall be adequately lubricated or manufactured from materials with self-lubricating properties.

II. Bearings shall conform to the standards of the Anti-Friction Bearing Manufacturers Association, Inc. (AFBMA).

III. Rolling element bearing shall be rated for a minimum L 10 life expectancy of 50,000 hours while operating at maximum load.

IV. Bearing housings or assemblies shall be provided with seals and self-aligning features, if appropriate, to prevent the ingress of dirt and water and/or accommodate misalignment.

V. Lubrication points on bearing housing containing sealed for life bearing shall be fitted with caps to prevent inadvertent bearing re-grease.

VI. Where sealed for life bearings are not provided, Automatic grease dispensers shall provide a clear indication of grease contents. The minimum capacity/life of the automatic grease dispensers shall be as specified in the tender.

VII. Lubrication points on bearing housing shall be readily accessible without the need to remove guards or covers. If lubrication points are not readily and safety accessible, they shall be connected via lubrication pipework which are readily accessible lubrication points, installed on a common battery plate. The

spacing of the lubrication points on the battery plate shall allow the retrofitting of automatic grease dispensers if required.

VIII. The requirement for lubrication pipework shall be as follow as minimum:

i. It shall be 316 stainless steel or if greater flexibility is required, a suitable polymeric material shall be proposed to engineer for approval

ii. It shall be minimum bore of 6mm and maximum length of 2 m

iii. It shall be adequately supported to prevent excessive sagging or distortion and if necessary, be protected against vibration (e.g. vibration loops)

IX. Where sealed for life bearing are not provided, the method of bearing re-greasing shall be proposed for ENGINEER approval. Lubrication points on bearing housing containing sealed for life bearing shall be fitted with caps to prevent inadvertent bearing re-greasing.

X. Automatic grease dispensers shall provide clear indication of grease contents, The supplier shall provide the first fill of lubricants to all components / system requiring lubrication. All bearings and lubrication pipework shall be fully charged with grease.

XI. Alemite grease fittings or equivalent shall be provided at locations accessible from the operating floor for the lubrication of all moving parts of the compactor

1.26.4 Gears and Gear Drives

(a) Unless otherwise specified, gears shall be of the helical or spiral-bevel type, designed and manufactured in accordance with AGMA Standards, with a minimum service factor (thermal and mechanical) of 1.7, a minimum L 10 bearing life of 100,000 hours and a minimum efficiency of 94 percent.

(b) Gear speed reducers or increasers shall be of the enclosed type, oil- or grease-lubricated and fully sealed, with a breather to allow air to escape but keep dust and dirt out. The casing shall be of cast iron or heavy-duty steel construction with lifting lugs and an inspection cover for each gear train. An oil level sight glass and an oil flow indicator shall be provided and installed for easy reading.

(c) Gears and gear drives as part of an equipment assembly shall be shipped fully assembled for field installation.

(d) Material selections shall comply with AGMA values and the manufacturer's recommendations. Input and output shafts shall be properly designed for the service and load requirements. Gears shall be computer-matched for minimum tolerance variation. The output shall have two positive seals to prevent oil leakage.

(e) Oil lubricated gearbox shall be fitted with oil filling and drain points and where appropriate, an oil breather and /oil level indicator. Oil level and drain location shall be readily accessible.

(f) The oil filling and drain points shall be designed so that oil can be easily drained and replaced without spillage.

(g) Where gear drive output shafts connect to couplings or sprockets, the gear drive manufacturer shall supply matching key.

(h) The gearbox type, number of stages, manufacturer, service factor and final drive ratio shall be stated in the submitted date sheet.

(i) All gears shall run in oil, and oil pans shall have means for fillings and draining the oil without dismantling any of the screen components. Bearings:

I. Bearings shall conform to the standards of the Anti-Friction Bearing Manufacturers Association, Inc. (AFBMA).

II. Except where otherwise indicated, bearings of process equipment shall have a minimum L-10 life expectancy of 100,000 hours.

1.26.5 Guarding and covers

(a) The screen shall be fitted with all necessary guarding and covers and shall be 316 stainless steel as minimum unless specified.

(b) Guarding shall comply BS EN ISO 12100 and BS EN 953 or equivalent

(c) If access is required to components for process correction or maintenance, mobile guards shall be used if the foreseeable frequency of access is high. Movable guards shall be interlocked in accordance with BS EN 1088 or equivalent.

(d) Components that may require regular access of maintenance or condition monitoring shall be accessible without removing guards by mean of access door or access hatches with padlocking and stainless steel, quick release fixings.

(e) All equipment shall be “lock out” to prevent automatic starting prior to any covers or guards being removed.

1.26.6 Odour Containment

(a) Suitable flanged connection to odour control ducting system shall be provided unless specified otherwise.

(b) Hinged panel shall be provided if specified. It shall be ease of access for inspection and maintenance. The hinged panel shall be air tight to prevent odour air escape and shall be interlocked with motors.

(c) The containment cover/ panel shall be fully comply with General specification Odour Containment Cover.

1.26.7 Products

In additional to the general requirement which stated in this specification, each individual type of the compactor shall be fully complied with the following as minimum:

(a) Dewatering compactors

I. The design of the screw compactor shall be such that the compacted screening materials shall have the following % reduction as minimum:-

a) Moisture reduction 50%,

b) Volume reduction 70%

c) Weight reduction 65 %

2) The screw compactor shall consists of inlet zone, compacting zone and discharged zone

3) The screenings shall enter the inlet hopper where it is may be washed and then transported and compressed by the screw conveyor and discharged. As the screenings are compressed, the liquid drains out and discharge back to inlet channel.

II. The dewatering compactor shall incorporate facilities to allow effective drainage if wash water (if required) and liquid generated in the compaction zone.

III. The inlet zone

a) The inlet of the dewatering compactor shall be designed to accommodate screenings volumes higher than the transportation capabilities of the conveyors which feed the compactor. An access cover shall be provided in the inlet for maintenance purposes or for the manual clearing of blockages.

b) The inlet zone shall be design suitable for the inlet hopper for receiving the screening materials.

c) Spray system to wash the screenings shall be provided at the inlet zone if required and shall be fitted before the compaction zone.

d) Unless otherwise specified, the sheet steel components of the screw compactor shall be stainless steel 316 as minimum.

IV. Drainage and Compactor zone

a) As the screw rotates it conveys screenings up to the compacting zone. As the screw rotates the material, gravity and the surface friction react to force the water from the screenings. All water content shall be discharge back to headwork channel.

b) The screw conveyor shall provide all motive force necessary to push the compacted screenings material through to the discharge chute.

c) The screw conveyor shall not extend into the screenings discharge chute.

d) The screw conveyor shall be helical shaft screw and shall be designed to withstand the subjected torsional forces impose during the operation condition.

e) The screw conveyor shall be bi-directional rotation to remove any blockages.

f) The screw conveyor shall have easily replaceable bearing shoes on the leading edge which shall support he screw through the trough and keep drain holes clean.

g) Lower bearing shall be enclosed in a watertight assembly suitable for submerged operation in grit service and the bearing life shall according to general requirement as above.

h) The bearing shall support the screw through the trough and keep drain holes clean. The bearings shall be designed to withstand the thrust forces imposed.

i) Local inching facility shall be provided for release blockages.

j) Local control panel shall be provided and shall be fully accordance with Electrical specification.

V. Conveying zone

a) Compacted screening material shall be automatically discharge from the discharge chute and to the screening silo for disposal off site.

b) The discharge chute shall be design and suitable for discharge the compacted materials to the conveyor for disposal off site.

VI. Wash water system

a) If specified, a washwater connection and spray bar shall be provided before the compaction zone to improve separation of faecal solids from the screenings materials.

b) The pipework and nozzles shall be 316 stainless steel and incorporate sufficient unions to allow easy dismantling for maintenance and replacement.

c) Plant water (Wash water) supply pipes with a suitable non-clogging stainless steel nozzles shall be provided for washing the screen trays. The nozzles shall be arranged to direct fan-shaped, over-lapping sprays across the full width to ensure full washing of the trays. All Pipe work and fittings shall be of stainless steel.

d) Nozzle diameters shall be sized adequately and suitable for the specified wash water supply to prevent blocking

e) Auto backwash strainer / filter for the plant water (washwater) source shall be installed if necessary and required to prevent blockage of the nozzles. Auto changeover basket filter shall not be used.

f) Spray bar shall be adequately supported and shall be positioned to minimise the accumulation of screenings on their surface.

g) Spray bars shall be removable from the outside of the compactor's support structure to permit maintenance

h) The plant water (washwater) pipe shall be extended outside of the head housing and shall be fitted with a control valve. The control valve shall be tight shut-off type suitable for flanged connections and complete with weatherproof electric motor actuator or solenoid valve as appropriate. The valve shall be full bore, quarter turn and shall be actuated ball valves unless otherwise specified. Suitable strainer / filter shall be provided for the washwater to avoid blockage of the solenoid valves.

(b) Washing Compactor

I. The washing compactor is processing the wet screening in two stages, washing and conditioning stage and compaction stage.

II. The washing compactor requirement are same as dewatering compactor with additional of washing and conditioning stage.

III. The washing and conditioning stage consists of a pump located in the washing conditioning zone which thoroughly agitates and disintegrate the screenings in the washwater so that the content of the conditioned screening material can be transfer to the compaction zone.

IV. The screw conveyor shall be same dewatering compactor as specified above. Shaftless screws conveyor are not acceptable as shaft is required to support flight and provide necessary torque and compaction.

V. Access cover shall be provided for inspect and rotate the bearing without disassembling the equipment.

VI. The wash water system which flush the separated organic material through the drainage basket/section in solution or as small particles or as part of the washing conditioning stage shall be accordance with washwater section of this specification.

VII. The compacted screenings shall be pushed through the compaction zone and the dewatered screenings shall be discharge in into an outlet chute.

1.27 Conveyors

1.27.1 General

(a) This specification cover the general requirement of the performance, design and construction of the conveyors system in used water (waste water) application with all relevant statutory regulations and the latest edition of all relevant international, harmonised European and British Standard and Indian standard and code of practices. This specification shall also comply with:-

(i) The specific data sheet

(ii) The relevant process specification.

(iii) The relevant Electrical specification

(iv) The relevant Instrumentation Control and Automation (ICA) specification.

(b) The equipment shall be provided with electric drive, wash water spray, control panel, anchor bolts, and all accessories and appurtenances specified, indicated on the drawings, or otherwise required for a complete and properly operating installation.

(c) All equipment furnished shall be fabricated and assembled in full conformity with drawings, specifications, engineering data, instructions and recommendations of the equipment manufacturer, unless otherwise specified.

(d) The proposed conveyors shall be selected taking into consideration its suitability and fit for use in environment and service conditions intended.

(e) Should anything be omitted from this Specification or other Contract Documents which is necessary for a clear understanding of the Works, or should it appear that various instructions are in conflict, the Contractor shall secure written instructions from the employer engineer before proceeding with the Works affected by such omissions or discrepancies. It is understood and agreed that the Works shall be performed and completed according to the true spirit, meaning, and intent of the Contract Documents.

(f) Should there any conflict between the General Specification and the Particular Specification, the particular specification shall take the precedence and Contractor shall inform the engineer for further conformation prior to the Works proceeding further.

1.27.2 Layout

The Contractor shall propose the layout area together with the manufacturer's layout drawings, and installation requirements to ensure proper installation subject to the approval of the engineer.

1.27.3 Submittals

The Contractor shall provide complete fabrication and assembly drawings, together with detailed specifications and data covering materials, power, drive, assemblies, and accessories forming a part of the equipment supplied. The data and specifications for each unit shall include, but shall not be limited to, the following:

Outline and assembly drawings of all furnished equipment. These drawings shall include:

1) Diameter, number and location of anchor bolts; thickness of metal through which bolts must pass and torque data.
2) Identification, size, rating, and location of all instrument and electrical connections.
3) Overall dimensions and estimated weights of all furnished equipment
4) General arrangement drawing of the conveyors indicating the designation overall dimension/ footprint and typical layout of key components systems. The drawing shall indicate the minimum clearance distance required for the removal of component for refurbishment or replacement with the conveyor in situ.
5) Components / system schedule manufacturer and all relevant technical specification including details of materials for each major components / system.
6) Component drawings showing detail of construction.
7) Wiring diagrams which show internal wiring, external connection wiring, and interconnection wiring requirements. Manufacturer shall indicate the power supply and control power supply requirements.
8) List of all instruments and controls, along with function, included with the screen system.
9) Typical control philosophy
10) Typical testing and commissioning plan and procedures

1.27.4 Design Requirements

(i) The equipment shall be able to convey sludge, screenings, slurry, or any other media in a neat, quiet, dependable, and nuisance-free manner as specified in particular specification.

(ii) The equipment furnished shall have adequate capacity to convey the specified quality of materials without failure.

(iii) The maximum capacity of the system shall exceed the peak loading design capacity to avoid any overflow or over spillage.

(iv) The equipment shall be able to operate 24 hours per day, at specified operating conditions.

(v) The equipment and their drives must be able to start when loaded to maximum capacity with the material conveyed.

(vi) When in operation, no piece of equipment shall exceed 85 dB (A) measured 1m away from the equipment.

1) Installations and equipment shall be easy to maintain and keep clean. The equipment shall be capable of withstanding a daily wash down using high pressure water.

2) Each conveyor shall be assemble to the greatest extent possible in the manufacturer's shop to insure proper fitting of parts. Assembled sections shall then be match-marked for field erection and disassembled prior to shipment. Deliveries shall be shipped in the maximum shipping lengths permitted.

(vii) Weight for each major heaviest component shall be submitted in the tender. The lifting strategy for maintenance and erection of these heaviest components shall be stated clearly in the tender. Components weight over 25kg that are likely to be removed for maintenance shall either:-

1) Incorporate clearly identified, permanent, lifting points located to give a safe balance lift or;

2) Be designed in such a way that standard lifting accessories (e.g. slings) can easily be attached.

3) If lifting points are not designed for lifting the complete component, they shall be clearly marked accordingly.

4) The complete unit shall include all necessary permanent safety device such as machinery guards, emergency stop and similar items required by local health and safety regulations.

5) Material selection for the conveyor system shall be accordingly to the media characteristic and the expected services lives of the specific type of conveyor components.

(viii) An inlet hopper shall be provided at the feed end, and a discharge chute equal to the full trough width shall be provided at the point of discharge.

(ix) Electric motors and electrical works shall comply with the electrical specifications.

(x) To minimise the friction and wear, conveyor component combinations that are likely come into contact and be subject to relative motion shall be adequately lubricated for manufactured from materials with self-lubrication properties.

(xi) All metallic items (such as fixing and fixtures etc.), which are routinely wetted or submerged or immersed in by wastewater shall be made of stainless steel 316 L unless otherwise specified. If stainless steel is unsuitable for use, an alternative corrosion resistance materials shall be proposed and approved by engineer.

(xii) The conveyor system shall be designed to accommodate the media volumes higher than transportation capabilities of the conveyor.

(xiii) Access cover for maintenance purposed and the provision of flange connection to the odour extraction pipeline shall be provided.

(xiv) Conveyor inlet and outlet openings shall be designed to avoid Choking and blockage.

(xv) Outlet slide gated shall be provided where specified in particular specification. The slide gate shall be electrically operated with manual operated override unless specified. The pneumatically or hydraulically actuated slide gate can be proposed to ENGINEER for approval. Limited switches shall be provided for the actuated gate.

1.27.5 Supporting Structure and Frame Structure

(i) The conveyor shall be of high quality and robust design for construction which, as a whole, will ensure satisfactory operation at all times under the conditions specified.

(ii) There shall be no projecting set screws or other parts to endanger workers. All devices required for compliance with local safety laws shall be provided.

(iii) Sharp corners of all cut or sheared edges shall be smoothed by power grinders.

(iv) The support structure shall be constructed from corrosion resistance materials or protected against suitable corrosion protection system. This shall be submitted and approved by engineer.

(v) The support structure shall be robust design and locally reinforced around foundation bolt holes. Adequate brace shall be provided to ensure rigidity under all operating condition. The supporting structure shall be design and endorsed by PE and the detail design with endorsement shall be submitted to S.O for approval.

(vi) All metal fabrications (i.e. frames, support structures etc.) shall be designed to prevent the collection of liquids and debris and, if appropriate, facilitate the application of paint systems and protective coatings.

(vii) All wetted, steel fabricated (frames, supports structure etc.) shall be continuously welded to prevent moisture traps. The end of all mild steel sections shall be sealed, to prevent ingress of liquids, after corrosion resistant coatings have been applied.

(viii) All metal fabrications shall be designed and assembled to avoid galvanic corrosion. If necessary, insulating washers ad sleeves shall be used to prevent direct contact between dissimilar metals,

(ix) All galvanising shall comply with BS EN ISO 1461.

(x) All shafting or belt shall be of ample size and provided with suitable bearings for the service required. Suitable means for making adjustments on parts subject to wear shall be provided.

(xi) Discharge trough which connected to the conveyor system shall be equipped with filling and/or discharge chutes, as required. Chutes shall be of welded construction and be fabricated from at least 3mm thick Type 304/316 stainless steel. The juncture of all joints in plates shall be continuously seal welded inside and out so that chutes are watertight. External stiffening ribs shall be provided as required limiting stresses and deformation in plates during shipping, installation, and operation.

(xii) The external surface of the trough and other exposed stainless steel surfaces shall have glass-bead blasted surface finishes.

(xiii) All conveyor support shall be based on the loading from a completely filled trough, weight of conveyor, and dynamic loading when operating.

(xiv) Supports shall not restrict access to other process systems.

1.27.6 Drive and gear box mechanism

(i) Each screw conveyor shall be driven by an electric motor connected to a gear reducer. Torque limiting coupling sensors and current monitoring facility shall be provided as mechanical overload protection devise to protect and prevent damage to the spiral and motor due to jammed materials, overloading conditions etc.

(ii) Motor power shall be as determined by the conveyor manufacturer to be adequate to drive the equipment under all operating conditions, and shall be at least 10 percent higher than the power required at the maximum operating point. Motor speed shall not exceed 1500 rpm.

(iii) The motors may be mounted horizontally relative to the screw centreline. Where space dictates, motors may be mounted vertically.

(iv) All necessary supports for the conveyors and the drive actuator shall be provided by the manufacturer with the conveyor.

(v) All drive system components shall be adequately supported.

(vi) All drive system shall be designed to withstand the maximum torque generated by the drive system.

(vii) Local control facility shall be provide for release and clean blockages.

(viii) Unless specified, the method of power transmission shall be closed coupled. Chain and Belt could be considered if applicable and shall subjected to engineer for approval.

1.27.7 Gearbox and Lubrication Mechanism

(i) The gear reducer shall be mounted to the conveyor end. The drive system shall be designed for starting the conveyor fully loaded. Drive size shall be as recommended by the manufacturer.

(ii) Oil lubricated gearbox shall be fitted with oil filling and drain points and where appropriate, an oil breather and /oil level indicator. Oil level and drain location shall be readily accessible.

(iii) The oil filling and drain points shall be designed so that oil can be easily drained and replaced without spillage.

(iv) Where gear drive output shafts connect to couplings or sprockets, the gear drive manufacturer shall supply matching key.

(v) The gearbox type, number of stages, manufacturer, service factor, and final drive ratio shall be stated in the submitted data sheet.

(vi) Unless otherwise specified, gears shall be of the helical or spiral-bevel type, designed and manufactured in accordance with AGMA Standards, with a minimum service factor (thermal and mechanical) of 1.7, a minimum L-10 bearing life of 100,000 hours and a minimum efficiency of 94 percent.

(vii) The gear reducer housing shall be cast iron with removable inspection covers, oil breathers, oil level indicators and oil drain plugs.

(viii) Gear reducers that are shipped from the factory without an initial factory oil fill shall be adequately treated or coated before shipment to protect the units during shipment and storage. Prior to installing the units, they shall be drained, flushed, and filled with oil.

(ix) All lubrication points shall be piped to a location accessible from a maintenance walkway and must be clearly labelled.

(x) All gear reducers shall be commercially built, to minimum Quality Class No. II per AGMA Standard 390.03 Gear Classification Manual. Gear reducers shall be single or double reduction, helical gear units with high capacity roller bearings. Gear shall be made of alloy steel, protuberance hobbed, gas carburised, oil quenched hardened, steel shot peened and ground, with a surface hardness after grinding of Rockwell RC-60 or greater and meeting the requirements of AGMA Standard

(xi) Gear reducers shall be suitable for the loading conditions imposed on the input shaft in the mounting arrangement. The gear reducers shall be suitable for continuous duty service with moderate shock loading and sized at the gear reducer's output shaft speed for not less than the greater of:

(xii) 1.5 times the brake power at the gear reduced output shaft or,

(xiii) 1.2 times the name plate motor power of the drive motor.

1.27.8 Bearing and lubrication

(i) Bearings shall conform to the standards of the Anti-Friction Bearing Manufacturers Association, Inc. (AFBMA).

(ii) Except where otherwise specified, bearings of process equipment shall have a minimum L-10 life expectancy of 100,000 hours.

(iii) Lubrication points on bearing housing containing sealed for life bearing shall be fitted with caps to prevent inadvertent bearing re-grease.

(iv) Bearings of all rolling elements of the conveyor shall be of the sealed-for-life type.

(v) Where sealed for life bearings are not provided, automatic grease dispensers shall provide with a clear indication of grease contents. The minimum capacity/life of the automatic grease dispensers shall be as specified in the tender. The supplier shall provide the first fill of lubricants to all components / system requiring lubrication. All bearings and lubrication pipework shall be fully charged with grease.

(vi) The automatic grease lubrication system shall be as following:

1) All grease lubricated bearings with grease fed from a central automatic lubrication system. Central lubrication system shall be provided by others. Contractor to co-ordinate single-point connection to central lubrication system.

2) Grease shall enter the conveyor through a high pressure stainless steel motorised valve .The valve shall be interlocked with the conveyor drive motor to open when the screw conveyor is operating.

3) Grease shall be injected into the bearings through a stainless steel, positive displacement type metering valve, adjustable and connected to the bearings with stainless steel tubing.

4) Lubrication piping on the screw conveyor shall be at least 15 mm 18 gauge stainless steel. All stainless steel tubing and piping shall be secured with stainless steel clips and screws.

(vii) Provide all grease lubricated bearings pre-packed with grease and with pipework and nipples for manual greasing. Greasing nipples shall be located for easy access from the floor or access platforms.

(viii) Lubrication points on bearing housing containing sealed for life bearing shall be fitted with caps to prevent inadvertent bearing re-greasing, where sealed for life bearing not provided, the method of bearing re-greasing shall be submitted to engineer for approval.

(ix) Bearing seal shall be equipped with a grease escape to prevent over pressurising of the bearing.

(x) Alemite grease fittings shall be provided at locations accessible from the operating floor for the lubrication of all moving parts of the screen except the chains, which shall be water lubricated. All gears shall run in oil, and oil pans shall have means for fillings and draining the oil without dismantling any of the screen components.

(xi) Lubrication points on bearing housing shall be readily accessible without the need to remove guards or covers. If lubrication points are not readily and safety accessible, they shall be connected via lubrication pipework which are readily accessible lubrication points, installed on a common battery plate. The spacing of the lubrication points on the battery plate shall allow the retrofitting of automatic grease dispensers if required.

(xii) The requirement for lubrication pipework for roller element bearings shall be as follow as minimum:-

1) It shall be stainless steel or if greater flexibility is required, a suitable polymeric material shall be proposed to engineer for approval

2) It shall be minimum bore of 6mm and maximum length of 2 m.

(xiii) It shall be adequately supported to prevent excessive sagging or distortion and if necessary, be protected against vibration (e.g. vibration loops)

1.27.9 Guarding and covers

(i) Guarding shall comply BS EN ISO 12100 and BS EN 953 or equivalent.

(ii) If access is required to components for process correction or maintenance, mobile guards shall be used if the foreseeable frequency of access is high. Movable guards shall be interlocked in accordance with BS EN 1088 or equivalent.

(iii) Hinged door /guards that open in an upwards direction shall be provided with supporting stays.

(iv) The hinged door guard shall be provided with full length, stainless steel, Piano type, two pin hinges.

(v) Components that may require regular access of maintenance or condition monitoring shall be accessible without removing guards by mean of access door or access hatches with padlocking and stainless steel quick release fixings.

(vi) All equipment shall be "lock out" to prevent automatic starting prior to any covers or guards being removed.

(vii) Suitable flanged connection shall be proved along the cover for the connection of the odour control duct as specified in the relevant specification.

(viii) The conveyor shall be provided with a number of permanently secured, open mesh viewing panels, to allow inspection of internal components while the conveyor is operational. The mesh panel shall be sized for finger protection to BS EN ISO 13854 or equivalent and be provided with hinged / quick release solid, sealed covers,

1.27.10 Odour air extraction

(i) Provide suitable flanged connection for odour air duct on the conveyor cover.

(ii) The containment cover shall be fully accordance with General specification Odour Containment Cover.

1.27.11 Local control panels

(i) Each conveyor shall come with a local control panel unless specified. The local control station shall incorporate all necessary components (e.g. selector switches, pushbuttons, lamps, and indicators etc.) and control systems to provide the following functions, as a minimum:

1) Automatic and manual control of the conveyor

2) Local and remote indication of the operational and/or fault status of the conveyor

3) Interlocking of adjacent drives, as required

4) Controlled restart of the conveyor after mains failure

5) Latching and/or reset of all conveyor protection and emergency stop systems

(ii) The local control station and its associated electrical installation shall comply with the relevant specifications.

(iii) Each conveyor shall be furnished with emergency trip cord and trip switch as part of emergency stop system as specified above.

(iv) An emergency stop system shall be provided fully accordance to the electrical specification. It shall comprise stop push buttons of the `mushroom' head stay put type for short length conveyors and for long conveyors the emergency stop shall consist of a lanyard trip wire system running the full length of the conveyor.

(v) The lanyard shall comprise an orange nylon rope supported in stainless steel eyes, anchored at one end and connected to a position limit switch in the emergency stop circuit.

(vi) The safety trip wire shall be provided along both sides of each conveyor. Trip switch shall immediately stop conveyor when trip wire is pulled.

1.27.12 Accessories

(i) Equipment Identification Plates: Provide 2mm thick, Type 316 stainless steel identification plate securely mounted in a readily visible location on each separate equipment component and control panel(s). Plate shall bear 10m high engraved block type black enamel filled equipment identification numbers and letters. The nameplate shall state, as a minimum, the following:

1) Manufacturer and date of manufacturer

2) Model Nº

3) Serial Nº

4) Power rating for the drive

5) Pressure Rating of power Pack if applicable

6) Major Component Weights

(ii) Lifting Lugs: Provide for equipment and components weighing over 40kgs.

1.27.13 Belt Conveyor

(i) The belt conveyor shall be complete with flat rubber belt, carrying idlers, return rollers, head and tail drums, side guards, loading end guards and adjustable support legs, etc., suitable for the application and environment as specified in the particular specification.

(ii) Fixed troughed belt conveyors shall be designed and constructed in accordance with BS 8438.

(iii) Where mobile or portable troughed belt conveyors are required these shall be designed and constructed in accordance with BS 4531.

(iv) The design load used for designing the carrying idler sets shall be on the full cross sectional capacity of the conveyor, taking into account the belt troughing angle, media characteristics, and pitch of the carrying idler sets. This design load shall also take into account any impact loads imposed on the belt.

(v) The whole conveyor system shall be mounted on a steel support frame. Metal surfaces shall be galvanised after fabrication and painted in accordance with the relevant specification.

(vi) A chute shall be provided to direct media from the discharge point of the upstream process / piece on to the tail (inlet end) of the conveyor. Without spillage.

(vii) A scraper, consisting of a spring loaded, flexible rubber blade, or other approved device shall be provided to discharge media from the head (discharge end) of conveyor into the downstream process/piece of equipment.

(viii) Where inclined conveyors are required, the angle of inclination shall not exceed 300 unless otherwise specified.

(ix) Where specified, conveyors shall be reversible.

(x) The belt shall be supported by sufficient number of roll idlers located at the centre spacing to ensure that belt sag does not exceed 2% of belt span when transporting the maximum transported media volume rate. A take-up device shall be incorporated at the non-drive end to adjust belt tension automatically.

(xi) The pitch spacing of the idlers at the loading point shall be reduced to half the normal pitch.

(xii) Return idlers shall be spaced at intervals not exceeding 2.0 m.

(xiii) The carting and return idlers shall be protected against the ingress of rags, grit , dust and dirt and other debris from the media and as far as practicable.

(xiv) Provision shall also be made in the design of the conveyor for adjustment of the tail pulley of the conveyor to ensure squareness of the belt.

(xv) The Belt

1) The belt shall be manufactured in accordance with BS ISO 251 or BS EN ISO 14890 or equivalent.

2) The usable width of the belt conveyor shall be not less than 500 mm. The conveyor shall incorporate a troughed belt having a width and running speed sufficient to remove the maximum amount of materials to be deposited on to the conveyor.

3) The belting material shall comply with the requirements of ISO 14890 and the belt edge clearance shall be in accordance with BS 8438 and shall be oil resistance.

4) Where necessary conveyors shall be fitted with side plates to ensure the materials deposited are retained on the belt. A drip tray shall be fitted below the belt to collect and return liquors to the sewage flow or site drainage system.

5) A counter balanced scraper shall be provided at the discharge end having a renewable rubber blade arranged to remove all materials adhering to the belt face.

6) Where the conveyor is required to be designed for chemical powder conveyance, it shall be able to contain all the chemical powder from the chemical bags so that no chemical powder would fall from the conveyor belt onto the floor during operation.

7) The belt speed shall be designed to match the capacity of the bag splitting machine. However, in no circumstances a belt speed greater than 18 m/min shall be accepted.

8) In the design of belt speed, the inclination of the belt conveyor shall be taken into account, and slatted belt instead of flat belt shall be used if the inclination of the belt conveyor together with the designed belt speed may render the chemical bags to slide down or tip over from the conveyor.

(xvi) Drive mechanism

1) The belt drive shall consist of an electric motor transmission and drive pulley. The transmission shall incorporate a reduction gearbox, direct coupled to the motor and with a chain and sprocket drive to the drive pulley.

2) Each conveyor shall be driven by a geared electric motor which shall be integral with the head drum. The motor shall have a degree of protection of IP 55 to BS EN 60034-5 and its design shall be suitable for intermittent operation. A mechanical overload protection and anti-run-back device shall be provided.

3) The drive pulley shall be crowned, and shall comply with the dimensions specified in the appropriate British Standard.

4) A snub pulley shall be provided to ensure adequate belt wrap on the drive pulley.

5) The internal drum drive shall incorporate a proprietary, non-slip coating on the drum to prevent slippage between the drum and belt.

(xvii) Condition monitoring and protection

The minimum condition monitoring and protection requirement in additional to general electrical and instrumentation and control automation specification are as following:-

1) Belt wear monitoring system

2) A belt tension monitoring system

3) A drive system overload protection system

Unless specified, Volt free contact shall be provided for the transmission of alarm signals.

1.27.14 Shafted Screw Conveyors

(i) The conveyor shall comprise a shafted screw running in an enclosed “U” section tough.

(ii) The conveyor shall be fixed or mobile as per particular specification required. If mobile conveyor is required the extent of movement shall be accordance with particular specification.

(iii) Screw conveyors shall be designed for horizontal, inclined or vertical application as required.

(iv) The equipment furnished shall have adequate capacity to convey the specified quality of materials without failure and without exceeding 70% active trough area.

(v) Fixed screw conveyors shall be designed and constructed in accordance with BS 4409 Part 1.

(vi) Where mobile or portable screw conveyors are required these shall be designed and constructed in accordance with BS 4409 Part 2.

(vii) Unless specified, the maximum allowable conveyor speed shall be 25rpm or 0.9 m/s whichever is the lower.

(viii) The conveyor shall incorporate expandable grease filled type shaft seals, which can be easily be recharged with grease by maintenance personnel.

(ix) For conveyors which handling screenings shall be designed to allow for any liquid entrained with the screenings to be returned to the main flow via a drain pipe at the bottom of the steel trough. Details requirement shall refer to Particular specification and Screening Handling general specification.

(x) Conveyor Troughs:

1) Trough bodies shall be minimum 5 mm, Type 316L stainless steel plate, rolled to shape. Trough flanges shall be minimum 5 mm thick, Type 316L stainless steel rolled with or welded to the trough. Unflanged trough sections shall not exceed 3 metres in length. Internal bolted stiffeners, where required, shall be minimum 5 mm, Type 316L stainless steel, and shall not interfere with material conveyance.

2) Trough cover:-

i. Sufficient rigid construction to ensure that permanent cover distortion does not occur during their removal /replacement, with a minimum thickness of 2mm.

ii. Maximum length 1500mm unless specified.

iii. Fixed covers requiring frequent removal / replacement shall be provided with a minimum screw fasteners with captive nuts. Studs. Cover shall be stainless steel 316L plate. Covers shall be gasket and attach to the conveyor trough with stainless steel bolts.

iv. Hinged or quick release covers shall be interlocked.

v. They shall be effectively sealed to prevent the escape of odours. The seal / gasket materials shall be compactable and resistant to the liquid/material that are likely to be present in the conveyor operating environment.

vi. Cover sealing gaskets shall be arranged so as to prevent accidental displacement during over replacement.

vii. Handles to facilitate manual handling the cover shall be provided if specified.

viii. The trough shall incorporate flanged ends bolted covers.

ix. Type SS 316L flushing inlets and drain outlets shall be welded on the trough. Welded to the trough. Size of inlets and outlets shall be as manufacturer’s design.

3) Conveyor troughs shall be complete with saddle type supports shaped to the profile of the screw conveyor trough and extending to a common fixed distance to the centreline of the screw. Supports shall not exceed 3.5 metres centre to centre.

4) End plates shall be minimum 10 mm thick, Type 316L stainless steel plate welded across ends of the trough.

(xi) Discharge Chutes:

1) Chutes shall be designed to collect and/or convey the material without spillage, leakage, or material build-up.

2) Chutes shall be fabricated from minimum 6 mm, Type 316L stainless steel plate. Connections shall be flanged and gasket, with 6 mm thick x 68 mm wide flanges.

3) Drop chutes longer than 500 mm, between connection flanges, shall include gasket flanges and at least four handles shall be provided on each chute section to facilitate removal. Handles shall be 13 mm diameter O rod, Type 316L stainless steel formed and welded to the sides of the section. Drop chute sections shall not exceed 2.5 metres in length or as approved by the ENGINEER.

4) Neoprene gasket or equivalent or better shall be provided to entire top face of trough top flange and stiffeners.

(xii) Washwater System

1) Where washwater system specified, the washwater connection, and spray nozzle shall be provided with the following as minimum:-

x. The pipework and nozzles shall be manufactured from corrosion resistant materials, such as stainless steel 316 and incorporate sufficient unions to allow easy dismantling for maintenance and replacement.

xi. Plant water (wash water) supply pipes with a suitable non-clogging stainless steel nozzles shall be provided for washing the screen trays. The nozzles shall be arranged to direct fan-shaped, over-lapping sprays across the full width to ensure full washing of the trays. All Pipe work and fittings shall be of stainless steel.

xii. Nozzle diameters shall be sized adequately and suitable for the specified wash water supply to prevent blocking

xiii. Auto backwash strainer / filter for the plant water (washwater) source shall be installed if necessary and required to prevent blockage of the nozzles. Auto changeover basket filter shall not be used.

xiv. Spray bar shall be adequately supported and shall be positioned to minimise the accumulation of screenings on their surface.

xv. Spray bars shall be removable from the outside of the compactor’s support structure to permit maintenance

xvi. The plant water (washwater) pipe shall be extended outside of the head housing and shall be fitted with a control valve. The control valve shall be of the tight shut-off type suitable for flanged connections and complete with weatherproof electric motor actuator or solenoid valve as appropriate. The control valve be full bore, quarter turn, actuated ball valves type unless otherwise specified. The strainer / filter shall be provided if necessary for the wash water to avoid blockage solenoid valves.

xvii. Horizontal extension and ball valve shall not present a tripping hazard.

(xiii) Conveyor Screw

1) Conveyor screws shall be sectional flight, stainless steel316L, 8 mm minimum thickness. Flights shall be fastened to the rotor by full and continuous welds on both sides of the flight.

2) Rotors shall be 316L stainless steel tubing of sufficient wall thickness to give a maximum deflection of 2.4 mm between any two bearing support points. Each length of rotor shall be 3 metres or less in length and made from single-piece tubing and not fabricated with butt-welding of two sections of tube. The end faceplates of the tube shall be a welded plate no less than 25 mm thick, drilled and tapped for bolted flanged connections. Flanges shall have a 3 mm or greater register relief fit matching the adjoining flange face.

3) Bolts, nuts, and washers used to attach the rotors to intermediate drive and end bearing shafts shall be stainless steel, hex head, and flat washers.

4) Spiral Fighting

i. Fighting shall be fabricated from stainless steel 316L. Design spiral flights with the stability to prevent distortion and jumping in the trough.

ii. Flights shall be of uniform thickness, formed to the pitch of the screw flight within plus or minus 4 mm.

iii. At its torsional rating, the stress in the spiral flighting shall not exceed 30 percent of the yield strength value in the extreme fibre of the flight material.

iv. At 250 percent torque of the motor nameplate kilowatt rating, the drive train shall not produce more torque than 250 percent of the spiral flighting's torsional rating.

(xiv) Conveyor supports:

1) Support Loads shall be based on completely filled trough, weight of the conveyor, and dynamic loading when operating.

2) Co-ordinate support locations with facility structure. Supports shall not restrict access to other process systems.

3) The supports shall be designed in conformance with the AISC Manual of Steel Construction, and AISC Specification for the Design, Fabrication, and Erection of Structural Steel for Buildings. Limit maximum total deflection to less than 1/300 of span. Supports shall be adequately braced to carry all horizontal loads. The supporting system shall be design and endorsed by PE.

4) The flange, webs, legs, or wall thickness of support framing shall not be less than 6 mm. Use tubular steel, pipe, flat bar or other members that provide a clean design which will minimise dust ledges and pockets.

5) The supports shall be shop fabricated of structural carbon steel conforming to ASTM A36. Steel plate shall conform to ASTM A36, or A283. Bolts shall conform to ASTM A325. All bolts and appurtenances necessary for conveyor and hopper system erection, including anchor bolts, shall be supplied by the Contractor. Suitable anti-corrosion protection system which suitable the application environment shall be proposed for SO approval.

(xv) Intermediate Bearing Assemblies:

1) Intermediate bearing assemblies shall include bearing housings, bearing supports, bearing spacers, seals, stub shaft with flanges, locking nuts, retaining clips, multi-ring flexible coupling, grease lubrication lines, and all interconnecting bolts and fittings. Intermediate bearing assemblies shall be all Type 316L stainless steel.

2) Flexible coupling shall be all stainless steel 316L construction to accommodate the flexible action required at the intermediate bearing. Coupling shall interconnect the intermediate bearing stub shaft and screw shaft flange. Flexible connection shall not involve the use of plastic or elastomers to achieve the flexible action. Multiple ring flexible coupling bolt holes shall have internal sleeve liners to prevent bolt thread engaging the multiple ring coupling during installation or operation. The clamping surfaces of the interconnecting bolt holes shall be reinforced to prevent damage to the multi-spring assembly from fittings or torque loadings during operation. Non-metallic materials are unacceptable.

3) Bearing housing shall be fabricated from stainless steel 316L and designed to accommodate bearings, seals, stub shaft, and connection to bearing housing support. Bearing housing shall be fabricated as two sections to centrally support the bearing and seals, permitting removal of the complete intermediate bearing assembly, without the removal of the adjoining rotor centre tubes, shafts, or bearings.

4) Intermediate bearings may be supported by a hanger. Bearing housing supports shall be fabricated from stainless steel 316L as a single unit. Support shall be fabricated from box and channel sections. Mounting flanges shall be provided for intermediate bearing housing and conveyor trough. Bearing hanger shall be supported by both sides of conveyor trough through a minimum 6 mm thick support bracket bolted through to trough.

5) Stub shaft shall be used to connect adjacent rotors. Stub shaft shall be stainless steel 316L. Stub shaft shall have end flanges for connection to adjacent rotors. Flanges shall be 170 mm diameter and 32 mm thick; all shall use six 16 mm interconnecting bolts and fittings. Flange face shall have a 100 mm diameter x 3 mm thick registered fit for connection of the rotor and stub shaft. The stub shaft shall be designed to be removable without removal of adjacent screw rotors, and shall be equipped with all appurtenances required for bearings, spacers, seals, locking rings, and retaining clips.

6) Provide spring-loaded lubrication retention mechanical seals on both sides of intermediate bearing to prevent sludge contamination of bearings and grease leakage into the conveyed sludge cake.

7) Bearing supports and bearing housing shall be fitted with an 8 mm diameter stainless steel 316L tubing grease lubrication line. Bearing housing shall be equipped with access ports allowing grease to enter the central bearing area of the bearing and seal assembly. Grease tubing shall be routed to prevent damage to tubing from conveyed material, and to prevent clogging or bridging of conveyed material.

8) The intermediate bearing shall be free-floating roller bearings, transmitting thrust to the thrust end fixed bearings.

(xvi) All other bearings and Lubrication shall be fully accordance to the general requirement of this specification.

(xvii) Bearings shall accommodate both torsional loads and misalignment and longitudinal movement in two directions due to thermal expansion and differential loadings of screw conveyor rotors both upstream and downstream due to material flow.

(xviii) Drive Mechanism

1) The screw conveyor drive shall consist of a close coupled motor and gear reducer trough end seal, and motor mount. The motor shall be protected to IP 56 as minimum.

2) Reducer shall be concentric shaft or combination helical gear and right angle bevel gear type. Reducer selection shall be based on continuous operation with a minimum 1.50 mechanical, 1.00 thermal, service factor as applied to the motor nameplate power. Gearing strength rating to catalogue rating ratio shall be 1.75 minimum and based on all applicable AGMA standards

3) Drive shafts shall be SAE 4140, 2025, ST 50, ST 60, C45, or equal. Shafts shall be complete with flanged ends and mating bolt holes to match the conveyor rotor flanged end plates.

4) Shaft shall be integral with the shaft flange as a single-piece forging or as a welded shaft-to-flange construction. Maximum torsional stress and maximum combined stress at full motor power shall be less than 40MN/m2 and 50MN/m2, respectively.

5) Reducer features shall include shielded grease purge seal cage to protect dual lip oil seals from the environment and accidental damage, breather assembly to prevent pressure build-up inside the unit, removable drive shaft assembly without removing unit from trough end, thrust plate assembly for gland seal system integral to the adapter for high temperature abrasive materials, all steel fabricated motor mount which shall bolt directly to the screw conveyor reducer. Reducer housing shall be cast iron.

6) The drive system shall be located at the feed end of the screw conveyor and function in a Pushing mode unless otherwise specified.

7) Drive shaft and sleeve shall be sealed with compression packing.

8) Stuffing boxes shall be cast iron completed with 12mm by 12mm nominal Teflon-impregnated packing rings. Two rings for horizontal and inclined conveyors shall be provided as a minimum. Provide a packing ring with each stuffing box to provide adjustment to tighten the packing onto the shaft. The packing ring housing shall be bolted to the screw conveyor trough end plate. Drive and non-drive shaft shall have wear sleeve in the area of the stuffing box. Stuffing boxes shall prevent the leakage of media such as sludge or washwater under all operating conditions.

9) Conveyor outside support bearings shall be spherical roller bearings, designed for a minimum 50,000 hour L 10 life mounted in cast iron pillow blocks. Bearings shall be mounted outboard of the stuffing box assembly, with sufficient clearance to permit removal of the stuffing box bolts, cover and repacking without having to remove the bearing housing or bearing from the housing. Fit each bearing housing with stainless steel grease tubing with fittings located in an easily accessible position at the floor or access platform level.

10) Conveyor thrust-carrying bearings shall be fixed location type, with spherical roller bearing mounted on the drive shaft, complete with bearing recess shroud.

11) Condition monitoring and protection

i. An inlet hopper high level sensor

ii. A wear plate/liner wear monitoring system

iii. A shaft rotation sensor, to detect shaft or drive failure. This shall monitor rotation at the non-drive end.

iv. A shaft misalignment sensor, to detect excessive bearing wear

v. A drive system overload protection system

vi. The wear plate/ liner monitoring system and shaft rotation sensor shall be positioned to avoid damage, if the shaft fails or becomes misaligned.

vii. Detect under speed or zero speed.

viii. Non-contacting motion sensing unit.

ix. Adjustable time delay for starting.

x. DPDT contacts rated 10 amperes at 230 V AC.

12) The location and mounting details of these sensor shall be as recommended by the conveyor manufacturer and approved by the engineer.

13) Motion sensors shall be the non-contacting type using a probe with pre-amplifier and main electronic assembly.

14) The probe shall be totally enclosed so it is impervious to dust and moisture. The pre-amplifier, if part of the probe, shall also be sealed. The probe shall be able to detect a moving ferromagnetic material from 25mm to 50mm away. The ferromagnetic material shall be sensed during each rotation of the conveyor spiral and the probe shall produce a voltage pulse. This pulse shall be processed by the pre-amplifier which is wired to the main electronic unit. The main electronic unit shall operate on 230 V, single-phase, 50 Hz power supply. A 0 to 60 second time delay shall be provided to allow start-up of the screw conveyor. The output shall be two dry contacts for remote alarm.

1.27.15 Shaftless Screw Conveyors

(i) Where applicable, design and construction of shaftless screw conveyor shall comply with the requirements of screw conveyors as stated above.

(ii) The conveyor shall comprise a shaftless spiral running in an enclosed trough.

(iii) The drive system shall be located at the discharge end of the screw conveyor and function in a Pulling mode.

(iv) Centreless Spiral screw

1) Centreless spiral flighting shall be provided with an outer spiral and an inner insert spiral to increase the torque rating of the assembly and transport capacity.

2) Spiral flights shall be formed from SS 316

3) The bar shall be formed in spiral forming machine to the diameter and pitch required with a tolerance of ± 3mm from the theoretical for both pitch and diameter.

4) Each formed section of spiral shall not be less than 3m in length and shall be factory welded to minimum 6m in lengths.

5) Field welds of spiral sections shall be done in strict accordance to relevant welding standards.

6) The splice connections between spirals shall be full penetration welds. The connection of the spiral to the drive system shall be through a flanged bolted connection plate that is welded to the spiral, forming a smooth and continuous transformation from the flange plate to the spiral. The drive shaft shall be bolted to the spiral flange and shaft mounted into the gear reducer output shaft via a mild steel, hot dip galvanized bell housing.

7) The spiral outside face shall be flat and smooth with the face parallel to the axis of the screw conveyor. The edges of the outside diameter face shall be rounded so as not to shave a sharp edge.

8) The flight assembly shall be designed to prevent distortion when operating under the specified design conditions.

(v) Internal wear liners:

1) The bottom half of the screw conveyor trough shall be lined with a replaceable wear liner. The wear liner shall be fabricated in sections not greater than 1.2m in length to permit ease of replacement.

2) The wear liners shall be fabricated from UHMWPE with a minimum thickness of 12mm and with different coloured wear indication layer.

3) For inclined angle more than 30 deg conveying application, the trough shall fully line at all side, compression fitted and held in placed by 316L stainless steel liner retaining bars. The screw shall be fully contained to prevent lifting or misalignment.

4) The wear liners shall be extremely wear resistant and easily replaceable with snap out/snap in operation. The liner shall be secured at intervals not to exceed 1,000 mm, using Type 316L stainless steel retaining clips of approved design.

(vi) Where UHMWPE cannot be used due to specified design conditions e.g. high temperature/abrasion application, manufacturer shall recommend suitable wear liners materials for S.O approval.

(vii) A hardened steel shear plate will be installed at the interface point between the washer compactor discharge pipe and the centreless spiral screw conveyor internal wear liner to insure that compacted material will be carried away by the screw flights without bridging or jamming as material enters the conveyor.

1.27.16 Slide Gates

(viii) The gates shall be completely assembled, including discharge spout, horizontal gate blade, rollers, and bearing support frames, drip pan assembly and drainage connection, pneumatic cylinder actuators, piping, valves, and miscellaneous accessories.

(ix) The gates shall be flanged, gasket, and bolted to the hopper discharge or screw conveyor. Pneumatic cylinder actuators shall be supported from the gate frame.

1) Each slide gate shall be designed to withstand the full capacity for the hopper when full.

2) All components of the gate shall be 316 stainless steel.

3) The gate shall be designed to minimise deflection and shall be fabricated from a solid piece of 316 stainless steel. Liners will not be acceptable.

4) The gate blade shall be supported on heavy-duty 304 stainless steel rollers. The bearings shall be pre- lubricated with contacting lip seals that will be sealed for the lifetime of the bearing to prevent infiltration of foreign material into the bearing housing. The rollers shall be protected, located out of the material flow, and run on antifriction roller bearing having a minimum of 50,000 hours L- 10 rating life as defined by AFBMA standards.

5) Gaskets shall be provided to match the flange, which bolts to the conveyor. Gaskets shall be neoprene rubber conforming to the applicable parts of ANSI B16.21 and AWWA C2707 or better. Gasket material shall be free from corrosive alkali or acid ingredients and suitable for material. Gaskets shall be one-piece, full-face, with holes to pass the bolts.

6) Slide gate shall provide limit switches for OPEN and CLOSE position indication. Limit switches shall be double-throw (SPDT) type. Limit switches shall be prewired to terminal strip housed in a flameproof enclosure

1.27.17 Pneumatic Actuators:

In the event pneumatic actuators required and specified, it shall be equipped with air sets, exhaust mufflers, speed control (needle) valves, and pilot solenoid valves. Limit switches shall be supplied on the valves. Actuators shall be suitable for non - lubricated dry air. Actuators shall size by the conveyor supplier and shall be factory mounted. The actuator shall be suitable for operation of the slide gates over the full operating range of the slide gate and shall be provided with a position gauge and a manual operator for opening and closing the gate in case of loss of air. Support shall be provided for the gate operator.

An air receiver shall be provided as part of the pneumatic control system for the fail closed operation of slide gates .It shall consists of integrally mounted check valve upstream of receiver, such that receiver will be capable of providing sufficient air for fail closed operation under loss of supply air. Air receivers shall be horizontal type constructed to ASME Section VIII, Division 1, unless otherwise stated. ASME rated pressure relief valve shall be provided. Pressure gauge with gauge cock, manual condensate drain valve, and miscellaneous fittings shall be provided.

1.28 Chemical Plant

1.28.1 Definitions

This specification shall cover the general minimum requirement of the chemical plants and systems which shall include the chemical storage tanks, solution preparation systems, water supply system, dilution, motive water, flushing and drainage systems, pumps and fittings, together with the system of administering the chemicals to the points of application.

For any conflict between this specification or any other standard, the process specification shall take the precedency and Contractor shall write to engineer for clarification according to the procedure stated in the tender documents.

1.28.2 Submittals

(b) The Contractor shall furnish complete fabrication, assembly, equipment and piping layout drawings, piping and instrumentation diagrams, and wiring diagrams, together with detailed specifications and data covering materials, parts, devices, and accessories for Client's review.

(c) The submittal shall be split up into different sections with a separate section for each chemical dosing system. Each system section shall be supplied with the following information:

(i) Chemical plant layout drawing

(ii) Dosing equipment or skid fabricator's name, contact particulars, phone number, address, and email address

(iii) Pump Manufacturer's Contact Name, Qualifications and Experience

(iv) Technical schedule which includes all plant and equipment with associated fittings and valves.

(v) Chemical plant and skid piping and instrumentation diagrams with legend

(vi) Equipment selection and datasheet which includes metering pump selections and performance curves, tank sizing, safety valves selection, etc.

(vii) Metering pump appurtenances including calibration column and pulsation dampener (where required)

(viii) Control panel layouts and skid wiring diagrams

(ix) Control narrative

(x) Pressure relief valves and back pressure valves

(xi) Spare parts

(xii) O&M manual

1.28.3 Chemical Plant and Ancillaries

(a) The Chemical Plant shall consist of but not be limited to the following items:

1) Diaphragm metering, digital diaphragm of the necessary duty, standby and maintenance units
2) Ball/diaphragm valves
3) Check valves (where required in consideration of the type of dosing pump used)
4) Calibration cylinders
5) Pulsation dampeners (where required in consideration of the type of dosing pump type used)
6) Pressure relief valves
7) Pressure sustaining valves
8) Diaphragm seals
9) Pressure gauges
10) Chemical Storage Tanks with all associated pipework and valving for fill, discharge, overflow, vent, drain, maintenance, instrumentations, interconnection and transfer
11) Complete pipework, valving, pipe and valve supports, skid framework including pipe and valve elements as required for isolation, sampling and flushing applications
12) Local control panels and instrumentations.

1.28.4 General

(d) The system shall be complete with chemical handling equipment, safety/personnel protection equipment (PPEs) and all other accessories, if specified and required to provide a comprehensive chemical plant in all respects.

(e) Each bund shall only serve one type of chemical and a common bund for more than one type of chemical is not allowed.

(f) The layout of the plant shall provide adequate space for access to carry out operations and maintenance of equipment.

(g) Installation arrangements for the pumps and associated pipework shall have unobstructed access to the controls, pump head, pump inlet and outlet check valves and sampling/flushing points.

~~(h)~~ All valves shall be suitable for the intended design purpose and application. Where specific valve types are recommended by the Contractor, full documents shall be submitted for SO approval~~.~~

1.28.5 Bulk Storage Tanks

(i) Storage tanks shall conform to the appropriate construction and welding standard, and shall be of enclosed vertical cylindrical construction, fabricated in either lined glass reinforced plastic or thermoplastic materials. The tanks shall be suitable for storing the solution at the concentration specified.

(j) Vertical bulk storage vessels shall be provided as specified for the storage of chemicals received from bulk tankers.

(k) The storage tank shall be designed suitable for outdoor conditions.

(l) Unless otherwise specified, the minimum capacity of a single storage tank shall be the quantity of one delivery or one week's consumption at average demand, whichever is the greater. When more than one tank is specified, each tank shall accept at least the quantity supplier in one delivery or half a week's consumption at average demand, whichever is the greater. In addition, a free space of 10% of the tank volume shall be allowed in determining the gross capacity of each tank.

(m) For purposes of design, the maximum specific gravity shall be taken in fixing the mass and the minimum specific gravity in fixing the volume.

(n) Vertical liquid storage vessels shall be mounted above flood level on flat concrete plinths.

(o) All liquid storage vessels shall be located within dedicated bunds specific to each chemical and designed to hold 110% of the contents of the largest vessel.

(p) Tank datasheets and specification shall be submitted with information of the tank construction, resin layer thickness (if applicable), fabrication materials connections sizes, nozzle schedule, supporting saddles, required accessories, shop drawings and test certificates etc. Drawings shall indicate connections and access manways locations and sizes. Drawing shall include a profile diagram of the entire tank wall laminated system indicating the thickness, resin designation, reinforcement and surfacing matt material of each layer including the structural and corrosion barrier layers.

(q) The connections shall be as follows, but not limited to:

(i) inlet;

(ii) outlet;

(iii) drain;

(iv) overflow;

(v) cooling or heating coil (if necessary);

(vi) vent; and

(vii) contents indicator and/or transmitter.

(r) Usable capacity shall be measured from the invert of the tank overflow nozzles to the top of the pump suction nozzle.

(s) Tank shall be designed to withstand the hydrostatic head resulting from the tank being surcharged to 150mm above the top of the tank.

(t) Flanges of tank nozzles shall be in accordance with BS 1092 PN10 minimum and nozzles shall extend at least 150mm from outside face of tank to face of flange. Flanged nozzles shall be fabricated of the same material as the tank and shall be gusseted to the tank and provided with backing rings in stainless steel or otherwise reinforced in accordance with the governing standard.

(u) The filling connection shall incorporate a line isolating valve and a drain valve or quick coupling as specified. Filling pipework shall be 50mm or 80mm NB or any other size to suit in carbon steel to BS 3602 with 3mm thick natural rubber or polyethylene lining.

(v) Nozzles for drain connections shall be installed so the invert is flush with the bottom of the tank to allow complete draining of the tank.

(w) A sight glass shall be provided. Material shall be suitable for clear vision of the fluid concerned. The material for construction of the sight glass shall be compatible with the chemical stored. Pipes connection with valves for the sight glass shall be provided.

(x) Unless otherwise specified, all tanks will be installed on concrete bases. The tanks will be anchored to the concrete base with suitable anchor bolts. The tank shall be provided with the appropriate number and size of lifting lugs for handling and installation and hold-down lugs for anchoring the tank to the concrete base.

(y) Bracketed flat surfaces shall be provided on the tank for installation of nameplate and certification plate.

(z) Glass reinforced plastic tanks (Includes fibre reinforced plastic tanks)

(i) Tanks shall be fabricated from uPVC or polypropylene lined glass reinforced plastic complying with BS4994 or AWWA D120. The exterior layer or body of the laminate shall be of chemically resistant construction. Design of glass reinforced plastic tanks shall include a cyclic loading equivalent to at least 7000 filling cycles over the design life.

(ii) Tank bottom shall be flat within 1 percent of tank diameter with a domed top.

(iii) All tank nozzles shall be finished internally such that there are no exposed fibres.

(iv) Flange nozzle tolerances shall be in accordance to ASME RTP-1-2005. Flange nozzle offset from tank wall or top shall have a maximum permissible angular deviation of 1 degree from the nozzle face. Flange Flatness Tolerance shall be +/- 0.8mm. Eccentricity between bolt holes and centre of nozzle shall be +/- 0.76mm for 50mm sized nozzles and +/- 1.52mm for 80mm sized nozzles or larger.

(v) All nozzle flanges shall have a minimum thickness of 30 percent to and conform in diameter to governing standard.

(vi) The mounting flange for ultrasonic type transmitters shall be not less than 450mm above the maximum liquid level. The centre line of the nozzle shall be at least 600mm from the tank sidewall, fill nozzle, and other obstructions.

(vii) The tanks shall be of hand lay-up, spray-up or filament-wound construction in accordance with the applicable governing standard. The finished laminate shall be constructed of a single generic type of thermoset resin and shall not contain colorants, dyes, fillers, or pigments unless otherwise specified.

(viii) Material of the resin shall be Bisphenol-A polyester or vinyl ester resins suitable for use with the specified chemical as recommended by the resin manufacturer. Material of the reinforcement shall be glass fibre with a suitable coupling agent. Surfacing mat shall be Burlington Formed Fabrics “Nexus Veil” or Nanofibers “Surmat 100”.

(ix) Unless otherwise stated, the inner surface layer of chemical storage tanks shall consist of a resin rich corrosion barrier with a minimum thickness of 110 mils. The surface of the corrosion barrier exposed directly to the corrosive chemical shall consist of a single-ply surfacing veil a minimum thickness of 10 mils. The remainder of the corrosion barrier shall consist of two layers or more of chopped strand mat or equivalent.

(x) The top of the tank shall be reinforced as specified in the applicable governing standard. Additional reinforcement shall be provided as necessary to support the required accessories and personnel loads. Tank roofs shall be provided with a nonslip finish over the enter roof surface as recommended by the tank manufacturer.

(xi) External coating of the tank shall contain UV inhibitor.

(aa) Thermoplastic tanks

(i) Tanks shall be fabricated from high density polyethylene or polypropylene and shall comply with BS EN 12573 Parts 1 & 2. Drilled flange connections and blank flange plates shall be fabricated to be resistant to corrosion from contact with small quantities of chemicals likely to be encountered during the design life.

(bb) Venting and Overflow Arrangement

(i) Venting and overflow pipes shall be independent.

(ii) Vent shall be provided with a cowl or gooseneck and an insect screen.

(iii) A vent pipe of at least 150mm in diameter shall be installed at the highest point in the tank roof and shall discharge to open atmosphere in a manner approved by the ENGINEER

(iv) An overflow pipe of at least 100mm in diameter shall be installed at a position of 350mm–400mm below the base of the vent pipe. The overflow shall discharge within the bund.

(v) The vent and overflow pipes shall be properly supported and arranged so that they can be dismantled for inspection.

(cc) Outlet Arrangement

(i) Each tank outlet connection shall be flanged, suitably gusseted and provided with a backing ring in stainless steel.

(ii) Two isolating valves shall be installed in series directly at the tank outlet.

(iii) A separate drain branch with isolating valve shall be provided at the lowest point in the tank.

(dd) Inspection manhole and cover

(i) Each storage tank shall have two 600mm diameter bolted manways, one in the top and one in the side above bund flood level. The manways shall be complete with davits.

(ii) Each manway shall be flanged, fully gasketed, and furnished with a fabricated blind flange having the same properties as the tank.

(iii) Side access manways shall be cantered approximately 900mm above the bottom of the tank.

(ee) Ladders and handrails

(i) An access platform shall be provided at the top of each storage tank complete with kick-plats and hand railing.

(ii) The platforms shall be supported independently of the tanks. Where more than one tank is installed, a walkway between adjacent vessels shall be provided also complete with kick-flats and hand railing.

(iii) Access to the top of the tanks shall be provided by means of an exterior ladder with safety cage and intermediate platforms where necessary. Tanks with a total height greater than 2000 mm from the finished floor shall be provided with a safety cage. The ladder shall be supported on and anchored to the concrete base and bracketed to the tank shell as needed.

(iv) The ladder, access steelwork and hand railing shall comply with the General Specifications on Metalwork and Workmanship requirements.

(ff) Level Sensor

(i) Each tank shall be equipped with a contents transmitter. The type of transmitter shall be ultrasonic type, or as per specified in the particular specification which shall be compactable for the chemical. The output signal shall be transmitted to an indicator mounted adjacent to the filling point and as per specified location.

(ii) Each storage tank shall be equipped with a level transmitter. The output signal shall be transmitted to the SCADA system and to an indicator mounted locally to the tank and as per specified location..

(iii) In addition, level switches shall be provided to initiate high-high level alarms on the SCADA system and at the tank filling point. These switches shall be independent of the contents gauge.

(iv) Each tank shall be equipped with a high level switch for initiating a high level alarm at the tank-filling point and low level switches for process control. The level switch shall be independent of the contents gauge / Indicator.

(v) Level indicator/transmitter shall be provided for continuous level measurement and high level and low level switches for the chemical tanks for alarms and feed pump control/trip for all required chemicals.

(gg) Nameplates

(i) Each tank shall be provided with a nameplate. The nameplates shall be of stainless steel or white phenolic material with black engraved lettering 75 mm high, and shall be mounted on the tank straight shell.

(ii) The chemical name and the tank tag number shall be engraved on the nameplate.

(iii) A stainless steel certification plate shall be mounted below each storage tank's nameplate, containing information of the tank fabricator's name, date of manufacture, manufacturer's serial number, and resin designation for entire tank (structural and corrosion barrier), maximum allowable concentration and temperature of the specified chemical solution that can be stored safely.

(iv) Material Safety Data sheet with cover shall be mounted onto tank.

(hh) Protective coating

(i) All nuts and bolts shall be manufactured from stainless steel 316.

(ii) A selection of colour pigments available for the vessel shall be provided.

1.28.6 Chemical Unloading/Filling Station

(ii) Facilities shall be provided to receive supplies of chemicals by road transport and shall be provided for unloading and transport to storage.

(jj) Where chemicals are delivered in Intermediate Bulk Containers or by road tanker, a bund shall be provided to accommodate the full length and width of the delivery vehicle and aligned with all storage tank filling points. The bund may be formed from the kerb of the pavement and raised humps in the road surfaces.

(kk) The bund shall be capable of holding liquid spillage of at least 1000 litres or the contents of the largest road tanker where applicable.

(ll) The bund shall have drainage channels or gulleys which discharge to a sump with open mesh cover. The sump shall have an outlet valve discharging to foul sewer. The valve shall have an extension spindle and headstock equipped with a key-operated mechanical interlock. The key shall be held captive unless the valve is fully closed whereupon it shall be released to operate the corresponding interlock on the tank filling valve. The valve shall normally be padlocked in the open position to prevent unauthorised tampering or removal of the interlock key. Each storage tank filling valve shall have a matching interlock which holds the key captive unless the valve is in the fully closed position.

(mm) The filling points for each chemical shall be clearly identified by a nameplate fixed firmly to an upstand local to filling point. The plate shall be in stove enamelled aluminium and the letters shall be 150mm high. If specified, a tank contents indicator with 300 mm dial or digital display of equivalent visibility showing both % full and tonnage shall be mounted at each filling point. If specified, an alarm panel with 75 mm diameter domed indicator lamps, audible alarm and acknowledgement/reset button all in a weatherproof enclosure shall be provided at each filling point.

(nn) A 25 litre capacity plastic carboy shall be provided for each filling point to allow chemical residue to be drained from the filling pipe after a delivery. The carboys are to be stored inside the fill point kiosk.

(oo) To prevent unauthorised use, each filling pipe shall be provided with a lockable isolating valve or, where a filling pipe terminates in a flange, a lock shall be fitted through one hole in the flange. Locks shall be different for each chemical.

(pp) Each filling point shall be provided with a safety shower complete with an eye bath and a water supply with a hose for washing down any spillages and leakages during

delivery. The hose shall be of reinforced plastic suitable for high pressure duties. The hose shall terminate in a nozzle and shall be complete with a hose reel and a suitable enclosure.

(qq) All metal components of the filling system shall be equipotentially bonded to the plant main earth terminal.

(rr) Filling Arrangement shall meet the following requirement:

(i) A dedicated filling point and filling line shall be provided for each storage tank design to receive deliveries direct from road tankers, by transfer pump or air padding at a pressure of 2.1 bar.

(ii) Filling pipes and tank outlet pipework shall be provided as specified. Unless otherwise specified the filling pipes for each chemical shall be brought to a single charging point and the charging points of different chemicals shall be segregated.

(iii) Plastic filling pipes shall not be used.

(iv) The filling pipe shall commence in a 2 inch or 3 inch ND flange to BS 10 Table E positioned in a vertical plane facing the roadway and approximately 750 mm above ground level or other requirements to suit the local suppliers of the chemical. It shall be no more than 2.5 m from the delivery vehicle outlet connection.

(v) The filing pipe shall be dedicated to the particular tank and not manifolded. The filling connection shall incorporate a line isolating valve, check valve and a drain valve.

(vi) The line shall rise vertically at the inlet point immediately behind an isolating valve to a height slightly above the inlet to the tank, then slope downwards to the tank to ensure that it drains towards the tanks and it shall be securely supported to withstand vibration. The vertical section of each filling line shall have a 1” nominal size drain leg with flexible tail tube within the kiosk.

1.28.7 Chemical Unloading/Transfer Pumps

(a) Horizontal end-suction centrifugal pumps of the back pull-out type shall be used for chemical transfer duties such as unloading the chemical.

(ss) Pumps shall be constructed in suitable plastic materials such as glass-filled epoxy resin or high density polyethylene with external metal armouring.

(tt) Road tanker discharge pumps where installed shall be rated at 20 m^3/h and suitable priming and venting provision shall be made.

(uu) The pumps shall be of the mechanical seal type. Alternatively sealless magnetic-drive pumps shall be used.

1.28.8 Local Control Panel and Instrumentations

(vv) Unless otherwise specified, dedicated control panels mounted on the skids or each pump shall have an integral control panel. All power and control wiring within the skid shall be wired to a stainless steel marshalling electrical panel or terminal box to facilitate a single electrical power connection and a minimum number of control wiring connections.

(ww) For all chemical dosing system, magnetic flow meter should be provided, for precise flow measurement. The suction of the pump shall be fitted with graduated calibration cylinders, to allow chemical flow drop test measurement, with proper isolation valves.

1.28.9 Dilution systems

(xx) System design

(i) The dilution water system shall be designed such that it is impossible for chemical to contaminate the drinking water supply system by back flow or other means or to cross contaminate other chemical dosing systems. Non return valves shall not be considered a sufficient method of back flow protection.

(yy) System components

(i) The system shall incorporate all isolating valves as necessary, check valves on the water inlets, flowmeter and flow switch for water supply. An alarm shall be raised if the water flow rate to any dosing point falls below a present minimum. In automatic systems, the water supply shall start and stop in proper sequence with the corresponding dosing system.

1.28.10 Pipework

(a) Pipework materials for chemicals shall be selected with due regard to chemical compatibility, corrosion resistance, location, environmental conditions and operating regimes.

(zz) Pipework material requirements for individual chemicals shall be according to the relevant section of the specification.

(aaa) Thermoplastic pipework may be polyvinylidene difluoride (PVDF), polypropylene, PVC/cPVC or uPVC lined GRP.

(bbb) The minimum size of all the chemical pipes shall be sufficient for maximum dosage of chemical to prevent potential blockage.

(ccc) Pipework systems shall be located to avoid temperature extremes, excessive vibration and the likelihood of accidental impact damage, especially in areas where personnel access is permitted. If this is not possible, components shall be suitably protected by the use of thermal insulation, electric surface heating, guarding, etc., as appropriate.

(ddd) If there is a significant likelihood of surface embrittlement occurring with plastic pipework due to exposure to ultra-violet radiation (e.g. on pipework installed outdoors), temperature and impact by wind-blown object, suitable protection of the pipe shall be provided.

(eee) Thermoplastic materials shall not be painted as a means of protection but shall be shielded from direct sunlight and adequately guarded against mechanical damage.

(fff) Unless otherwise specified, all external chemical pipework shall be laid in trenches provided with removable covers.

(ggg) Pipework system shall be designed to safely withstand the maximum system pressure. If necessary, components shall be derated, in accordance with the pipework manufacturer's instructions, to allow for high temperatures, repeated pressure

fluctuations and/or the corrosive effects of aggressive dosing chemicals (e.g. concentrated sulphuric acid, sodium hypochlorite etc.)

(hhh) Where pressure and temperature de-rating precludes the use of thermoplastics, suitably lined reinforced plastics, rubber-lined carbon steel or stainless steel shall be used. Stainless steels shall not be used for chemicals containing chlorides.

(iii) The pressure drop along pipework systems shall be kept to a practical minimum and shall be carefully considered during dosing pump selection/system design. Pipework sections shall incorporate as few bends as possible and bends, if necessary, shall be of the long radius type.

(jjj) The wetted internals of all pipework systems (including gaskets and O-rings) shall be resistant to corrosion/degradation by the dosing chemical.

(kkk) All pipework and hoses shall be adequately supported throughout their run. Pipes shall be fixed to walls or mounted on channel sections fixed to walls or on cantilevered supports off walls. Hanger type supports shall not be acceptable nor shall pipes be underslung from roofs or cantilevered supports or supported on the underside of pipe supports.

(lll) Pipework laid on the floor shall be supported on channel sections or similar off the floor.

(mmm) Pipework shall be supported in accordance with manufacturers' recommendations and adequate provision shall be made for thermal expansion and contraction. Supports shall not be positioned in close proximity to fittings which would interfere with the natural movement of the pipes. Supports shall be sufficiently wide to offer adequate bearing surface and shall be installed so as to offer lateral restraint without restricting axial movement of the pipe.

(nnn) Valves and other devices shall be supported independently of the pipe.

(ooo) Fixings of pipes shall by clips (cobra type) or clamps. Where clamps are used on plastic pipes, pipe cushioning shall be used and the pipe shall be mounted on channel sections with a plastic strip in between.

(ppp) All pipe supports shall be hot dipped galvanised or made of higher grade materials such as SS316L to guarantee against corrosion resistance in the specific environment in which they are installed.

(qqq) Hoses carrying chemical solutions shall be laid on horizontally mounted trays. Hoses shall be securely fixed to trays by clips or similar.

(rrr) Hoses and pipes shall be laid in such a way that individual pipe/hoses can be removed without dismantling adjacent pipes/hoses.

(sss) The racks or trays used to carry chemical pipes/hoses and water service pipes shall not be used for conveying electrical/instrument cable. Where electric/instrument cables are laid in the same trench or gallery with chemical/water pipes, the electric/instrument cables shall be laid on uppermost trays.

(ttt) Particular attention shall be paid to the layout of the chemical pipework, which shall be functional and neat in appearance.

(uuu) All pipework above access ways shall be at not less than 2.5m above floor level. Pipes laid at or near floor level across access ways shall be suitably protected from damage.

Joints in pipelines and fittings shall be sited away from access ways and working areas; where this is unavoidable anti-splash guards over the joints shall be provided.

(vvv) Pipework connecting to and near pumps shall be rigid and well supported so that strain is not placed on pumps. Suction pipes shall, where possible, be straight and short. Elbows shall be avoided in pipework as far as possible and shall be replaced by 45 degree or long-sweep 90 degree fittings.

(www) Chemical transfer pipework shall be arranged for self-draining either towards the dosing pumps or dosing point. Provision shall be made for draining all pipe sections at low points and for flushing the same with clean water and facilities shall be provided for safe disposal of the drainage.

(xxx) Pipework shall be provided with flushing connections and drains to facilitate cleaning of pipes/hoses and fittings.

(yyy) It shall be possible to isolate sections of pipework for flushing with minimum of interruption to dosing. Unless otherwise specified, all dosing pipes/hoses and associated injection/diffuser lances/quills/fittings shall be provided in duplicate (1 duty, 1 standby).

(zzz) Chlorine and ammonia solution lines shall not be laid inside buildings (not designated for these gases). Where chlorine and ammonia solution lines are laid in dosing chambers and other confined spaces which are accessible by personnel, the Contractor shall provide a permanently installed leak detectors for continuous monitoring of leaks and mechanical ventilation systems.

(aaaa) All nuts, bolts, washers and screws shall be manufactured from stainless steel as set out in the Specification.

(bbbb) Unless otherwise specified, flanges for steel pipework shall be of the weld-neck type, Type 11 to BS EN 1092 the appropriate pressure designation but not less than PN10 according to the design pressure for the specific applications.

(cccc) Unless otherwise specified or approved by ENGINEER, all joints in rigid metallic and plastic pipework systems shall be fully welded or flanged (i.e. not threaded). If threaded connections and fittings are used, the seal shall be obtained via double ferrule, olive or O-ring type connections that can be dismantled and re-made without the need for new parts i.e. without the need for sealing tape.

(dddd) Solvent welded joints in rigid plastic pipework systems shall be made strictly in accordance with the pipework system supplier's instructions. The solvent shall be compatible with the dosing chemical; where special solvents are available for use with aggressive dosing chemicals, these shall be used instead of the standard solvent.

(eeee) Pipework connections to tanks shall be of the bolted flange type. Metal backing rings shall be used on plastic flanged connections and shall be resistant to corrosion/degradation by the dosing chemical.

(ffff) All uPVC pipework used as liners shall be 'hi-impact' type to BS 3505 or BS 3506 Class E, with solvent welded joints and fittings complying with the relevant parts of BS 4346. Reinforced plastics shall comply with BS 6464 and shall contain a uPVC liner as specified. The pipework shall be fabricated and assembled such that only the liner comes into contact with the fluid. The piping system shall be designed and constructed in accordance with BS 7159.

(gggg) Where flanged joints are required in thermoplastic pipework, full-face plastic flanges, where available, and stainless steel backing rings shall be used. Flanges shall conform to BS 4504 PN10 minimum.

(hhhh) Joint rings shall be of Viton encapsulated in PTFE.

(iiii) Unless specified otherwise, the chemical piping systems shall be designed, fabricated and constructed to provide double containment pipe to contain any chemical leakage from pipe joints or from accidently damaged portion.

(jjjj) The double containment piping systems shall comply with the following as a minimum unless specified otherwise:

(i) General:

1) Primary and secondary containment piping shall be as defined in the particular specification.

2) All other unlisted components that are intended for use as pressure retaining components shall have sufficient thickness and reinforcement so as to be able to maintain the same pressure ratings as the secondary containment piping.

3) Interstitial supporting devices used to centre and support the primary piping within the secondary containment piping shall be manufactured from PVC spider clips or C-Type, according to ASTM and ANSI. Annular spacing throughout piping system shall allow for leak detection cable installation. Supporting devised shall allow for leak detection cable installation. Supporting devices shall allow continuous drainage in the annular space to the drain points.

4) All fitting shall be pre-assembled and pre-tested by the manufacturer.

5) At all piping low points, or at a minimum spacing of 75 metres, a drip leg and drain valve with hose connection shall be provided.

(ii) Leak Detection System

(iii) Testing

1) The secondary containment piping shall be pneumatically tested at design pressure or 1.5 times the working pressure for a minimum of 2.5 hours duration.

2) The external joints should be soaped and visually inspected for leaks. A pressure regulator and safety relief valve shall be used during the pneumatic test to ensure that over-pressurisation cannot occur.

3) The testing of the primary and secondary containment piping shall be done in strict accordance with the recommendations of the manufacturer.

(iv) Purging

1) The annular space shall be purged of moisture containing air and foreign matters (dirt, mud, oil) by replacing the volume of air with clean, dry nitrogen or minus 30 degrees C dew point air.

1.28.11 Isolating Valves

(a) General

(v) All isolating valves shall be positioned with due regard to routine access for operational and maintenance purposes. It shall not be necessary to enter any bunded facility to operate isolating valves.

(vi) Isolating valves shall be compatible generally with the pipework systems in which they are installed.

PVC/cPVC valves

(vii) Isolating valves shall be of the full port ball type with PVC/cPVC body, PVC/cPVC steam, Teflon seat, Viton O-rings. Assembly nuts and bolts shall be stainless steel. Reflux valve shall be ball check type with PVC/cPVC body.

(viii) End fittings may be plain sockets for solvent welding or flanged as appropriate. Flanges shall be drilled to the standard matching the pipe selected.

(ix) For Diaphragm ball valve, it shall be Weir type, PTFE- / PVDF-lined, PVC / PP / PE body, manual operator indicating, rising stem type with handwheel with adjustable travel stop and shall be accordance with BS EN 13397 or equivalent.

Actuated for valve

(x) 50 mm and larger, shall be of the diaphragm actuated, spring loaded, single seat composition disc, packless globe valve type controlled by a suitable solenoid pilot valve.

(xi) Less than 50 mm in size, shall be of the direct acting single integral seat, full pipe area, globe type. They shall be of all bronze construction with tight seating, renewable composition discs and shall be provided with a manual operator.

(xii) Operating solenoid shall have direct current coils and an integral rectifier for use on a 230 V AC supply, unless otherwise specified. The coils shall be encapsulated in epoxy resin.

1.28.12 Injection fittings

Where the chemical is to be dosed into an open channel, weir chamber or upstream of a hydraulic jump, it shall be applied using a distributor. The distributor shall be tubular with orifices drilled at even intervals to ensure uniform distribution of the chemical.

(kkkk) Where it is to be dosed into flow in pipelines, it shall be applied using a suitable arrangement of injection tubes designed for the specified duty flow rate.

(i) Pipelines up to 600mm in diameter.

- A single horizontal injection tube shall be used extending one third of the pipeline diameter into the fluid stream.

(ii) Pipelines up to 1000mm in diameter

- Two injection tubes shall be used mutually located at 90^{o} with their axes at 45^{o} to the horizontal and extending 15% of the pipeline diameter into the fluid stream.

(iii) Pipelines up to 2500mm in diameter

- Four injection tubes shall be used mutually located at 90^{o} with their axes at 45^{o} to the horizontal and extending 15% of the pipeline diameter into the fluid stream.

(llll) The nozzle velocity shall exceed 0.75m/s or one half of the large pipe velocity whichever is greater.

Distributors and injection tubes shall be of sturdy design and adequately supported. They shall withstand the flow of velocity at the point of application and any flow or turbulence induced vibrations.

The materials of construction of the distributors and injection tubes shall be resistant to erosion and chemical attack over the full range of operating conditions.

The distributors and injection fittings shall be supplied complete with the necessary isolating valves and, where applicable, non-return valves.

(mmmm) Where solutions are dosed into static mixers and the injection unit forms an integral part of the static mixer, the injection fitting design shall be as recommended by the static mixer supplier.

1.28.13 Dosing skids

The dosing skids shall be provided and shall comprise a factory-assembled and tested skid-mounted system including dosing pumps and associated components and a control panel. The skid shall comprise a rigid frame fabricated from Kevlar coated carbon steel and have a uPVC backboard for mounting pipework and an integral uPVC bund. The skid shall have external lugs for bolting down to a concrete plinth and lifting eyes to facilitate offloading at site. The bund floor shall slope at a gradient of 1:100 towards one corner draining into a bunded area provided with a sump.

Each dosing pump and its associated components handling undiluted chemical shall be enclosed by transparent plastic anti-spray screens with removable panel to permit access for maintenance whilst the adjacent system remains in service and fully screened. Removal of the panel shall require the use of a tool. Where pipework conveying concentrated chemical to one dosing stream passes through the enclosure housing the other dosing stream, there shall be no joints.

Chemical dosing equipment including skids shall be of substantial construction with all parts designed for long life under working conditions including corrosive atmospheres and intermittent or continuous operation.

Skid materials shall be constructed of materials resistant to the pumped solution.

All wearing parts and items requiring adjustment shall be readily accessible.

All parts which are exposed to corrosive conditions shall be made from corrosion-resistant materials or covered with suitable protective coatings.

Each skid shall be constructed such that the bund wall elevation is flush with the skid bottom unless otherwise indicated. The skids shall be mounted on legs that extend down to the finished floor in the bund area.

1.28.14 Chemical Plant Safety

The chemical plant shall be designed to a high standard of safety and shall comply with all local statutory requirements and where such local standards do not exist, those of any other relevant bodies recognised or applied locally unless otherwise specified.

The chemical storage and handling plant shall conform to the relevant material safety datasheets, technical service notes and literature published by the potential chemical suppliers and plant manufacturers and any other guidelines published by reputable authorities.

The Contractor shall obtain the approval of the chemical supplier for the design of the reception and storage facilities before proceeding with installation. In the case of toxic or hazardous chemicals the Contractor shall afford the suppliers the opportunity of offering advice on safety precautions to be taken on the design layout, operation and maintenance of the plant.

The Contractor shall provide safety equipment like safety showers, eye baths, eye irrigators, etc. as necessary. Safety equipment shall comply with the General Specifications on safety equipment.

The Contractor shall provide all necessary warning and safety signs to BS EN ISO 7010 and BS 5499.

Safety signs shall use local or internationally recognised pictorial representations, such as those in BS EN ISO 7010 and BS 5499.

Signs shall be manufactured from durable, non-fading, and weather resistant materials. Materials shall be of durable quality and chemical resistant for their intended environment, and suitable for both indoor and outdoor use. Signs shall be in stove enamelled aluminium with rounded corners and drilled fixing holes as specified.

Chemical suppliers' notices shall be framed with Perspex cover and a suitable backing board and mounted either on a clear wall just inside the access door or adjacent to plant as appropriate.

Drawings of all warning signs and notices shall be submitted to the ENGINEER for approval.

Transparent spray guards shall be fitted over the storage tank outlet pipework, within the tank bund. The guards shall be in Perspex or similar sheet mounted horizontally from the side walls of the bunds using suitable brackets.

The dosing pumps shall be provided with screens mounted around the periphery of the dosing pump area or light weight removable transparent covers over the pumps.

Perspex covers shall be provided over joints in the pipework or any other point of leakage to protect personnel from possible leaks.

The delivery areas shall be level.

1.28.15 Storage of packages

(a) Facilities shall be provided as specified for unloading chemicals delivered in individual or palletised packages.

Chemicals delivered in packages shall be arranged in storage areas so as to provide access corridors for personnel and mechanical handling equipment.

The following features shall be considered in the layout of the storage areas:-

Good access for mechanical handling equipment such as fork lift trucks, pallet trucks, trolleys, overhead monorail hoists etc. Adequate access corridors shall be provided and shall be sized for manoeuvring fork lift trucks and other trucks into position making allowances for their turning radius;

Packages shall be placed about 25 to 50mm away from the walls, particularly if condensation on walls is likely to occur.

Good access to packages shall be provided to ensure good stock rotation.

Bags shall be stacked on pallets.

Adequate space shall be provided in storage areas to accommodate any listing of palletised crates.

Chemical handling

(i) Fork lift trucks

1) Fork lift trucks shall be of the 'sit-down' driver type with two stage mast and standard free lift. Trucks employed solely for use externally shall be diesel driven, and trucks employed for internal use to any degree shall be of the battery-operated type. Full recharge of the batteries of the fork lift trucks shall be possible in less than eight hours.

2) The trucks shall have hydraulic lift, back and forward tilt, and manually adjustable lateral fork spacing, and shall be complete with overhead guard, load backrest, buffer and automatic battery charger.

3) Each truck shall be provided with a battery charge indicator and POWER ON light and also with a 'dead man' type brake.

4) The lifting forks shall be made as single piece forgings in steel to PD 970, Grade 150 M19 or Grade 150 M28. Each fork shall be clearly forged and finished with a smooth surface and adequately radius corners.

5) Each truck shall be permanently and legibly marked with:-

- Identification number.
- Safe working load.
- Where applicable, the tyre pressure.

6) Fork lift truck design and testing shall conform to BS ISO 22915, BS 4338, BS 5639 and BS ISO 22915.

(ii) Pallet trucks

1) Pallet trucks shall be of the hand powered hydraulic type with wheels made of polyurethane.

2) When loaded to its maximum safe working load the full lift from the lowered position shall not be less than 100mm.

3) The lowering speed shall be infinitely variable by hand lever which shall be in the neutral position whilst manoeuvring.

(iii) Pallets

1) Pallets for transport and storage of chemicals and other specified material shall be of the close and open boarded and reversible and non-reversible types with two-way and four-way entry, as specified.

2) In open boarded pallets a maximum spacing of 50mm between deck boards (whether top or bottom) shall not be exceeded.

3) Pallets dimensions shall be as specified and shall be fully compatible with the fork lift and pallet trucks supplied under the Contract.

4) Pallets shall be constructed in accordance with BS ISO 6780.

5) Deck boards shall have sectional dimensions not less than 25 x 125mm and shall be of European redwood or approved equal. Blocks shall be 100mm cubes and bearers shall have sectional dimensions 50 x 100mm.

6) Blocks and bearers shall be of European Oak or approval equal. Wood shall be fully treated against fungal, insect and animal attack. The Client's name shall be burnt into pallets.

1.28.16 Hydrated Lime Plant

(a) General

This Section describes the components and applicable requirements which, where relevant to the Contract, shall apply to the supply, installation and testing of hydrated lime plant.

Lime Silos capacity, design and fabrication

(iv) Silos shall be either straight vertical cylinders of carbon steel construction or cuboids of reinforced concrete construction with respectively conical or pyramidal hopper bottom sections in carbon steel.

(v) The silos shall accommodate the specified mass of hydrated lime with a bulk density of approximately 480 kg/m^3.

(vi) Subject to the particular requirements of installation, the minimum capacity of a single silo shall be 30 tonnes whilst in multiple silo installations, the capacity of each silo shall be at least 25 tonnes.

(vii) Silos shall be designed, constructed and tested in accordance with the Code of Practice for the Design of Silos, Bins and Bunkers published by the British Material Handling Board, latest edition, and with the relevant parts of BS EN 618:2002 and BS EN 620:2002+A1:2010.

(viii) Due allowance shall be made for pressure exerted by material in storage and during filling and emptying.

(ix) Wind loading shall be taken into account whether or not the silos will ultimately be enclosed in a building.

(x) Fabrication of silo storage systems shall be carried out by companies who have constructed satisfactory systems for storing the same material in similar quantities in the past. Proof shall be submitted at time of tender that the proposed manufacturer has been engaged in the fabrication of silo systems for at least 10 years and that he has had silos of the type proposed in satisfactory operation for the same application for at least 5 years.

Filling arrangement

(xi) Silos shall be filled from bulk air pressure discharge vehicles unless otherwise specified.

(xii) The filling pipe shall be at least 100mm NB carbon steel to BS EN 10216 which shall enter a cylindrical silo tangentially near the top or a rectangular silo downwards through the top. The pipe shall rise vertically from the point of connection to the bulk delivery vehicle to the top of the silo and then horizontally. Bends shall have a minimum radius of 1000mm and the number of bends shall be kept to a minimum, preferably not more than two. Long horizontal lengths of pipe shall be avoided and the total length shall not exceed 40 metres.

(xiii) A 100mm NB "Unicone" tail piece shall be fitted to the lower end of the filling pipe just above which shall be a hand operated isolating valve of the straight-through type.

Air filter

(xiv) Air filters shall be designed to remove fine dust from the total volume of air vented when the silo is being filled. Each filter shall be sized for a throughput greater than the air flow rate used in charging the silo for a period not less than the time taken to transfer the contents of one tanker into the silo.

(xv) Filters shall be in a fully weatherproof casing mounted on top of the silo with a facility for automatic cleaning. The controls for this cleaning facility shall be sited at ground level. Swivel lifting davits or like devices shall be provided to facilitate ease of replacement of filters and transportation of parts and components that may be required in the filters replacement.

(xvi) Where silos are located in an enclosed area, each silo shall be provided with two fully rated filters with the necessary quantities of replacement components/parts as specified.

Inspection manhole and cover

(xvii) Each silo shall have a manhole for inspection and maintenance purposes and removable grid bars shall be fitted for safety during inspection. The manhole cover shall be hinged and shall effect an air-tight seal when in the closed position.

Pressure relief device

(xviii) A suitable pressure relief device shall be fitted to the top of each silo in order to relieve pressure should the air filter become partially or totally blocked or if overfilling occurs during a delivery.

(xix) When in the fully open position, at the most restricted part of the opening, the device shall have a cross sectional area greater than that of the filling pipe.

(xx) Facilities shall be included to prevent any part of the device becoming detached.

(xxi) During normal operation, the device shall not allow emission of dust.

Dehumidifier

(xxii) Each silo shall be equipped with a dehumidifier of the desiccant type designed to ensure a dry ullage space in the silo and prevent condensation of moisture in the silo.

(xxiii) The dehumidifier shall dry the air supplied to the silo to a dew point 7.5°C below the ambient temperature. The dried air shall be introduced into the silo at a rate greater than the lime withdrawal rate to create a positive pressure in the silo and shall vent excess air through the air filter unit.

(xxiv) The desiccant unit shall comprise of an absorption rotor with several segments and shall be so arranged that the air drying process is continuous whilst exhausted segment(s) is being reactivated/replaced. The desiccant shall be activated alumina or silica gel. The reactivation of the desiccant shall be effected thermally. The reactivation air system shall be separated from the process air system and the air inlets to both the systems shall be fitted with filters.

High level indicator

(xxv) A high level indicator of the rotating paddle type or similar or better shall be installed in a suitable position which minimises interference from inflow of the material. The associated control panel shall be located adjacent to the silo filling point and shall have the following features: -

1) Isolating switch;
2) On/off switch for paddle drive;
3) Indicator lamp for PADDLE RUNNING;
4) Indicator lamp for SILO FULL;
5) Audible warning bell;
6) Push-button for LAMP TEST;
7) Instruction notice to driver.

(xxvi) The panel enclosure shall be protected to BS EN 60529. The power supply shall be 110V a.c. unless otherwise specified.

Hopper outlet

(xxvii) The hopper outlet shall be designed for reliable flow of bulk solids based on cohesive arching and wall friction considerations.

(xxviii) The angle at the bottom of the silo shall not be less than 60° to the horizontal.

(xxix) The outlet shall not be less than 200mm in diameter or 0.04m^2 square rectangular cross section.

(xxx) An isolating valve of the slide gate type shall be fitted to each outlet.

(xxxi) Where applicable, the hopper section shall be fitted with an arch breaking device which shall be of the aeration or vibratory type or a combination of both the types. Evidence of proven suitability of the proposed system shall be made available before selection is made.

Support structure

Support structures for steel silos and steel hoppers shall be in structural steel complying with BS EN 10137, BS 7668 and BS EN 10029 and shall be complete with base plates and anchor bolts.

Man access

(xxxii) The top of the silo shall be designed as a maintenance platform and be provided with kick-flats, hand railing, walkway, ladders shall be provided as specified.

Equipment access

(xxxiii) Silos shall be provided with an electrically operated wire hoist designed to handle the heaviest item on top of the silo. Where more than one silo is installed, a monorail shall be provided over the silos to enable the hoist to serve all the silos.

Protective coating

(xxxiv) Steel silos shall be blast cleaned and coated externally as set out in the General Specifications on painting and protective coatings.

(xxxv) Unless otherwise specified, internal surfaces shall remain untreated.

Screw Conveyors

(xxxvi) Screw conveyors shall be totally enclosed in a fabricated steel 'U' trough with removable top cover and Perspex inspection panel. Where required for outdoor installation, the conveyors shall be fully weatherproofed. They shall comply with BS 4409 Part 1.

(xxxvii) The filling of the trough shall be limited to a maximum of 30% and the angle of inclination of the conveyor shall not exceed 15 degrees to the horizontal.

(xxxviii) Screw blades shall be of the continuous helicoidal type with mild steel flights welded to a central shaft. The pitch of the screw shall be uniform or graduated to suit the application.

(xxxix) The central shaft shall be heavy duty steel tube having sufficient strength in bending and tension to eliminate the need for intermediate support by hanger bearings.

(xl) End bearings shall be provided for rigidly supporting the flighted shaft and due allowance made for thermal expansion and contraction.

(xli) Drive motors shall be geared and provided with a chain and sprocket drive arranged within a guard. The motor shall be preferably mounted on top.

(xlii) When used for metering purposes, screw conveyors shall be controlled by means of a timer. The reproducibility of metering conveyors shall be better than ± 5% by weight.

(xliii) Subject to the engineering's approval, the manufacturer's protective coating system shall be as for silos.

Slurry tanks

(xliv) Tanks for slurry preparation and dilution of lime slurry shall be vertical cylindrical tanks. Slurry tanks shall be fabricated from mild steel with necessary lining or coating where applicable and designed to hold the required volume of hydrated lime slurry at concentrations up to the specified value.

(xlv) Each tank shall be provided with the following components and fittings:

1) Bolted dust-tight cover fitted with a manhole and serving as a maintenance platform.

2) Hand railing around periphery of tank cover and access ladder from floor level.

3) Top entry paddle mixer (or any other mixer type subject to ENGINEER's approval) of the slow speed type with driving motor and speed reduction gearbox mounted on structural steel supports spanning the diameter of the tank shall be provided.

4) The gearbox output shaft shall be coupled to the mixer shaft by means of a flexible coupling. The upper end of the mixer shaft shall have a combined journal and thrust bearing and the lower end shall have an inert non-metallic bearing.

5) The paddle blades shall be inclined from the vertical plane. Unless otherwise specified, the mixer shaft and paddles shall be in stainless steel to PD 970 or BS EN ISO 9445-2 grade 316S11.

6) Where necessary for maintenance purposes, a steel lifting beam complying with BS 2853 shall be provided for removal of the mixer and its drive assembly.

7) Sight glass type level gauge with isolating valves and flushing connections.

8) Conductivity type level probes for automatic slurry batch preparation and tank changeover, where specified.

9) Powder inlet flange to suit charging system and venting connection with dust filter where applicable.

10) Flanged connections drilled to BS EN 1092 PN 10 for water inlet, slurry inlet (where applicable), slurry outlet, overflow and drain.

11) Where specified, additional connections shall be provided for slurry re-circulation. The tank design shall ensure that insoluble impurities are not passed into the outlet system.

12) Strainer shall be provided in the tank outlet.

13) Unless otherwise specified, the tanks shall be mounted on load cells of the mechanical shear beam type to enable lime usage to be recorded and to control lime slurry preparation. Each tank shall be provided with three live load cells protected to IP 67. Facilities shall be built in to allow load cells to be easily replaced when necessary.

14) The tank shall be blast cleaned and coated internally (epoxy system) and externally (chlorinated rubber system) as set out in General Specifications for painting and protective coatings.

Lime Slurry and Lime Sludge Pumps

(xlvi) Lime slurry and lime sludge pumps shall be peristaltic type pumps for the advantage of conveying fluids with high tendency to cause chokage in other types of pumps.

Slurry pipework

(xlvii) Slurry tank outlet manifolds, dosing pump suction manifolds and dosing pump delivery manifolds shall be in seamless carbon steel to BS EN 10216.

(xlviii) Delivery lines to points of application shall be in reinforced flexible hose unless otherwise specified. Connections between manifolds and dosing pumps may also be made with reinforced flexible hose.

(xlix) Slurry hoses shall be secured to horizontally laid trays fixed to duct walls or walls of galleries as necessary. Pipe supports shall be close enough to prevent sagging.

(l) Tees and crosses shall be used in place of elbows where mechanical cleaning may be required.

(li) Rodding points shall be provided opposite the dosing pump suction off-take points.

(lii) Reducers shall have level inverts and branches shall be taken from the top of a pipe. Long vertical rises shall be avoided especially above the discharge valve of a dosing pump.

(liii) Pipework design shall minimise any tendency for settlement of particles. Provision shall be made for flushing all sections with clean water.

(liv) Wherever possible, the velocity of the slurry in any part of the pipework system shall be maintained above 0.3m/s over the entire range of operating conditions.

Slurry isolating valves

(lv) Manual isolating valves for hydrated lime slurry shall be either ball valves of the full bore type or diaphragm valves of the straight through type.

(lvi) Valve bodies shall be of cast iron whilst balls shall be stainless steel. Flexible diaphragms shall be selected for maximum resistance to abrasion.

(lvii) Assembly nuts and bolts shall be in stainless steel.

(lviii) End connections shall be flanged and drilled to BS 1092 PN 10 minimum.

Loading valves

(lix) The valves shall be of the tubular pinch type pressurised externally with compressed air or of a non-clogging alternative approved type. Where pinch type or similar is used a separate non-return valve shall be provided downstream.

Injection fittings

(lx) Where hydrated lime slurry is to be dosed into flow in pipelines, a suitable arrangement of injection tubes shall be used which shall be withdrawable from the pipelines whilst the latter are in service.

1.28.17 Sodium Hypochlorite Plant

General

This section contains requirements which where relevant to the contract shall apply to the supply and installation of sodium hypochlorite plant.

Storage tanks

(i) Sodium hypochlorite solution storage tanks shall be of enclosed vertical cylindrical construction, fabricated from uPVC lined glass reinforced plastic complying with BS EN 13923 and BS EN 13121 or alternatively from high density polyethylene.

(ii) The tanks shall be suitable for storing the solution at the concentration specified. Where delivery of sodium hypochlorite by road tanker or pumped from intermediate bulk containers (IBC) is required, the tanks shall be suitable for solution concentrations up to 15% w/w. Where differing concentration value(s) are specified in the Particular Specifications for the specific intended purpose, the particular specifications shall take precedence.

(iii) Connections

1) Where specified, each storage tank shall be equipped with a filling connection to facilitate charging from a road tanker or pumped supply from an IBC.

2) The overflow connection shall incorporate an internal dip tube to function as a gas trap. The external overflow pipe shall include a siphon break.

3) The outlet arrangement shall incorporate double isolating valves, an in-line strainer and a sample valve. The tank connection shall be positioned so as to prevent entrainment of gas bubbles.

4) The vent shall discharge at a safe distance from tank roof level and from adjacent buildings.

(iv) Tank cooling

1) A tank cooling system will be required if the concentration of sodium hypochlorite is likely to decrease by 2% w/w over 14 days.

2) Cooling system shall be thermostatically controlled and shall be designed to maintain the temperature of the contents at 15^{o}C.

Pipework

(v) Pipework materials for hypochlorite service shall be selected with due regard to chemical compatibility, location, environmental conditions and operating regime.

(vi) Specific material requirements are set out above for the filling pipe of sodium hypochlorite storage tanks.

(vii) In the case of pipework located outdoors, particular consideration shall be given to the effects of ultra-violet rays, temperature and impact by wind-blown objects. Thermoplastic materials shall not be painted as a means of protection but shall be shielded from direct sunlight and adequately guarded against mechanical damage.

(viii) Where pressure and temperature de-rating precludes the use of thermoplastic materials, suitably lined reinforced plastics or rubber lined carbon steel shall be used.

(ix) Provision shall be made for flushing all pipe sections with clean water.

(x) Where pipework and fittings are subject to freezing, trace heating and lagging shall be applied.

(xi) Pipework shall be supported in accordance with manufacturers' recommendations and adequate provision shall be made for thermal expansion and contraction.

(b) Flanges shall conform to BS EN 1092 PN10 minimum.

(c) uPVC valves

(i) Valves shall be of the diaphragm type with PVC/cPVC bodies, Teflon and EPDM diaphragms. Assembly nuts and bolts shall be stainless steel. Reflux valve shall be ball check type with PVC/cPVC bodies.

(ii) End connections shall be PN10 rating flanges to BS EN 1092.

(iii) These valves may not be used for isolating tank outlets and drains.

(d) Rubber lined valves

(i) Isolating valves shall be of the diaphragm type to BS EN 13397 with weir bodies in grey cast iron to BS EN 1561 grade 220 (or alternative grade allowed by the design standard) having integral flanged ends, a natural rubber ebonite lining, PTFE diaphragms and top works in standard proprietary materials. Assembly nuts and bolts shall be in stainless steel. The valves shall be tested in accordance with BS EN 12266-1.

(ii) Isolating valves for tank outlets shall be of the sealed bonnet type.

(e) Stainless steel shall not be used for internal wetted parts for pressure-relief valves.

(f) Loading valves shall be of tubular pinch type pressurised externally with compressed air or of an alternative approved type.

(g) Injection fittings

(i) In situations where scaling may occur at the point of application, the injection tubes shall be withdrawable from the pipelines whilst the latter are in service.

1.28.18 Caustic Soda (Sodium Hydroxide) Plant

(h) General

This Section contains requirements which, where relevant to the Contract, shall apply to the supply, installation and testing of caustic soda plant.

(i) Materials

Aluminium, aluminium alloys, tin, zinc (galvanising), lead, bronze and brass shall not be used on the caustic soda plant. Iron and steel, natural rubbers (up to a temperature of 80^0C) and thermoplastic materials shall be used as specified. PVDF and nylon shall not be used. GRP shall only be used with a PVC lining.

(j) Solution tanks

(i) Capacity, design and fabrication

1) The tank shall be fabricated from FRP or equivalent material, which shall comply with BS 476: Part 6 or equivalent with fire propagation index meeting latest FSD requirements, to give maximum resistance to aqueous solution of sodium hydroxide and sodium hypochlorite after reaction with chlorine. The tank construction shall be robust and suitable for installation on a concrete plinth. The solution tank shall be suitable for installation inside a compartment with a bund wall for retaining of sodium hydroxide solution in case of tank leakage and shall be suitable for the rise in temperature due to heat evolved during dilution. The dilution system shall be designed to minimise local boiling and shall be provided with mixing facilities. In the dilution process caustic soda shall be added to the water. Unless otherwise specified, the tanks shall be located within a building.

2) Alternatively, tanks (up to 50% w/w NaOH) can be enclosed vertical cylindrical construction, fabricated from steel to BS EN 14015 or uPVC lined glass reinforced plastic complying with BS EN 13923 and BS EN 13121-3.

3) Mixing of contents during preparation shall be by a mixer.

(ii) Tank heating

1) Unless otherwise specified, a tank heating arrangement will be required only if the ambient temperature falls below 15^0C.

2) The materials of construction shall be suitable for receipt of caustic soda deliveries at temperatures up to 55^0C.

(iii) Filling arrangement

1) The filling pipe shall be carbon steel or uPVC at the appropriate pressure rating and wall thickness schedule.

(iv) Outlet arrangement

1) The tanks shall be provided with an internal plug valve for sealing the outlet in an emergency. If it is not practicable to fit an internal plug value two isolating valves shall be installed in series directly at the tank outlet with one of these valves operable from outside the bund.

(v) Temperature sensor

A temperature sensor shall be installed for local and remote indication together with an alarm set at temperature slightly higher than the maximum allowable temperature at 50^0C for the sodium hydroxide solution for the protection of FRP tank.

(k) Mixer

(i) Mixer impellers may be of single or dual arrangement. No bottom support bearing is to be incorporated in the tank as stabilizers. The motor and gearbox shall be fixed to a combined baseplate.

(ii) The mixer shaft shall be of adequate stiffness to minimize flexing and so driven that no flexural load from the shaft is transmitted to the gearbox or motor.

(iii) All wetted parts, bedplates and holding down bolts shall be of 316L stainless steel or superior materials suitable for sodium hydroxide solution application.

(iv) Other components exposed to splashing shall be suitably protected to the ENGINEER's approval.

(l) Solution preparation tanks

Where solution preparation tanks are required, solution preparation tanks shall be constructed of steel or thermoplastic and shall be suitable for the rise in temperature due to heat evolved during dilution. The dilution system shall be designed to minimise local boiling and shall be provided with mixing facilities. In the dilution process caustic soda shall be added to the water.

(m) Recirculation pumps

(i) Recirculation pumps shall be of the centrifugal type with cast iron casing, stainless steel or cast iron impeller and stainless steel shaft. Glands packed with mechanical seals shall be used.

(ii) Pump glands shall be covered by an anti-splash and the pump shall be housed over a mild steel catchment tray which drains to a sump.

(iii) Alternatively, glandless centrifugal pumps with magnetic couplings shall be used.

(iv) As an alternative to centrifugal pumps, positive displacement pumps of the reciprocating type or progressive cavity type may be used.

(v) Centrifugal, reciprocating and progressive cavity pumps shall be as specified in the relevant section of the specifications.

(vi) Connections shall be provided for draining and flushing out the pumps.

(vii) Recirculation pumps shall be located in bunded areas and shall be fully accessible for operating and maintenance purposes without personnel having to enter the bund itself.

(n) Pipework

(i) Pipework shall be stainless steel Type 316S13 to BS EN 10029, BS EN 10259, BS EN 10258, BS EN 10048, BS EN 10095, BS EN 10051. Plastic pipework shall only be used for diluted caustic soda.

(ii) Stainless steel pipework shall be type 316S13 to BS EN 10216 and BS EN 10217 and shall be flanged. Fittings shall comply with BS EN 10253 Part 4. All welding shall be carried out to BS 4677 and procedures shall be subject to approval in accordance with BS EN ISO 15614-1:2004+A2:2012. Welders shall be tested by an independent testing authority and shall satisfy the requirements of BS EN ISO 9606-1.

(iii) All welds shall be dressed.

(iv) Alternative plastic materials such as polypropylene and polyvinylidene difluoride (PVDF) may be used in certain circumstances subject to approval by the ENGINEER

(v) Flanges shall conform to BS EN 1092 with minimum PN 10 where appropriate.

(vi) Joint rings for plastic pipework shall be of Viton encapsulated in PTFE.

(o) Isolating valves

(i) Isolating valves shall be of the diaphragm type with uPVC bodies, glass filled polypropylene top works and PTFE diaphragms. Assembly nuts and bolts shall be stainless steel.

(ii) End fittings may be plain sockets for solvent welding or flanged as appropriate. Flanges shall be to BS EN 1092 with minimum PN16 or PN 25 where appropriate.

(iii) These valves may not be used for isolating tank outlets and drains unless otherwise approved by the ENGINEER

(iv) Main isolating valves for tank outlet and drain shall be of the tapered plug type with PTFE sleeve and cast iron body.

(v) All valves shall be tested in accordance with BS 12266: Part 1.

(p) Rubber lined valves

(i) General isolating valves requiring rubber-lining shall be of the diaphragm type to BS EN 13397 with weir bodies in grey cast iron to BS EN 1561 grade 220 (or alternative grade allowed by the design standard) having integral flanged ends, a natural rubber ebonite lining, PTFE diaphragms and top works in standard proprietary materials.

(ii) Assembly nuts and bolts shall be in stainless steel. The valves shall be flanged to BS EN 1092 with minimum PN 10 where appropriate.

1.28.19 Sulphuric Acid Plant

(a) General

This Section contains requirements which, where relevant to the Contract, shall apply to the supply, installation and testing of sulphuric acid plant.

(q) Storage tanks

(i) Capacity, design and fabrication

(ii) Storage tanks for 50% w/w H_2SO_4 shall be of enclosed vertical cylindrical construction, fabricated in either lined glass reinforced plastic or thermoplastic materials. Where differing concentration value(s) are specified in the Particular Specifications for the specific intended purpose, the particular specifications shall take precedence.

(iii) Glass reinforced plastic tanks shall be as specified above.

(iv) Thermoplastic tanks shall be as specified above.

(v) Steel tanks

1) Steel tanks shall comply with BS EN 14015. The tanks shall be rubber lined internally to BS 6374.

(vi) Filling arrangement

1) The filling point isolating valves shall be 2" diameter flanged PN10 rubber lined cast iron diaphragm valves fitted with a key-operated mechanical interlock which will release the key when in the fully closed position and otherwise hold the key captive. The interlock shall accept the key from the interlock serving the road vehicle delivery bund drain valve. The filling line drain valves shall be 1" diameter rubber lined cast iron diaphragm valves. Where stainless steel pipework is used, then both diaphragm valves shall also be in stainless steel.

(r) Dilution systems

Sulphuric acid solution shall be diluted prior to injection to improve mixing. The dilution ratio shall generally be as specified. Where necessary, dilution tees with PTFE coating may be implemented.

(s) System design

The dilution water system shall be designed such that it is impossible for sulphuric acid to contaminate the drinking water supply system by back-flow or other.

(t) System components

(i) The system shall incorporate all isolating valves for water and the chemical, check valves on the water inlets, flowmeter, flow regulating valves and flow switch for water supply.

(ii) An alarm shall be raised if the water flow rate to any dosing point falls below a present minimum.

(iii) In automatic systems, the water supply shall start and stop in proper sequence with the corresponding dosing system.

(u) Pipework

(i) Carbon steel pipework compatible only for certain concentrations of sulphuric acid shall be in accordance with the requirements below and shall be lined with natural rubber 3 mm thick to BS 6374.

(ii) Carbon steel pipework shall be specified in nominal diameters in accordance with BS 3600 Table 1 and shall be in seamless material to BSEN 10216 and BS EN 10217 grade 360 or 430.

(iii) Carbon steel fittings shall comply with BS EN 10253.

(iv) Unless otherwise specified, flanges for steel pipework shall be of the weld neck type, Type 11 to BS EN 1092 with the appropriate pressure designation but not less than PN10. Valves and other devices mounted in the pipework shall be supported independently of the pipes to which they connect.

(v) Welding of carbon steel shall be carried out in accordance with BS 2633 Class 1 arc welding. All welders shall be tested by an independent inspection authority and shall satisfy the requirements of BS EN 287–1.

(vi) All fabrication and corrosion protection such as lining of carbon steel shall be carried out at the manufacturers' works. Coating shall comply with the General Specifications on painting and protective coatings.

(v) Isolating valves

(i) Isolating valves for the storage tank filling line, outlet and drain shall be sleeved plug valves as set out above except that the bodies shall be lined with PTFE throughout.

(ii) Other isolating valves shall also meet this specification in instances where the pressure rating exceeds PN10.

(iii) All other isolating valves shall be of the diaphragm type to BS EN 13397 with weir bodies in grey cast iron to BS EN 1561 grade 220 (or alternative grade allowed by the design standard) or alternatively carbon steel, a natural rubber ebonite lining, PTFE diaphragm end top works in proprietary materials.

(iv) Assembly nuts and bolts shall be in stainless steel. The valves shall have integral flanges to BS EN 1092 PN10.

(v) All valves shall be tested in accordance with BS EN 12266-1.

1.28.20 Ferric Chloride Plant

(w) General

This Section contains requirements which, where relevant to the Contract, shall apply to the supply, installation and testing of ferric chloride plant.

(x) Storage tanks

(i) Capacity, design and fabrication

(ii) Storage tanks for 41% w/w Ferric Chloride shall be of enclosed vertical cylindrical construction, fabricated in either lined glass reinforced plastic or thermoplastic materials. Where differing concentration value(s) are specified in the Particular Specifications for the specific intended purpose, the particular specifications shall take precedence.

(iii) Glass reinforced plastic tanks shall be as specified above.

(iv) Thermoplastic tanks shall be as specified above.

(v) Steel tanks

1) Steel tanks shall comply with BS EN 14015. The tanks shall be rubber lined internally to BS 6374.

(vi) Filling arrangement

1) The pipe shall be in carbon steel to BS EN 10216 and BS EN 10217 with 3mm thick natural rubber to BS 6374 or polypropylene lining and shall be used as specified herein.

2) The filling point isolating valves shall be 2” diameter flanged PN10 rubber lined cast iron diaphragm valves fitted with a key-operated mechanical interlock which will release the key when in the fully closed position and otherwise hold the key captive. The interlock shall accept the key from the interlock serving the road vehicle delivery bund drain valve. The filling line drain valves shall be 1” diameter rubber lined cast iron diaphragm valves. Where stainless steel pipework is used, then both diaphragm valves shall also be in stainless steel.

(y) Dilution systems

Ferric chloride solution shall be diluted prior to injection to improve mixing. The dilution ratio shall generally be as specified. Where necessary, dilution tees with PTFE coating may be implemented.

(z) Pipework

(i) Carbon steel pipework compatible only for certain concentrations of ferric chloride shall be in accordance with the requirements below and shall be lined with natural rubber 3 mm thick to BS 6374.

(ii) Carbon steel pipework shall be specified in nominal diameters in accordance with BS 3600 Table 1 and shall be in seamless material to BSEN 10216 and BS EN 10217 grade 360 or 430.

(iii) Carbon steel fittings shall comply with BS EN 10253.

(iv) Unless otherwise specified, flanges for steel pipework shall be of the weld neck type, Type 11 to BS EN 1092 with the appropriate pressure designation but not less than PN10. Valves and other devices mounted in the pipework shall be supported independently of the pipes to which they connect.

(v) Welding of carbon steel shall be carried out in accordance with BS 2633 Class 1 arc welding. All welders shall be tested by an independent inspection authority and shall satisfy the requirements of BS EN 287–1.

(vi) All fabrication and corrosion protection such as lining of carbon steel shall be carried out at the manufacturers' works. Coating shall comply with the General Specifications on painting and protective coatings.

(aa) Isolating valves

(i) Isolating valves for the storage tank filling line, outlet and drain shall be sleeved plug valves as set out above except that the bodies shall be lined with PTFE throughout.

(ii) Other isolating valves shall also meet this specification in instances where the pressure rating exceeds PN10.

(iii) All other isolating valves shall be of the diaphragm type to BS EN 13397 with weir bodies in grey cast iron to BS EN 1561 grade 220 (or alternative grade allowed by the design standard) or alternatively carbon steel, a natural rubber ebonite lining, PTFE diaphragm end top works in proprietary materials.

(iv) Assembly nuts and bolts shall be in stainless steel. The valves shall have integral flanges to BS EN 1092 PN10.

(v) All valves shall be tested in accordance with BS EN 12266-1.

1.28.21 Sodium Silicofluoride Plant

(bb) General

This Section contains requirements which, where relevant to the Contract, shall apply to the supply, installation and testing of sodium silicofluoride plant.

(cc) Unloading and storage facilities

(i) Means shall be provided for unloading sodium silicofluoride from supplier's delivery vehicles and transferring the same to store. The packages may be in the form of palletised or individual bags.

(ii) Manual handling of packages within the store using sack trolleys or similar will be acceptable only when the maximum consumption does not exceed 100kg/day or as otherwise specified. Any lifting of packages below levels shall be fully mechanised.

(iii) The material shall be stored in their original packages in a cool and dry area on pallets.

(iv) All necessary steps shall be taken to alleviate hazards from sodium silicofluoride dust and to contain spillages during handling operations.

(dd) Solution Concentrations

(i) Stock solutions of sodium silicofluoride shall be prepared at a concentration less than its solubility at the lowest temperature of the water used to dissolve.

(ii) The solution preparation system shall be designed to accurately measure the quantity of the fluoride and the volume of water used to prepare a batch of solution.

(iii) All areas where fluoride dust is likely to be generated shall be provided with mechanical dust extraction/ filtration systems.

(ee) Charging System

The charging systems shall comprise all necessary means for unloading delivery vehicles, transferring the chemical into store, movement of the chemical into the charging area and for charging the dissolving tanks.

(ff) Dissolving tanks

(i) Dissolving tanks shall operate in a rotational batch basis with a cycle frequency as specified.

(ii) The tanks may be constructed from rubber lined mild steel or fibre reinforced polyester or alternative material approved by the ENGINEER

(iii) The tanks shall be provided with a bag loader which shall comprise a hinged lid to place the bag, a spike to retain the bag when the lid is in the closed position and coarse screen and shall be connected to a dust extractor.

(iv) Pneumatic conveying used to transfer the powder from bags to the dissolving tanks shall be vacuum operated, with the vacuum derived through air operated eductors. The system shall be designed to ensure that motive air is not contaminated with the powder.

(v) Any associated and necessary lifting equipment to raise chemical bags from storage area floor level to tank charging level shall be provided.

(vi) Unless specified, each tank shall be provided with a turbine type mixer constructed of stainless steel to PD 970 or BS EN ISO 18286 grade 316S11. Circular tanks shall be fitted with baffles to minimise vortex formation.

(gg) Dilution systems

(i) General

Sodium silicofluoride solution shall be diluted prior to injection to improve mixing. The dilution ratio shall generally be greater than 10.

(hh) Pipework

(i) Stainless steel pipework shall be type 316S13 to BS EN 10216 with tolerances in outside diameter to Table 1 of BS ISO 8434-2:2007 and tested in accordance with Category 2 requirements. Pipe couplings shall be light series compression Type A to BS EN 1452.

(ii) uPVC pipework shall be as specified above.

(iii) Reinforced plastics pipework shall be as specified above.

(iv) Alternative plastic materials such as polypropylene and polyvinylidene difluoride (PVDF) may be used in certain circumstances subject to approval by the ENGINEER

(v) Joint rings for steel pipework shall be compressed fibre or proprietary alternative approved by the ENGINEER

(ii) Isolating valves

(i) uPVC valves

1) Isolating valves shall be of the diaphragm type with uPVC bodies, glass filled polypropylene top works and PTFE diaphragms. Assembly nuts and bolts shall be stainless steel.

2) End fittings may be plain sockets for solvent welding or flanged as appropriate. Flanges shall be to BS EN 1092 PN10 minimum.

3) These valves may not be used for isolating tank outlets and drains unless otherwise approved by the ENGINEER

(ii) Stainless steel valves

1) Isolating valves shall be of the diaphragm type to BS EN 13397 with weir bodies in stainless steel 316C16 to BS EN 10293, having integral flanged ends, PTFE diaphragms and top works in standard proprietary materials. Assembly nuts and bolts shall be in stainless steel. The valves shall be flanged to BS EN 1092 PN10 minimum.

2) Isolating valves for tank outlets shall be of the sealed bonnet type.

3) All valves shall be tested in accordance with BS EN 12266-1.

1.28.22 Ammonium Sulphate Plant

(jj) General

This Section contains requirements which, where relevant to the Contract, shall apply to the supply and installation of an ammonium sulphate plant.

(kk) Unloading and storage facilities

(i) Means shall be provided for unloading ammonium sulphate from supplier's delivery vehicles and transferring the same to store. The packages may be in the form of palletised or individual bags.

(ii) Manual handling of packages within the store using sack trolleys or similar will be acceptable only when the maximum consumption does not exceed 100kg/day or as otherwise specified. Any lifting of packages below levels shall be fully mechanised.

(iii) The material shall be stored in their original packages in a cool and dry area on pallets.

(iv) All necessary steps shall be taken to alleviate hazards from ammonium sulphate dust and to contain spillages during handling operations.

(ll) Solution Concentrations

(i) Stock solutions of ammonium sulphate shall be prepared at a concentration less than its solubility at the lowest temperature of the water used to dissolve.

(ii) The solution preparation system shall be designed to accurately measure the quantity of the ammonium sulphate and the volume of water used to prepare a batch of solution.

(mm) Charging System

This Section covers the requirements of the chemical bag splitting machine and its associated equipment, including the roller table, inclined belt conveyor, horizontal screw conveyor, vertical/inclined screw conveyor, bag compactor and dust extraction unit.

(i) The splitting machine and accessories shall be of proven design with records of installation showing that they are free of operation and maintenance problems. In particular, the machine shall not be choked by small pieces of bag paper cut out during the splitting process.

(ii) In general, chemical bags shall be loaded onto the roller table and shifted one by one to the inclined belt conveyor for automatic transfer to the splitting machine. The splitting machine shall then cut the chemical bags, sieve the bag fabrics, separate and discharge the chemical to a screw conveyor assembly. The screw conveyor assembly comprising horizontal (or slightly inclined), vertical and/or inclined screw conveyors shall transfer the chemical from the splitting machine into the chemical hoppers. Waste bags discharged from the splitting machine shall be compacted into a plastic sack for collection and subsequent disposal. The splitting machine and associated equipment shall be fully enclosed for dust containing in operation. A dust extraction unit shall be provided to prevent dust from flying out of the system during operation.

(iii) The splitting machine and its associated equipment shall be fabricated from stainless steel grade 316 (termed as “stainless steel” hereafter).

(iv) The charging systems shall comprise all necessary means for unloading delivery vehicles, transferring the chemical into store, movement of the chemical into the charging area and for charging the dissolving tanks.

(v) Conveyor loading tables shall be used to transfer the powder bags at floor level to a bag splitter.

(vi) The conveying unit shall comprise a bag splitter with integral grinder and a bag inlet, self-operating outlet of the flap type, level switch, replaceable dust filter with automatic pulse jet filter purge and waste bag compactor.

(vii) The conveying unit shall be suitable for mounting on a bag splitter. The bag splitter shall be provided with a dust extractor complete with a filter.

(viii) Any lifting equipment such as hoists necessary to raise chemical bags from storage area floor level to tank charging level shall be provided.

(ix) All areas where ammonium sulphate dust is likely to be generated shall be provided with ambient air mechanical dust extraction/ filtration systems.

(x) The powder in the bag splitter shall be transferred by conveyor. The system shall comprise a flexible hose complete with a pipe terminating in a nozzle into the hopper. The unit shall be of stainless steel construction. A 'no-powder' alarm shall be provided which shall cut out the motor after three attempts.

(xi) The feeding unit shall incorporate a screw feeder for accurately metering the powder to the wetting device. The screw feeder shall operate under control of an adjustable timer to provide a means of varying the batch concentration. The reproducibility of the feeder shall be better than + or - 3% by weight.

(nn) Vacuum bag loaders

(i) Vacuum bag lifters shall comprise an extendible flexible lift tube with manually directed suction operating foot. Operating vacuum shall be provided by an electrically operated vacuum pump. Raising and lowering of the suction foot shall be achieved by adjustment of the air flow in the lift tube; air flow shall be controlled by a trigger mechanism or similar hand operated device on the operating foot.

(ii) The unit shall be capable of lifting bags or drums of up to 50kg. The suction foot shall be suitable for lifting paper, plastic, woven polypropylene or jute sacks as applicable. Precautions shall be taken to minimise wear at the attachment point of the suction foot to the lifting tube.

(iii) The lift tube shall be in reinforced plastic material and shall be capable of lifting bags to any height between 150mm and at least 1400mm above floor level unless otherwise specified. Lateral movement either side of vertical of at least 500mm shall be possible when the tube is fully extended. PVC hosing with steel reinforcing wire shall be used for the suction tube connecting the vacuum pump to the lift tube.

(iv) When specified for installation on a support jib the design shall allow loads to be lifted and manoeuvred upwards, downwards, sideways or rotated through a minimum of 270^0 for exact position requirement. Vacuum hose shall be provided with catenary supports. Jibs and associated stanchions, where specified, shall be of mild steel.

(v) A safety release system shall be incorporated to ensure that loads are handled with complete safety in the event of a sudden loss of vacuum.

(vi) The vacuum generation system shall be powered by an electric motor protected to at least IP54. Precautions shall be taken to prevent excessive vacuum from harming the vacuum pump.

(vii) The system shall be provided with an in line cartridge filter system. A "bin" filter system, fitted with a primary cloth element and a secondary cartridge filter, shall be provided to protect the pump when the unit is to be installed in a particularly dust prone area.

(oo) Roller table

(i) The roller table shall be formed from rollers with sealed-for-life bearings attached to a frame fixed onto the floor.

(ii) The top of the roller table shall be about 1000 mm above the floor to facilitate manual loading and manoeuvring of chemical bags.

(iii) The outside diameter of rollers shall not be less than 65 mm and the clearance between rollers shall be not less than 40 mm.

(pp) Inclined belt conveyor

(i) The belt conveyor shall be complete with flat rubber belt, carrying idlers, return rollers, head and tail drums, side guards, loading end guards and adjustable support legs, etc., suitable for handling chemical bags of dimensions as specified.

(ii) The usable width of the belt conveyor shall be not less than 500 mm. The belting material shall comply with the requirements of BS EN ISO 14890 and the belt edge clearance shall be in accordance with BS 8438.

(iii) The conveyor shall be designed to contain all the chemical powder escaped from the chemical bags so that no chemical powder would fall from the conveyor belt onto the floor during operation.

(iv) The belt speed shall be designed to match the capacity of the bag splitting machine as specified. However, in no circumstances a belt speed greater than 18 m/min shall be accepted. In the design of belt speed, the inclination of the belt conveyor shall be taken into account, and slatted belt instead of flat belt shall be used if the inclination of the belt conveyor together with the designed belt speed may render the chemical bags to slide down or tip over from the conveyor.

(v) Provision shall be made in the design of the conveyor for maintaining the belt tension automatically and the adjustment of the tail pulley of the conveyor to ensure the squareness of the belt. Intermediate guide rollers shall be provided to keep the belt in alignment.

(vi) Bearings of all rolling elements of the conveyor shall be of the sealed-for-life type.

(vii) Each conveyor shall be driven by a geared electric motor which shall be integral with the head drum. The motor shall have a degree of protection of IP 55 to BS EN 60034-5 and its design shall be suitable for intermittent operation. A mechanical overload protection and anti-run-back device shall be provided.

(qq) Bag splitters

(i) Automatic bag splitters shall accept all bag sizes up to 1200 x 600 x 280mm containing up to 50kg material.

(ii) Bags shall be introduced via an automatic infeed conveyor at a rate of up to 600 bags per hour.

(iii) Sacks shall be split by rotary blades which shall adjust automatically to the size of bags introduced to the splitter. Blades shall be selected for long life, taking into account the bag material type and the properties of the chemical being handled.

(iv) Splitters shall be suitable for handling all types of paper, plastic and jute sacking materials.

(v) Splitters shall be designed to ensure that a minimum of 99% of bag contents is recovered from each bag. Discharged chemical shall fall through an outlet screen where extraneous material shall be removed.

(vi) Empty bags shall be discharged automatically into an integral compactor unit which shall extrude emptied and compacted bags into receiving bags.

(vii) Geared drive assemblies shall be protected from contact with chemical being discharged so far as possible. Viewing windows shall be provided to allow inspection of the internals of the bag splitting section during operation.

(viii) Bag splitters shall be designed to minimise dust escape into the atmosphere and shall be provided with integral dust control and pulse jet dust extraction systems. These shall be self-cleaning and shall return collected material to the discharge outlet from the splitter.

(ix) Bag splitters shall be fabricated from mild steel, suitably protected to suit the chemical being handled.

(x) Control units for each bag splitter shall be located adjacent to the loading station, readily accessible to the operator.

(rr) Bag Compactor

(i) Each bag splitting machine shall be equipped with its own bag compactor to reduce the volume of the waste bags to less than one sixth of the original volume. The empty bags shall be transferred to the bag compactor automatically without manual operation.

(ii) The bag compactor shall be of mechanical type or hydraulic type. A discharge nozzle shall be provided for transferring and compacting waste bags into a plastic sack. The discharge nozzle shall be not less than 400 mm in diameter, fabricated from not less than 6 mm thick stainless steel plate with a compactor transition section made of not less than 9 mm thick stainless steel plate.

(iii) The bag compactor shall be mounted on the floor to facilitate operation and maintenance. The compactor housing shall be fabricated of structural steel and steel panels. A bin with castors shall be provided at the bottom of the bag compactor to collect the residual chemical powder. The bin shall be constructed of stainless steel Type 316S13 to BS EN 10029, BS EN 10259, BS EN 10258, BS EN 10048, BS EN 10095, BS EN 10051 or other suitable corrosion and abrasive resistant suitable material approved by the ENGINEER

(ss) Horizontal Screw conveyor

(i) Horizontal screw conveyor shall be of trough type. Cross connections of horizontal and vertical screw conveyors for the formation of a chemical transfer system may be formed from tube type shell. The drive to the screw conveyor shall be by motor directly coupled to the drive-end gudgeon and bolted to a supporting stool forming the end plate of the conveyor. The flight of the screw conveyor shall be supported by sealed-for-life bearings. The motor shall have a degree of protection of IP 55 to BS EN 60034-5.

(ii) Conveyor trough shall be covered by lids with lapped edges for stiffness. Lids shall seat on rubber or other suitable material to completely seal off against the escape of dust and shall be secured by toggle catches of heavy industrial pattern. All joints shall be flanged and gasketed to prevent the escape of chemical dust.

(iii) Intermediate bearings shall be self-lubricating, carried on adjustable hangers, and capable of easy exchange of bushes. The spacing of intermediate bearings shall not exceed 2.5 m.

(iv) The sizing of the screw conveyor shall be such that when handling the rated capacity of the equipment discharging into the screw conveyor, the contents shall not flood the hanger bearing.

(v) The flight of the screw conveyor shall be at least 4 mm thick fabricated from stainless steel strip and continuously welded to the shaft to form a varying pitch helicoid flight. Where outlets occur at the end of conveyors, the end flight shall be opposite-handed to prevent material packing into the end plate.

(tt) Vertical / Inclined Screw conveyor

(i) Vertical/inclined screw conveyor shall be of tube type complete with inspection openings at cross connections. The drive to the screw conveyor shall be by motor directly coupled to the drive-end gudgeon. The drive shall be either bolted to a supporting stool forming the end plate or flange mounted to the conveyor. The flight of the screw conveyor shall be supported by sealed-for-life bearings. The motor shall have a degree of protection of IP 55 to BS EN 60034-5.

(ii) The conveyor tube shall be formed by continuously spiral welded stainless steel plate of not less than 5 mm thick and stainless steel inspection panels shall be at least 2 mm thick with lapped edges for stiffness. Inspection panels shall seat on rubber or other suitable material to completely seal off against the escape of dust and shall be secured by toggle catches of heavy industrial pattern.

(iii) The flight of the screw conveyor shall be supported from intermediate bearings of the sealed-for-life design. The weight of the flight supported by the drive motor shall not be accepted. Purposely made brackets shall be provided and installed for the support of the screw conveyor. Arrangement shall be made to provide access for routine inspection, maintenance and removal of the flight of the screw conveyor.

(iv) The vertical/inclined screw conveyor shall be designed for transferring chemical powder from a low level to a higher level. Powdered chemical entering the receiving port shall be lifted by continuous rotation of the flight whereas the dropping shall be achieved by gravity. Chemicals shall be discharged at the outlet chute of the screw conveyor in the form of a discharging duct at an inclined angle to the longitudinal axis of the conveyor. All joints shall be flanged and gasketed to prevent the escape of dust.

(v) The direction of rotation of the screw conveyor shall be designed to suit the associated upstream screw conveyor such that powdered chemical shall be discharged at the side port and removed by the screw at the cross connection.

(vi) The flight of the conveyor shall be at least 4 mm thick fabricated from stainless steel strip and continuously welded to the shaft to form a varying pitch helicoid flight.

(vii) Close tolerance fit between screw flight and conveyor casing shall be adopted for the conveyor design to allow efficient feed of powdered chemical with minimum operating noise. To facilitate maintenance, seals and bearings shall be of easily accessible design.

(uu) Chemical dust extraction unit

(i) Each bag splitting machine shall be equipped with its own dust extraction unit. The dust extraction unit shall be provided in such a way that no dust of appreciable concentration or quantity is discharged to the atmosphere. The filtered chemical dust shall be returned directly to the screening section for a built-in unit. Should an external unit be provided, a dust bin of not less than 50 litre shall be provided at the bottom of the dust extractor for the collection of filtered chemical dust.

(ii) The dust extractor shall be of stainless steel construction. The unit shall include an electrically driven dust extractor, chemical dust filter elements, side access doors and cable termination box. Dust extraction motor shall not be located inside the dust extractor.

(iii) The dust extractor shall be of side filter bag removal type. Removal of the filter assembly shall be effected from the front of the unit through a hinged access door. The filter assembly shall comprise flexible inserts which shall maintain the form of the element under dynamic air flow conditions.

(iv) Filter elements shall be made of suitable chemical resistant material and certified to BS EN 60335-2-69 Class L or better. Dust shall be removed from the filters by operation of a cleaning mechanism in the form of repulse air jets or vibration.

(v) All electrical components shall have IP65 or better enclosures to BS EN 60529.

(vi) Solenoid valves shall be manifolded. Each unit shall be furnished with solid state sequencing timer and air pressure gauge. A differential pressure indicator and switch shall be provided to the compressed air pipelines feeding the extractor. A high differential pressure alarm shall be provided when cleaning or replacement of filter bag is required.

(vii) If the connection between the dust extractor and the chemical handling equipment is by air duct, sizing of the air duct shall be designed to have the dust particles to travel at an optimum speed of not less than 18 m/s.

(vv) Solution tanks

(i) Solution tanks shall operate in a rotational batch basis with a cycle frequency as specified.

(ii) The tanks may be constructed from stainless steel Type 316S13 to BS EN 10029, BS EN 10259, BS EN 10258, BS EN 10048, BS EN 10095, BS EN 10051or other suitable corrosion and abrasive resistant material approved by the ENGINEER. Mild steel tanks shall not be used.

(iii) Each tank shall be provided with a turbine type mixer constructed of stainless steel to BS EN 10095, BS EN 10250-4, BS EN 10085, PD 970, BS EN 10087, BS EN 10083-1, BS EN 10084 or BS EN 10029, BS EN 10259, BS EN 10258, BS EN 10048, BS EN 10095, BS EN 10051 grade 316S11. Circular tanks shall be fitted with baffles to minimise vortex formation.

(ww) Pumps

(i) Variable stroke mechanisms shall be incorporated in the drive arrangement to allow infinitely variable adjustment of pump output by means of a micrometer, hand wheel or similar mechanical device whilst the pump is running.

(ii) Where the pump is part of an automatic coagulation control or other process control loop, the stroke mechanism shall be fitted with a three phase bi directional motor with torque limiter and automatic stops at both extremes of travel. A position feedback potentiometer shall be provided to facilitate control and remote indication of position. The operational range of stroke adjustment shall be not less than 6:1.

(iii) Where the pump output is specified to be proportional to flow past the dosing point, then the pump output shall be varied by altering the pump speed and not by altering the pump stroke.

(iv) The pump head shall be driven through a totally enclosed speed reduction gearbox with integral reciprocating drive device of the adjustable crank or mechanical lost motion type. The gearbox and reciprocating drive shall be oil bath lubricated. The unit shall incorporate filling and drain plugs for oil and an oil level indicator.

(v) Drive motors shall be of the three phase cage induction type whether for fixed speed or variable speed operation.

(vi) Where variable speed operation is specified, the speed turn down ratio shall be not less than 5:1.

(vii) Transfer pumps shall be progressive cavity type with rotors of hardened steel and stators shall be moulded to metal type using natural or synthetic rubber.

(viii) Dosing pumps of horizontal end-suction centrifugal pumps of the back pull-out type shall be used for dosing to final water. Pumps shall be constructed in suitable plastic materials such as glass-filled epoxy resin or high density polyethylene with external metal armouring.

(ix) The pumps shall be of the mechanical seal type. Alternatively sealless magnetic-drive pumps shall be used.

(xx) Dilution systems

(i) Ammonium sulphate solution shall be diluted prior to injection to improve mixing. The dilution ratio shall generally be as specified in the relevant section of the specifications.

(yy) Pipework

(i) Stainless steel pipework shall be type 316S13 to BS EN 10216 Part 5 with tolerances in outside diameter to BS ISO 8434-2, BS EN ISO 8434-1and tested in accordance with Category 2 requirements. Pipe couplings shall be light series compression to BS ISO 8434-2.

(ii) uPVC pipework shall be as specified above.

(iii) Reinforced plastics shall be as specified above.

(iv) Alternative plastic materials such as polypropylene and polyvinylidene difluoride (PVDF) may be used in certain circumstances subject to approval by the Engineer.

(v) Joint rings for steel pipework shall be proprietary and approved by the ENGINEER

(zz) uPVC valves

(i) Isolating valves shall be of the diaphragm type with uPVC bodies, glass filled polypropylene top works and PTFE diaphragms. Assembly nuts and bolts shall be stainless steel.

(ii) End fittings may be plain sockets for solvent welding or flanged as appropriate. Flanges shall be to BS EN 1092 with minimum PN16 or PN 25 where appropriate.

(iii) These valves may not be used for isolating tank outlets and drains unless otherwise approved by the ENGINEER

(aaa) Stainless steel valves

(i) Isolating valves shall be of the diaphragm type to BS EN 13397 with weir bodies in stainless steel 316C16 to BS EN 10293, having integral flanged ends, PTFE diaphragms and top works in standard proprietary materials. Assembly nuts and bolts shall be in stainless steel. The valves shall be flanged to BS EN 1092 with minimum PN10 or PN 16 where appropriate.

(ii) Isolating valves for tank outlets shall be of the sealed bonnet type.

(iii) All valves shall be tested in accordance with BS EN 12266-1, BS EN 12266-2.

1.28.23 Citric acid plant

(bbb) General

This Section contains requirements which, where relevant to the Contract, shall apply to the supply and installation of citric acid plant.

(ccc) Storage Tanks (for dilute acid)

(i) Storage tanks for citric acid (e.g. 50% w/w) shall be of enclosed vertical cylindrical construction, fabricated from fibre glass reinforced polyester or uPVC lined glass reinforced plastic complying with BS EN 13923 AND BS EN 13121 or alternatively from high density polyethylene. Where differing concentration value(s) are specified in the Particular Specifications for the specific intended purpose, the particular specifications shall take precedence.

(ddd) Pipework

(i) Stainless steel pipework shall be type 316S11 to BS EN 10216 and BS EN 10217. Flanges shall be of stainless steel type 316C12 to BS EN 10213 if cast type or type 316S11 to BS EN 10222 if forged.

(ii) Thermoplastic pipework may be uPVC, polyvinylidene difluoride (PVDF), polypropylene or uPVC lined GRP or fibre reinforced polyester.

(iii) All uPVC pipework used as liners shall be `hi-impact` type to BS EN 1452 Parts 1 to 5 or BS 3506 Class E, with solvent welded joints and fittings complying with the relevant parts of BS EN 1452. Reinforced plastics shall comply with BS 6464 and shall contain an uPVC liner as specified. The pipework shall be fabricated and assembled such that only the liner comes into contact with the fluid. The piping system shall be designed and constructed in accordance with BS 7159.

(iv) Where flanged joints are required in thermoplastic pipework, full face plastic flanges, where available, and stainless steel backing rings shall be used. Flanges shall conform to BS EN1092-1 PN16 minimum.

(v) Joint rings shall be of Viton encapsulated in PTFE.

(vi) Where reinforced plastics such as fibre reinforced polyester or GRP are used, these shall comply with BS6464 and FRP shall contain an uPVC liner if required, as specified above for uPVC pipework. The pipework shall be fabricated and assembled such that only the liner comes into contact with the fluid.

(vii) The piping system shall be designed and constructed in accordance with BS 7159.

(viii) Flanges shall conform to BS EN1092-1 PN 16 minimum.

(eee) Valves

(i) Isolating valves

1) Isolating valves for the storage tank filling line, outlet and drain and those where the pressure rating exceeds PN10 shall be sleeved plug valves having forged bodies in carbon steel lined with PTFE throughout and with integral flanges, tapered plug with PTFE sleeve, top seal arrangement with PTFE diaphragm and delta seal ring, back up metal diaphragm, floating thrust collar, electrostatic eliminator, four bolt cover and three point self-aligning plug adjustment. The valve design shall ensure that excess pressure in the plug and body cavity of the closed valve is relieved spontaneously towards the direction of high pressure. The valve shall be operated by a forged steel wrench with padlocking facility in the closed position or otherwise by power actuator as specified. Where necessary, a remote operating linkage shall be provided.

2) Valves shall be flanged to BS EN 1092 PN10 minimum.

3) All valves shall be tested in accordance with BS EN 12266-1.

4) All other isolating valves shall be of the diaphragm type to BS EN 13397 with weir bodies in grey cast iron to BS EN 1561 grade 220 (or alternative grade allowed by the design standard) or alternatively carbon steel, a natural rubber ebonite lining, PTFE diaphragm end top works in proprietary materials. Assembly nuts and bolts shall be in stainless steel. The valves shall have integral flanges to BS EN 1092 PN10.

5) All valves shall be tested in accordance with BS EN 12266-1.

1.28.24 Sodium Bisulphite Plant

(fff) General

This Section contains requirements which, where relevant to the Contract, shall apply to the supply, installation of sodium bisulphite plant.

(ggg) Storage Tanks

(i) Capacity, design and fabrication

(ii) Storage tanks for sodium bisulphite (20% w/w to 35% w/w) shall be of enclosed vertical cylindrical construction, fabricated from uPVC lined glass reinforced plastic complying with BS EN 13923 AND BS EN 13121 or from stainless steel type 304S14 to BS EN 10216 AND BS EN 10217 or polypropylene or fibre reinforced polyester. The tanks shall be designed for storing the acid at up to 38% w/w concentration. Where differing concentration value(s) are specified in the Particular Specifications for the specific intended purpose, the particular specifications shall take precedence.

(iii) Filling arrangement

1) The pipe shall be in stainless steel type 316S13 to BS EN 10216 and BS EN 10217 or carbon steel to BS EN 10216 with 3mm thick natural rubber or polypropylene lining.

2) Pipework

(hhh) Pipework

(i) Stainless steel pipework shall be type 316S11 to BS EN 10216-5 or 10217-7. Flanges shall be of stainless steel type 316C12 to BS EN 10213 if cast type or type 316S11 to BS EN 10222 if forged.

(ii) Thermoplastic pipework may be uPVC, polyvinylidene difluoride (PVDF), polypropylene or uPVC lined GRP or fibre reinforced polyester.

(iii) All uPVC pipework used as liners shall be `hi-impact` type to BS EN 1452 parts 1 to 5 or BS 3506 Class E, with solvent welded joints and fittings complying with the relevant parts of BS EN 1452. Reinforced plastics shall comply with BS 6464 and shall contain an uPVC liner as specified. The pipework shall be fabricated and assembled such that only the liner comes into contact with the fluid. The piping system shall be designed and constructed in accordance with BS 7159.

(iv) Where flanged joints are required in thermoplastic pipework, full face plastic flanges, where available, and stainless steel backing rings shall be used. Flanges drilling shall conform to BS EN1092-1 PN16 minimum.

(v) Joint rings shall be of Viton encapsulated in PTFE.

(vi) Where reinforced plastics such as fibre reinforced polyester GRP are used, these shall comply with BS6464 and shall contain an uPVC Liner if required, as specified above for uPVC pipework. The pipework shall be fabricated and assembled such that only the liner comes into contact with the fluid.

(vii) The piping system shall be designed and constructed in accordance with BS 7159.

(viii) Flanges drilling shall conform to BS EN1092-1 PN 16 minimum.

(iii) Valves

(i) Isolating valves for the storage tank filling line, outlet and drain and those where the pressure rating exceeds PN10 shall be sleeved plug valves having forged bodies in carbon steel lined with PTFE throughout and with integral flanges, tapered plug with PTFE sleeve, top seal arrangement with PTFE diaphragm and delta seal ring, back up metal diaphragm, floating thrust collar, electrostatic eliminator, four bolt cover and three point self-aligning plug adjustment.

1) The valve design shall ensure that excess pressure in the plug and body cavity of the closed valve is relieved spontaneously towards the direction of high pressure. The valve shall be operated by a forged steel wrench with padlocking facility in the closed position or otherwise by power actuator as specified. Where necessary, a remote operating linkage shall be provided.

2) Valves shall be flanged to BS EN 1092 PN10 minimum.

3) All valves shall be tested in accordance with BS EN 12266-1.

4) All other isolating valves shall be of the diaphragm type to BS EN 13397 with weir bodies in grey cast iron to BS EN 1561 grade 220 (or alternative grade allowed by the design standard) or alternatively carbon steel, a natural rubber ebonite lining, PTFE diaphragm end top works in proprietary materials. Assembly nuts and bolts shall be in stainless steel. The valves shall have integral flanges to BS EN 1092 PN10.

5) All valves shall be tested in accordance with BS EN 12266-1.

(ii) Loading valves

1) The valves shall be of the tubular pinch type pressurised externally with compressed air or of an alternative approved type.

1.28.25 Polyelectrolyte Plant

(a) General

This Section contains requirements which, where relevant to the Contract, shall apply to the supply, installation and testing of polyelectrolyte plant.

(jjj) Polyelectrolyte products

The polyelectrolyte plant shall be suitable for use with the chemical product or selection of products specified in the Particular Specifications.

(kkk) Polyelectrolyte plant configuration

(i) Polyelectrolyte plant for handling powdered or granular material shall comprise all necessary means for charging, feeding, wetting, dissolving, ageing and storage of the specified products.

(ii) The plant shall comprise a single train of the following systems which may be assembled into a packaged unit.

1) charging, storage, feeding and wetting units;

2) dissolving/ageing tank;

3) stock tank.

(iii) If dissolving tank and stock tank are set at the same level or gravity transfer is not possible, the system shall incorporate a suitable transfer pump.

(iv) Where full standby provision is required, the packaged unit comprising charging, storage, feeding and wetting unit, dissolving/ageing tank and stock tank shall be duplicated.

(v) Where pumps are required to transfer polyelectrolyte from dissolving/ageing tank to stock tank, these shall be duplicated and shall be capable of operating with any combination of tanks.

(lll) Polyelectrolyte concentration.

The polyelectrolyte plant shall be designed to prepare stock solution of polyelectrolytes at concentrations up to those recommended by the product manufacturer. The solution shall be diluted 5 to 10 fold for dosing purposes.

(mmm) Charging systems

(i) This Section covers the requirements of the chemical bag splitting machine and its associated equipment, including the roller table, inclined belt conveyor, horizontal screw conveyor, vertical/inclined screw conveyor, bag compactor and dust extraction unit.

(ii) The splitting machine and accessories shall be of proven design with records of installation showing that they are free of operation and maintenance problems. In particular, the machine shall not be choked by small pieces of bag paper cut out during the splitting process.

(iii) In general, chemical bags shall be loaded onto the roller table and shifted one by one to the inclined belt conveyor for automatic transfer to the splitting machine.

(iv) The splitting machine shall then cut the chemical bags, sieve the bag fabrics, separate and discharge the chemical to a screw conveyor assembly.

(v) The screw conveyor assembly comprising horizontal (or slightly inclined), vertical and/or inclined screw conveyors shall transfer the chemical from the splitting machine into the chemical hoppers.

(vi) Waste bags discharged from the splitting machine shall be compacted into a plastic sack for collection and subsequent disposal.

(vii) The splitting machine and associated equipment shall be fully enclosed for dust containing in operation. A dust extraction unit shall be provided to prevent dust from flying out of the system during operation.

(viii) The splitting machine and its associated equipment shall be fabricated from stainless steel grade 316 (termed as “stainless steel” hereafter).

(ix) The charging systems shall comprise all necessary means for unloading delivery vehicles, transferring the chemical into store, movement of the chemical into the charging area and for charging the dissolving tanks.

(x) Conveyor loading tables shall be used to transfer the powder bags at floor level to a bag splitter.

(xi) The conveying unit shall comprise a bag splitter with integral grinder and a bag inlet, self-operating outlet of the flap type, level switch, replaceable dust filter with automatic pulse jet filter purge and waste bag compactor.

(xii) The conveying unit shall be suitable for mounting on a bag splitter. The bag splitter shall be provided with a dust extractor complete with a filter.

(xiii) Any lifting equipment such as hoists necessary to raise chemical bags from storage area floor level to tank charging level shall be provided.

(xiv) All areas where polyelectrolyte dust is likely to be generated shall be provided with ambient air mechanical dust extraction/ filtration systems.

(nnn) Vacuum bag loaders

(i) Vacuum bag lifters shall comprise an extendible flexible lift tube with manually directed suction operating foot. Operating vacuum shall be provided by an electrically operated vacuum pump. Raising and lowering of the suction foot shall be achieved by adjustment of the air flow in the lift tube; air flow shall be controlled by a trigger mechanism or similar hand operated device on the operating foot.

(ii) The unit shall be capable of lifting bags or drums of up to 50kg. The suction foot shall be suitable for lifting paper, plastic, woven polypropylene or jute sacks as applicable. Precautions shall be taken to minimise wear at the attachment point of the suction foot to the lifting tube.

(iii) Extendible flexible lift tube with manually directed suction operating foot. Operating vacuum shall be provided by an electrically operated vacuum pump. Raising and lowering of the suction foot shall be achieved by adjustment of the air flow in the lift tube; air flow shall be controlled by a trigger mechanism or similar hand operated device on the operating foot.

(iv) The unit shall be capable of lifting bags or drums of up to 50kg. The suction foot shall be suitable for lifting paper, plastic, woven polypropylene or jute sacks as applicable. Precautions shall be taken to minimise wear at the attachment point of the suction foot to the lifting tube.

(v) The lift tube shall be in reinforced plastic material and shall be capable of lifting bags to any height between 150mm and at least 1400mm above floor level unless otherwise specified. Lateral movement either side of vertical of at least 500mm shall be possible when the tube is fully extended. PVC hosing with steel reinforcing wire shall be used for the suction tube connecting the vacuum pump to the lift tube.

(vi) When specified for installation on a support jib the design shall allow loads to be lifted and manoeuvred upwards, downwards, sideways or rotated through a minimum of 270^0 for exact position requirement. Vacuum hose shall be provided with catenary supports. Jibs and associated stanchions, where specified, shall be of mild steel.

(vii) A safety release system shall be incorporated to ensure that loads are handled with complete safety in the event of a sudden loss of vacuum.

(viii) The vacuum generation system shall be powered by an electric motor protected to at least IP54. Precautions shall be taken to prevent excessive vacuum from harming the vacuum pump.

(ix) The system shall be provided with an in line cartridge filter system. A "bin" filter system, fitted with a primary cloth element and a secondary cartridge filter, shall be provided to protect the pump when the unit is to be installed in a particularly dust prone area.

(ooo) Roller table

The roller table shall be formed from rollers with sealed-for-life bearings attached to a frame fixed onto the floor. The top of the roller table shall be about 1000 mm above the floor to facilitate manual loading and manoeuvring of chemical bags. The outside diameter of rollers shall not be less than 65 mm and the clearance between rollers shall be not less than 40 mm.

(ppp) Inclined belt conveyor

(i) The belt conveyor shall be complete with flat rubber belt, carrying idlers, return rollers, head and tail drums, side guards, loading end guards and adjustable support legs, etc., suitable for handling chemical bags of dimensions as specified.

(ii) The usable width of the belt conveyor shall be not less than 500 mm. The belting material shall comply with the requirements of BS EN ISO 14890 and the belt edge clearance shall be in accordance with BS 8438.

(iii) The conveyor shall be designed to contain all the chemical powder escaped from the chemical bags so that no chemical powder would fall from the conveyor belt onto the floor during operation.

(iv) The belt speed shall be designed to match the capacity of the bag splitting machine. However, in no circumstances a belt speed greater than 18 m/min shall be accepted. In the design of belt speed, the inclination of the belt conveyor shall be taken into account, and slatted belt instead of flat belt shall be used if the inclination of the belt conveyor together with the designed belt speed may render the chemical bags to slide down or tip over from the conveyor.

(v) Provision shall be made in the design of the conveyor for maintaining the belt tension automatically and the adjustment of the tail pulley of the conveyor to ensure the squareness of the belt. Intermediate guide rollers shall be provided to keep the belt in alignment.

(vi) Bearings of all rolling elements of the conveyor shall be of the sealed-for-life type.

(vii) Each conveyor shall be driven by a geared electric motor which shall be integral with the head drum. The motor shall have a degree of protection of IP 55 to BS EN 60034-5 and its design shall be suitable for intermittent operation. A mechanical overload protection and anti-run-back device shall be provided.

(qqq) Bag splitters

(i) Automatic bag splitters shall accept all bag sizes up to 1200 x 600 x 280mm containing up to 50kg material.

(ii) Bags shall be introduced via an automatic infeed conveyor at a rate of up to 600 bags per hour.

(iii) Sacks shall be split by rotary blades which shall adjust automatically to the size of bags introduced to the splitter. Blades shall be selected for long life, taking into account the bag material type and the properties of the chemical being handled.

(iv) Splitters shall be suitable for handling all types of paper, plastic and jute sacking materials.

(v) Splitters shall be designed to ensure that a minimum of 99% of bag contents is recovered from each bag. Discharged chemical shall fall through an outlet screen where extraneous material shall be removed.

(vi) Empty bags shall be discharged automatically into an integral compactor unit which shall extrude emptied and compacted bags into receiving bags.

(vii) Geared drive assemblies shall be protected from contact with chemical being discharged so far as possible. Viewing windows shall be provided to allow inspection of the internals of the bag splitting section during operation.

(viii) Bag splitters shall be designed to minimise dust escape into the atmosphere and shall be provided with integral dust control and pulse jet dust extraction systems. These shall be self-cleaning and shall return collected material to the discharge outlet from the splitter.

(ix) Bag splitters shall be fabricated from mild steel, suitably protected to suit the chemical being handled.

(x) Control units for each bag splitter shall be located adjacent to the loading station, readily accessible to the operator.

(rrr) Bag Compactor

(i) Each bag splitting machine shall be equipped with its own bag compactor to reduce the volume of the waste bags to less than one sixth of the original volume. The empty bags shall be transferred to the bag compactor automatically without manual operation.

(ii) The bag compactor shall be of mechanical type or hydraulic type. A discharge nozzle shall be provided for transferring and compacting waste bags into a plastic sack. The discharge nozzle shall be not less than 400 mm in diameter, fabricated from not less than 6 mm thick stainless steel plate with a compactor transition section made of not less than 9 mm thick stainless steel plate.

(iii) The bag compactor shall be mounted on the floor to facilitate operation and maintenance. The compactor housing shall be fabricated of structural steel and steel panels. A bin with castors shall be provided at the bottom of the bag compactor to collect the residual chemical powder.

(sss) Horizontal Screw conveyor

(i) Horizontal screw conveyor shall be of trough type. Cross connections of horizontal and vertical screw conveyors for the formation of a chemical transfer system may be formed from tube type shell. The drive to the screw conveyor shall be by motor directly coupled to the drive-end gudgeon and bolted to a supporting stool forming the end plate of the conveyor. The flight of the screw conveyor shall be supported by sealed-for-life bearings. The motor shall have a degree of protection of IP 55 to BS EN 60034-5.

(ii) Conveyor trough shall be covered by lids with lapped edges for stiffness. Lids shall seat on rubber or other suitable material to completely seal off against the escape of dust and shall be secured by toggle catches of heavy industrial pattern. All joints shall be flanged and gasketed to prevent the escape of chemical dust.

(iii) Intermediate bearings shall be self-lubricating, carried on adjustable hangers, and capable of easy exchange of bushes. The spacing of intermediate bearings shall not exceed 2.5 m.

(iv) The sizing of the screw conveyor shall be such that when handling the rated capacity of the equipment discharging into the screw conveyor, the contents shall not flood the hanger bearing.

(v) The flight of the screw conveyor shall be at least 4 mm thick fabricated from stainless steel strip and continuously welded to the shaft to form a varying pitch helicoid flight. Where outlets occur at the end of conveyors, the end flight shall be opposite-handed to prevent material packing into the end plate.

(ttt) Vertical/ Inclined Screw conveyor

(i) Vertical/inclined screw conveyor shall be of tube type complete with inspection openings at cross connections. The drive to the screw conveyor shall be by motor directly coupled to the drive-end gudgeon. The drive shall be either bolted to a supporting stool forming the end plate or flange mounted to the conveyor. The flight of the screw conveyor shall be supported by sealed-for-life bearings. The motor shall have a degree of protection of IP 55 to BS EN 60034-5.

(ii) The conveyor tube shall be formed by continuously spiral welded stainless steel plate of not less than 5 mm thick and stainless steel inspection panels shall be at least 2 mm thick with lapped edges for stiffness. Inspection panels shall seat on rubber or other suitable material to completely seal off against the escape of dust and shall be secured by toggle catches of heavy industrial pattern.

(iii) The flight of the screw conveyor shall be supported from intermediate bearings of the sealed-for-life design. The weight of the flight supported by the drive motor shall not be accepted. Purposely made brackets shall be provided and installed for the support of the screw conveyor. Arrangement shall be made to provide access for routine inspection, maintenance and removal of the flight of the screw conveyor.

(iv) The vertical/inclined screw conveyor shall be designed for transferring chemical powder from a low level to a higher level. Powdered chemical entering the receiving port shall be lifted by continuous rotation of the flight whereas the dropping shall be achieved by gravity. Chemicals shall be discharged at the outlet chute of the screw conveyor in the form of a discharging duct at an inclined angle to the longitudinal axis of the conveyor. All joints shall be flanged and gasketed to prevent the escape of dust.

(v) The direction of rotation of the screw conveyor shall be designed to suit the associated upstream screw conveyor such that powdered chemical shall be discharged at the side port and removed by the screw at the cross connection.

(vi) The flight of the conveyor shall be at least 4 mm thick fabricated from stainless steel strip and continuously welded to the shaft to form a varying pitch helicoid flight.

(vii) Close tolerance fit between screw flight and conveyor casing shall be adopted for the conveyor design to allow efficient feed of powdered chemical with minimum operating noise. To facilitate maintenance, seals and bearings shall be of easily accessible design.

(uuu) Chemical dust extraction unit

(i) Each bag splitting machine shall be equipped with its own dust extraction unit. The dust extraction unit shall be provided in such a way that no dust of appreciable concentration or quantity is discharged to the atmosphere. The filtered chemical dust shall be returned directly to the screening section for a built-in unit. Should an external unit be provided, a dust bin of not less than 50 litre shall be provided at the bottom of the dust extractor for the collection of filtered chemical dust.

(ii) The dust extractor shall be of stainless steel construction. The unit shall include an electrically driven dust extractor, chemical dust filter elements, side access doors and cable termination box. Dust extraction motor shall not be located inside the dust extractor.

(iii) The dust extractor shall be of side filter bag removal type. Removal of the filter assembly shall be effected from the front of the unit through a hinged access door. The filter assembly shall comprise flexible inserts which shall maintain the form of the element under dynamic air flow conditions.

(iv) Filter elements shall be made of suitable chemical resistant material and certified to BS EN 60335-2-69 Class L or better. Dust shall be removed from the filters by operation of a cleaning mechanism in the form of repulse air jets or vibration.

(v) All electrical components shall have IP65 or better enclosures to BS EN 60529.

(vi) Solenoid valves shall be manifolded. Each unit shall be furnished with solid state sequencing timer and air pressure gauge. A differential pressure indicator and switch shall be provided to the compressed air pipelines feeding the extractor. A high differential pressure alarm shall be provided when cleaning or replacement of filter bag is required.

(vii) If the connection between the dust extractor and the chemical handling equipment is by air duct, sizing of the air duct shall be designed to have the dust particles to travel at an optimum speed of not less than 18 m/s.

(vvv) Feeding and wetting devices

(i) Pneumatic conveying shall be used to transfer the powder from feeder to the ejector.

(ii) The feeding unit shall incorporate a screw feeder for accurately metering the polyelectrolyte to the pneumatic conveyance system. The screw feeder shall operate under control of an adjustable timer to provide a means of varying the batch concentration. The reproducibility of the feeder shall be better than + or - 3% by weight.

(www) Mixing/ageing tanks

(i) Mixing/ageing tanks shall be designed for receipt of polyelectrolyte from a suitable particle wetting device. The polyelectrolyte shall be dissolved/diluted to form a solution of uniform concentration and consistency, free of lumps and 'fish-eyes' and allowed to age before being discharged.

(ii) The tanks shall be sized such that the required stock volume can be produced in a single batch at the specified concentration.

(iii) The tanks shall be fabricated from stainless steel Type 316S13 to BS EN 10029, BS EN 10259, BS EN 10258, BS EN 10048, BS EN 10095, BS EN 10051or other suitable corrosion and abrasive resistant suitable material approved by the Engineer. The tanks shall generally be cylindrical and suitable for mounting on a flat concrete plinth. Alternatively the tanks may be mounted on a platform above the stock tanks or on top of the stock tank. Mild steel tanks shall not be used.

(iv) The tanks shall be located within a bunded area inside a building. The bund shall be dedicated to polyelectrolyte handling and shall be designed to accommodate 110% of the contents of the largest tank contained therein.

(v) Each tank shall be equipped with an electric medium speed propeller type or similar mixer operating at 400-500 rpm. The shaft and propeller shall be fabricated from stainless steel type 316S13 to BS EN 10095, BS EN 10250-4, BS EN 10085, PD 970, BS EN 10087, BS EN 10083-1, BS EN 10084 or BS EN 10029, BS EN 10259, BS EN 10258, BS EN 10048, BS EN 10095, BS EN 10051. The mixer shall operate under control of an adjustable timer.

(vi) Where applicable, suitable level switches or probes shall be provided for operational purposes including low level, initial fill level, high level and overflow level.

(vii) Where specified in the Particular Requirements, mixing/ageing tanks may also serve as stock tanks subject to the further requirements of the following clause.

(xxx) Stock tanks

(i) Stock tanks shall be designed for receipt of polyelectrolyte solution from a mixing/ageing tank and/or where specified, liquid polyelectrolyte from drums. The capacity of the stock tank shall be greater than or equal to the capacity of the dissolving tank and shall be sized to provide storage at the maximum demand over the time taken to prepare a batch.

(ii) The stock tank could be an integral part of the mixing/ageing tank.

(iii) The tanks shall be fabricated from stainless steel type 316S13 to BS EN 10029, BS EN 10259, BS EN 10258, BS EN 10048, BS EN 10095, BS EN 10051or other suitable corrosion and abrasive resistant material approved by the Engineer The tanks shall be generally cylindrical and suitable for mounting on a flat concrete plinth. Mild steel tanks shall not be used.

(iv) The tanks shall be located within a bunded area inside a building. The bund shall be dedicated to polyelectrolyte handling and shall be designed to accommodate 110% of the contents of the largest tank contained therein.

(v) Where applicable, suitable level switches or probes and level measuring equipment shall be provided for operational purposes including extra low level, low level and overflow level and for monitoring purposes.

(yyy) Dilution system

(i) Polyelectrolyte solution shall be diluted prior to injection to improve mixing. The dilution ratio shall generally be as per specified.

(zzz) Pipework

(i) Stainless steel pipework shall be type 316S13 to BS EN 10216 and BS EN 10217 and shall be flanged. Fittings shall comply with BS EN 10253 Part 4. All welding shall be carried out to BS 4677 and procedures shall be subject to approval in accordance with BS EN 288 3. Welders shall be tested by an independent testing authority and shall satisfy the requirements of BS EN 287 1.

(ii) Welder test certificates shall be provided by the Contractor for examination by the Engineer.

(iii) All welds shall be dressed.

(iv) uPVC pipework shall be as specified above.

(v) Reinforced plastics shall be as specified above.

(vi) Alternative plastic materials such as polypropylene and polyvinylidene difluoride (PVDF) may be used in certain circumstances subject to approval by the Engineer.

(vii) Joint rings for steel pipework shall be proprietary and approved by the engineer.

(aaaa) Isolating valves

(i) General

1) All isolating valves shall be positioned with due regard to routine access for operational and maintenance purposes. It shall not be necessary to enter any bunded facility to operate isolating valves.

2) Isolating valves shall be compatible generally with the pipework systems in which they are installed.

(ii) uPVC valves

1) Isolating valves shall be of the diaphragm type with uPVC bodies, glass filled polypropylene top works and PTFE diaphragms. Assembly nuts and bolts shall be stainless steel.

2) End fittings may be plain sockets for solvent welding or flanged as appropriate. Flanges shall be to BS EN 1092-1 with minimum PN10 or PN 16 where appropriate.

3) These valves may not be used for isolating tank outlets and drains unless otherwise approved by the ENGINEER

(iii) Rubber lined valves

1) Isolating valves shall be of the diaphragm type to BS EN 13397 with weir bodies in grey cast iron to BS EN 1561 grade 220 (or alternative grade allowed by the design standard) having integral flanged ends, a natural rubber ebonite lining, PTFE diaphragms and top works in standard proprietary materials. Assembly nuts and bolts shall be in stainless steel. The valves shall be flanged to BS EN 1092- with minimum PN10 or PN 16 where appropriate.

2) Isolating valves for tank outlets shall be of the sealed bonnet type.

1.29 Odour Control System

1.29.1 General

This specification covers the general requirement of the performance , design and construction of odour treatment units for the neutralisation or absorption of odorous compounds by physical, chemical or biological action in used water (wastewater) application with all relevant statutory regulations and the latest edition of all relevant international, harmonised European and British Standards and Indian Standards and Code of Practices.

The specification covers the following type of treatment plant:

- Dry Scrubber
- Bio Scrubbers (i.e. Bio-Trickling Filter)

This specification shall also comply with:-

- The relevant Process Specification;
- All associated General Specifications;
- The specific technical data schedules accompanying the Particular Specifications (if applicable);
- The relevant Electrical General and Particular Specifications;

The relevant Instrumentation and Control and Automation (ICA) General and Process Specification.

1.29.2 Submittal Requirements

(a) The Contractor shall provide the following data and specifications for each equipment unit supplied, but not limited to, the information outlined in General Specifications Drawings, Documentation, and Recording of the Works, and Operation and Maintenance Manuals and also includes the following additional requirements:

3) Proposed media bed depths and retention time.

4) Any requirement for media re-generation (if applicable).

5) The potable water demand and final effluent demand (flow and pressure requirement) (if applicable).

6) The estimated energy consumption and electrical drive loadings list

7) Completed and final Technical Schedules attached in the Specifications:

8) Process verifications to demonstrate that any scrubber media provided meets the required performance criteria

(bbbb) With respect to the above, where appropriate, the drawings shall include the minimum clearance distance required for the removal of plant and equipment and its associated components with the equipment in situ and termination points for the connection of external services.

1.29.3 Products

(a) General

(i) This section covers the various possible technologies for odour control equipment which may be supplied by the Contractor, which includes:

1) Dry Scrubbers – such as Activated Carbon media odour scrubbers

2) Bioscrubbers – such as Bio-Trickling Filters

(ii) Specific odour control technology requirements (if any) will be outlined in the Process Specifications for each site.

(iii) The Contractor shall only offer those proven technologies as listed above with references as its primary offer. While a new technology may be available and may be considered by the ENGINEER, primary offers which include unproven technologies will be rejected during the review process

(cccc) Dry Scrubber Units

(i) General

1) This section covers odour control equipment where foul air is passed through dry media and odorous compounds are adsorbed by the media. The performance may be enhanced by the use of adsorption media impregnated with a chemical agent.

2) Typical dry scrubbers used for the purposes of odour control are Activated Carbon (AC) based scrubbers.

3) The Contractor shall provide pre-filters installed upstream of the Foul Air Fans and Activated Carbon vessels for removal of aerosols and particulates from the inlet air stream such that the inlet face of the Activated Carbon bed does not become blocked with aerosols or particulates

4) The complete odour treatment system based on dry adsorption such as AC as proposed by the Contractor shall fit within the designated areas as outlined in the process specifications.

    a) The AC systems shall be a single pass system, (multiple beds installed in each vessel acceptable), and with all necessary internals and support structures to provide a complete functional system.

    b) The vessel dimensions (length x width and/or diameter) and media volume shall be calculated by the Contractor and properly designed to achieve the specified Performance Guarantees stipulated in the Specifications.

    c) The following minimum distances between adjacent AC vessels shall be satisfied to allow adequate access for maintenance and AC media replacement:

        i) All AC vessels shall be installed adjacent to a dedicated service road or grassed area capable of passing standard sized vehicles and trucks;

        ii) Quad-bed AC vessels mounted horizontally shall be provided with at least 3m between adjacent AC vessels;

        iii) Dual-bed AC vessels mounted vertically and single-bed AC vessels shall be provided with at least 1.5m between adjacent AC vessels;

    d) AC reactors shall be designed such that extra depth of AC media or addition of AC vessels may be added to meet performance requirements, should the initial odour performance testing results show failure to meet emission limits. The addition of extra AC media depth or AC vessels to meet performance requirements will be at the Contractor's cost.

5) The AC systems shall incorporate the following ancillary systems as minimum:

    a) Inlet pre-filters; and

    b) Inlet heaters/dehumidifiers (specific to Contractor's proposed AC blend);

6) For AC based systems, the following instrumentation must be built into the Odour Treatment Plant and Control Systems, along with the local operator interface:

    a) AC inlet common H_2S analyser, measuring down to 1ppmv and with a minimum H_2S analysis rate of 60 readings per hour;

b) AC exhaust common H_2S analyser, measuring down to 0.01ppmv and with a minimum H_2S analysis rate of 60 readings per hour;

c) Stack exhaust H_2S analyser, measuring down to 0.01ppmv and with a minimum H_2S analysis rate of 60 readings per hour.

7) For AC based systems, the following interlocks and alarms must be built into the Odour Treatment Plant Control System and local operator interface, in addition to the standard alarms required for operation of the entire odour control system:

a) For each AC bed:

i) High AC bed temperature alarm;

ii) High AC bed differential pressure alarm;

(ii) AC Media Requirements

1) The type and composition of the AC media required / provided shall be subject to the Contractor's specifications as specified in the Specifications.

2) The Contractor shall be responsible for the appropriate carbon selection for the duty specified. This may include a dual-bed or quad-bed system if considered appropriate by the Contractor. The Contractor shall provide justification for the carbon selection including calculations to demonstrate that the minimum requirements will be achieved, and supported by case studies or references which must be submitted to validate claims.

3) The AC media shall be of granular or pelletized form, and its composition shall match those specified in the Particular Specifications, with no more than 5% variation in weight for each component making up the AC media;

4) The AC media depth shall provide a minimum ventilation air contact time within the AC media bed as specified in the Particular Specifications, with no more than 5% compaction or shrinkage of media within the bed;

5) The depth of media shall be such that the minimum contact time for the airstream in the OCS shall satisfy the requirements outlined in the Technical Data Schedules accompanying the Particular Specifications for each site, at the maximum design airflow, without exceeding the manufacturer recommended gas velocity through the AC media face (typically maximum 0.25m/s). The AC media shall be evenly distributed in the bed so that no bypassing or short circuiting of foul air occurs within the OCS.

6) The Contractor shall ensure that all AC media beds receive equal airflow and that no short circuiting occurs. Where multiple AC media beds or multiple AC cells are proposed, the contractor shall provide calculations and supporting documentation that demonstrate how equal airflow distribution will be achieved and how short circuiting will be eliminated or minimised.

a) For horizontal flow systems the Contractor shall install baffles to prevent short circuiting.

b) For multiple AC cells in a single bed reactor, the Contractor shall install flow restricting orifices on each inlet plenum to prevent unequal airflow distribution.

7) AC media adsorption H_2S efficiencies (to break through, not saturation) based on the proposed media blend shall be supplied by the Contractor for reference. Recent extensive testing by the Australian Research Council (ARC) Sewer Corrosion and Odour Research (SCORe) project has identified that the typical H_2S adsorption capacity to H_2S breakthrough is much less than, and can be as low as half of typical literature claims. Literature claims of AC media H_2S adsorption are typically based on ASTM D6646-03 or equivalent, which quantifies the total H_2S adsorption capacity of the media to saturation. This is impractical for field operation of OCSs as H_2S and odour nuisance will be caused at H_2S breakthrough, with AC media changeover required when this occurs. Contractors shall adopt AC media efficiencies outlined in the table below in their design of proposed AC systems. The ENGINEER reserves the right to test AC media efficiency to breakthrough and validate sizing claims.

Carbon Type	**Adopted Values for H_2S Adsorption Capacity (g/cm^3 media)**
Virgin Activated Carbon	0.03
Chemically Impregnated Activated Carbon or Alumina (Hydroxide or Permanganate impregnated)	0.14
Catalytic Activated Carbon	0.16

8) The Contractor is to ensure that each lot of AC media delivered to the project site for installation into the AC vessels comply with the requirements outlined in the Particular Specifications and is accompanied by an analysis sheet of the measured characteristics of the carbon in that lot.

9) The Contractor shall include information including details and price of the activated carbon media intended to be supplied in the tender documents. The ENGINEER may agree to proceed with this intended carbon, however the ENGINEER reserves the right to request the Contractor to amend the specified carbon blend if deemed unsuitable for the contaminants in the foul air requiring treatment.

10) The ENGINEER also reserves the right to source the proposed AC media blend independently from the Contractor, and not use the media offered by the Contractor. Should the ENGINEER agree to use the Contractor's carbon, it shall comply with the following requirements:

    a) Details of the proposed AC media blend, and its performance characteristics, particularly moisture ingress shall be provided by the Contractor. Peat, coconut shell or high grade coal are the preferred base materials for carbon manufacture.

    b) The AC media shall also be required to absorb levels of hydrocarbons that may be present at times.

    c) Unless otherwise specified in the Particular Specifications, a minimum of 30% virgin activated carbon (or similarly suitable AC media) shall be incorporated into the AC media blend, for removal of Reduced Sulphur Compounds (RSCs) and Volatile Organic Compounds (VOCs) which are typically resistant to adsorption onto impregnated activated carbon or catalytic activated carbon;

(iii) Breakthrough and Media Replacement

1) Breakthrough of H_2S and odour is defined to occur when the H_2S and odour reduction criteria in the Performance Guarantees stipulated in the Particular Specifications are exceeded, and consequently the AC media bed requires replacement.

2) Unless otherwise specified in the Particular Specifications, the Contractor shall guarantee the AC media bed life shall exceed one (1) year to break through of H_2S and odour based upon average inlet gas conditions as outlined in the Particular Specifications.

3) Unless otherwise specified in the Particular Specifications, the activated carbon shall have an odour removal efficiency of not less than 99% for all sewer based odours and meet discharge H_2S and odorous gas concentration limits as stipulated in the Schedule of Performance Guarantees in the Particular Specifications.

(iv) Specific Design Requirements

1) The treatment unit shall be designed so that volume of condensate accumulating within it is minimised. Facilities shall be provided with water traps for the collection and drainage of condensate to the point where it will prevent escape of odorous air.

2) The volume and arrangement of the media shall be such that the rates of chemical and physical reaction between the media and odorants within each treatment state are optimised to achieve the specified performance.

3) The configuration of the media bed shall be submitted with the Contractor's response to this tender. Carriage trays/baskets where provided, shall satisfy the following requirements:

a) Be composed of FRP or other proven corrosion resistant material such as HDPE and be effectively seam sealed to their support structure.

b) Trays/baskets shall be designed so that they can be removed and replaced without damaging the treatment unit housing unit and without prolonged disruption to the odour treatment process.

4) The installed AC media shall have sufficient compressive strength to resist all operational loads without excessive deformation or bed settlement.

5) Utility

a) Plant service water of suitable quality shall be the primary source for fire-fighting sprinkler system sprays to the individual AC beds (provision of fire-fighting sprinkler systems is system dependant, and a requirement for systems treating high H_2S loads).

b) Dedicated safety showers with eye wash stations shall be provided in the vicinity of each AC vessel, with a maximum distance of 6m between safety showers. Potable water service water shall be the only source of water for the safety showers and eye wash stations at the individual AC beds.

c) Dedicated hose reels shall also be provided in the vicinity of the pre-filters and at each AC vessel, which may be sourced by potable water or industrial water, if available on site.

6) Adequate drainage facilities shall be provided and incorporate a water sampling point and water trap for containment of entrained moisture. Specific design requirements for AC odour scrubber vessels are listed below:

a) The AC vessel shall be fitted with a suitable sized drain line not less than DN 25 with “U” bend water trap to drain leachate.

b) The “U” bend shall be made of clear plastic so that visual confirmation of the seal fluid can be undertaken. The drain line must contain a tapping on the “U” bend for inspection and wash-down if required.

c) The AC vessel shall also be fitted with an extra DN50 drain line with manual isolation valve to drain leachate in case of blockages in the DN25 drain line;

d) The AC vessel shall be installed and mounted such that it is not necessary to disassemble the vessel for access to remove and replace the media in each AC bed.

7) Vessel Access Manways

a) Provide flanged and sealed manways for each AC at the following locations:

i) One manway at (or above) each AC media bed/cell
ii) One manway at each AC media inlet plenum
iii) One manway at each AC media outlet plenum

8) For AC vessels, each AC scrubber vessel and/or AC media bed shall be fitted with the following additional sampling ports to collect air samples within the AC media bed at different bed depths (3 of). Each port shall take the form of DN50 ball valve and be located at:

   a) One port that allows sampling of air within the inlet plenum of the carbon vessel;

   b) One port that allows sampling of air at 25% of the depth of the activated carbon bed;

   c) One port that allows sampling of air at 50% of the depth of the activated carbon bed;

   d) One port that allows sampling of air at 75% of the depth of the activated carbon bed;

   e) One port that allows sampling of air within the discharge plenum of the carbon vessel;

   f) All sampling ports along the AC vessel shall be fitted with devices which prevent aerosols or activated carbon media from exiting the port when opened.

(v) GAC Regeneration System

1) Should regenerable AC (GAC) be proposed by the Contractor, the following requirements must be satisfied:

   a) Full details of the GAC re-generation system shall be provided with the tender response

   b) The type of the regenerating liquid required, frequency and duration of the re-generation cycle and volume of liquid waste produced during each cycle shall be provided with the tender response.

2) Drainage facilities for the excessive/waste re-generating liquid shall be fitted with water traps and water seals to ensure no simultaneous escape of odorous air.

(vi) Spent Media Disposal

1) The method of removal, disposal, and waste classification of the spent media shall be stated in the tender submissions.

2) The time required to completely remove all of the spent media from each treatment unit and replenish it with fresh media shall be stated in the tender documents.

Bio-Scrubber (Bio-Trickling Filter)

(vii) General

1) This section covers odour control equipment where the treatment process utilises the growth of a biofilm on an inert media irrigated with final effluent or potable water supplemented with nutrients, such as a Bio-Trickling Filter.

2) The irrigating liquid, type, quality, pressure and flow shall be stated in the Contractor's tender submissions.

3) The target operating pH of the Bio-Trickling Filter (BTF) shall be stated in the Contractor's tender submissions.

4) Each BTF shall comprise the following as a minimum:

    a) Mist eliminator

    b) Irrigating liquid conditioning system, inclusive of nutrient storage tanks, transfer pumps, and nutrient flow monitoring devices (Contractor and system dependant).

    c) Irrigating liquid irrigation system, inclusive of irrigation water tanks, irrigation pumps, and irrigation flow monitoring devices.

    d) Irrigating liquid re-circulating system (Contractor and system dependant)

    e) Scrubbing blowdown system (Contractor and system dependant)

5) The complete BTF system as proposed by the Contractor shall fit within the designated areas as outlined in the Particular Specifications.

    a) The vessel dimensions (length x width and/or diameter) and media volume shall be calculated by the Contractor and properly designed to achieve the specified Performance Guarantees outlined in the Particular Specifications.

    b) The following minimum distances between adjacent BTF vessels shall be satisfied to allow adequate access for maintenance:

        i) Minimum of 1m between adjacent Bio-Trickling Filters (BTFs),

        ii) All BTF vessels shall be installed adjacent to a dedicated service road or grassed area capable of passing standard sized vehicles and trucks along one side of the vessel;

6) Unless otherwise specified, the installation shall only incorporate bypass ductwork to allow odorous air to be removed from its source with all BTF units offline when the BTF system is combined with a dry scrubber polishing system such as an AC scrubber system.

7) Detail of the number, treatment stages and configuration of the BTFs and ancillary components/system provided shall be stated by the Contractor in the tender submissions and satisfy the minimum empty bed residence time (EBRT or contact time) as outlined in the Particular Specifications and accompanying Tender Schedules.

8) Each treatment stage shall comprise a random or structured bed of inert media and its associated support structure. The volume and arrangement of the media shall be such that the rates of mass transfer of odorants from the gas to the liquid phase within each treatment stage are optimised to achieve the required performance.

9) For BTF systems, the following interlocks and alarms must be built into the Odour Treatment Plant control system and local operator interface, in addition to the standard alarms required for operation of the entire odour control system:

a) For each BTF vessel:

i) Low flow alarm
ii) High bed differential pressure alarm;
iii) Leachate Low pH / High pH alarm;

(viii) Media Requirements

1) The proposed inert media shall not inhibit the growth of a biofilm nor have any leachable constituents, which could be detrimental to the operation of the treatment works or receiving waters.

2) The inert media shall be compatible with and/or resistant to the scrubbing liquid and have sufficient compressive strength to resists all operational loads without excessive deformation.

3) The inert media shall be supported on a support grid, which will have sufficient free area to allow the free passage of air up through it with the simultaneous drainage of irrigation water and sloughed biomass down through it.

4) The volume of inert media provided in the BTF shall be sufficient to achieve the reduction in H_2S and odour as specified in the Particular Specification.

5) The following media information shall be stated by the Contractors in the tender submissions as a minimum, and are outlined in the Particular Specifications:

a) The type and composition of media

b) Specific surface area

c) Pressure drop across the media at given air speeds

6) The method of removal, disposal, and waste classification of the spent media shall be stated in the tender submissions

7) The time required to completely removed all of the spent media from each treatment unit and replenish it with fresh media shall be stated in the Contractor's tender submissions.

(ix) The BTF irrigation system shall incorporate the following as minimum:-

1) Wire mesh strainer along the irrigation water line - to prevent solids carry over and blocking of the irrigation system, such as spray nozzles. The strainer mesh size shall be selected based on the spray nozzles size and specifications proposed by the Contractor.

2) A flow monitoring device for the BTF irrigation flow.

3) A pressure relief device and irrigation liquid overflow from the BTF – in the event of excess pressure/flow of irrigation liquid.

4) An irrigation liquid sampling facility – to allow measurement of leachate pH for confirmation of BTF operation.

5) The irrigating liquid requirement (i.e. type, quality, pressure and flow) and the frequency and duration of the irrigation cycle shall be stated in the tender submissions.

6) The proposed irrigation system shall be arranged to ensure that the entire face of the media bed receives a uniform distribution of irrigating liquid.

7) Should recirculation of the irrigation liquid be required for permanent long term operation of the BTFs, associated recirculation pumps, piping, and valves shall be provided.

(x) Specific Design Requirements

1) All materials that will come into contact with the irrigation liquid shall be compatible with and/or resistant to the irrigation liquid. The minimum pH value that the materials are designed to withstand, without excessive corrosion, shall be stated in the Contractor's tender submissions.

2) An irrigation system shall be supplied to provide uniform distribution of the scrubber irrigation liquid over the surface of the media.

3) Full details of the scrubbing liquid conditioning system, scrubbing liquid irrigation system, scrubbing liquid recirculating system (if required for long term permanent normal operation of the bioscrubber system) and scrubbing liquid blowdown (if provided), shall be provided with the Contractor's tender submissions.

4) The blowdown system (if supplied) shall regulate the levels of dissolved oxidation products in the irrigating liquid and thereby maintain its target ph. If supplied, full detail of the blowdown system shall be provided with the Contractor's tender submissions.

5) The blowdown system (if supplied) shall incorporate facilities to visually confirm there is a flow of spent scrubbing liquid to drain.

6) The excess/waste scrubbing liquid characteristics shall be stated on the Contractor's tender submissions.

7) A differential pressure indicator across the inlet and outlet of each BTF vessel shall be provided to monitor the pressure drop through the media in the vessels.

8) The housing shall be designed to contain the bed of media above a recycle liquor sump and air inlet plenum. An outlet air plenum and mist eliminator shall also be provided above the bed of media. External mist eliminators in the ductwork separate from the bio scrubber will not be allowed.

1.29.4 System Guarantee

(a) The Contractor shall warrant that:

(i) All equipment provided by the Contractor as part of the OCS package shall be in accordance with this specification and shall perform as specified in the Process Specifications and accompanying Technical Data Schedules;

(ii) All equipment provided as part of the OCS package shall be free from defects in workmanship and materials for a period of twenty four (24) months from the date of final commissioning;

(iii) The OCS shall operate automatically at an unattended facility, monitored remotely via central SCADA system. All equipment supplied by the Contractor shall be suitable for unattended operation;

(iv) Based on the anticipated air flows through the OCS and the ambient conditions of the installation sites, all equipment items forming part of the OCS shall retain their structural and functional integrity for a period of twenty (20) years from the date of final commissioning.

(v) The Contractor shall repair or provide replacements for any defective components under the warranty provided that the defect is not the result of misuse by the owner. Replacements for any defective parts shall be provided by the Contractor to restore equipment to its "as commissioned" working condition.

1.29.5 Performance Guarantee:

(a) The Contractor shall guarantee that all equipment forming part of the OCS proposed shall achieve the following performance:

(i) The proposed odour control technology presented by the Contractor shall be in accordance with the requirements as outlined in the Process Specifications.

(ii) The H_2S and odour removal performance shall be in accordance with the specified removal efficiencies referenced in the Performance Guarantees outlined in the Particular Specifications, as measured between the OCS gas common inlet and the common discharge stack.

(iii) The maximum outlet H_2S and odour concentration at the exhaust stack must not exceed the guaranteed concentrations as specified in the Performance Guarantees outlined in the Process Specifications under all operating concentrations of H_2S and odour at the inlet to the OCS.

(iv) If stipulated in the Process Specifications, the maximum H_2S concentration at the site boundary as demonstrated by air dispersion modelling using an appropriate model (such as 3D Calpuff) by the Contractor must not exceed the guaranteed concentrations as specified in the Particular Specifications Performance Guarantees under all operating concentrations of H_2S and odour at the inlet to the OCS.

(v) The maximum pressure differential across each OCS component shall not exceed that specified in the Process Specifications for all design conditions throughout the life of the installation, when measured between the OCS gas inlet and outlet.

(vi) Media life

1) Unless otherwise specified in the Process Specifications, the media life for AC systems shall be no less than twelve (12) months for each AC vessel, to H_2S and/or Odour breakthrough, defined as when the outlet H_2S and/or Odour concentrations exceeds the guaranteed concentration limits specified in the Particular Specifications Performance Guarantees and Technical Data Schedules

2) Unless otherwise specified in the Particular Specifications, the media life period for Bio-Trickling Filter systems shall be no less than ten (10) years for each BTF vessel, to media breakdown and deterioration.

(vii) Process performance testing comprising of H_2S and Odour removal performance testing shall be the means of proving the performance criteria outlined in the Schedule of Performance Guarantees stipulated in the Particular Specifications has been met following installation and commissioning of the OCS.

(viii) Performance testing shall be undertaken during the current dry season (i.e. between months of June to August) if the equipment is to be installed in the dry season, or the following dry season after installation if installation does not occur during the dry season, and not within ONE week of a significant rain event. A significant rain event is defined as a rain event which results in the sewage flows at the site to be greater than or equal to a wet weather event.

1.29.6 General Design Requirements

(a) General

(i) Details of the plant and equipment requirements shall refer to the Process Specifications.

(ii) Unless otherwise specified in the Process Specifications, the odour treatment system will normally operate continuously and in a remote unmanned site, i.e. 24 hours per day, 365 days per year, reliably.

(iii) Unless otherwise specified in the Process Specifications, adequate equipment redundancy shall be provided by the Contractor to allow a minimum of ONE (1) duty mechanical equipment item (e.g. foul air fans, irrigation pumps, etc.) and/or process vessel (e.g. AC scrubber vessel, BTF vessel, Bio filter cell, etc.) to be taken offline for maintenance and/or replacement without causing process upsets or critical failures.

(iv) The plant layout drawing is provided for the information of the Contractor. It shows general dimensions and locations of features that the Contractor shall incorporate into the final design. Any changes to these features that the Contractor may find necessary in his design or detail work must be approved by the engineer.

(v) Preliminary Process and Instrumentation Diagrams (P&IDs) are also provided for the information of the Contractor. It shows the expected equipment which shall be supplied by the Contractor and which will need to be incorporated into the final design.

(b) Minimum Equipment Items

(i) The odour treatment units shall include as a minimum, but is not limited to, the following equipment items:

1) Odour covers to contain the odour air at its sources

2) An inlet manifold and associated ductwork to receive odorous air from the specified extraction points and stipulated ventilated sources which direct it to the odour treatment units for treatment.

3) The odour treatment units along with its associated ancillaries, including but not limited to: containers, tanks, access stairways/ladders, walkways and hand railings, pumps, fans, nozzles, filters, cablings, trunkings, control and instrumentation, pipework, flow control dampers, isolation dampers, valves, fittings and its supports etc. Access to the top of AC vessels will be required and adequate access staircases, platforms, and handrails must be provided for this purpose.

4) If the odour treatment unit incorporates an Exhaust Stack, an outlet manifold and associated ductwork, to receive the treated air from the Odour Treatment Plant and direct it to the Exhaust Stack for discharge.

5) Extraction fans to extract air from the specified extraction points and convey it through the various odour treatment equipment.

6) Associated electrical, instrumentation, and control equipment necessary to allow automatic operation of the odour control units. This includes local control panels, integration with the plant Programmable Logic Controller (PLC), plant SCADA, and associated monitoring facilities and equipment.

(ii) Any AC vessels proposed shall consist of a single pass system, and may consist of single, dual, or quad-beds installed in each vessel, and supplied with all necessary internals to provide a complete functional system. Modular AC vessels in the form of rectangular AC vessels are also acceptable for this purpose.

(c) Materials of Construction

(i) The materials of construction must be 100% compatible for corrosion resistance to compounds typically associated with sewerage foul air conditions and climatic. These compounds and expected climatic conditions are noted in the Process Specifications for each site. Unless otherwise specified or agreed with the engineer, the only acceptable materials of construction comprise of Fiberglass Reinforced Plastic (FRP).

(ii) Untreated foul air could contain hazardous levels of air contaminants. Consequently, electrical components or other equipment proposed by the Contractor which are to be located within 1 meter of potential air leakage sources shall be suitable for use in Class 1, Zone 2 hazardous areas and installed in accordance with the relevant Standards. Local control panels and controls shall all be located at least 1 meter from possible air leakage paths on separate mounts to avoid the need for a Class 1, Zone 2 classification.

(d) Noise levels

(i) Unless otherwise specified in the Particular Specifications, noise levels from the components comprising the equipment (i.e. fans and ductwork) shall be less than 80 dB(A) at a distance of 1m from the component centre line (based on the components being mounted in free field conditions).

(e) Air balancing

(i) General

1) Air handling systems, ductwork, and headers shall be air balanced to give flow rates within 10% of designated air quantities, subject to the following:

a) Air shall be distributed to minimise duct velocities; and

b) Air resistance at fans shall be minimised, and the fans shall be adjusted to run at lowest fan speeds and power consumption.

2) Balancing points shall be provided in ducts in sufficient number to facilitate the proper testing and commissioning of the air collection system, but in any case at least one for each branch duct and each main duct.

3) All balancing points shall be located in readily accessible positions in straight duct, at least seven 'hydraulic diameters' downstream from any bend or air control device. Where the required distance (seven 'hydraulic diameters') cannot be achieved, the Contractor shall design, supply and install straightening vanes or diffusing grid to achieve stable flow conditions at the balancing point. All balancing points shall be easily accessible for measurement.

(ii) Procedure

1) Air balancing shall commence after the entire odour containment covers and odour control system installation have been completed.

2) Where there are inter-connecting ducting header systems, all inter-connected systems shall be operated concurrently.

3) Final position of flow balancing dampers shall be marked upon completion of balancing and locked into position.

(iii) Reporting

1) The following shall be included on the air balance data sheets:

a) Static pressure differentials,

b) Air quantities through each sub-system or branch ducting after balancing, and

c) Fan capacity and fan speed.

2) The final operating point shall be shown on the fan characteristic curve.

1.29.7 Mechanical Design Requirements

(a) Ductwork

(iv) All ducting which form common air headers going into or out of the OCS shall comply with the following:

1) All ductwork within the OCS compound shall be supported with galvanised mild steel brackets as necessary.

2) Ductwork shall be designed and installed in accordance with Sheet metal and Air Conditioning Contractor National Association (SMACNA) or equivalent standards subject to engineer's approval.

3) Ductwork shall be designed in accordance with duct pressure class B (medium pressure) with respect to static pressure and air leakage limits, unless otherwise approved engineer.

4) Unless otherwise specified in the Process Specifications, the maximum ductwork air velocity shall satisfy the following requirements:

   a) 5m/s for ducting up to 150mm diameter

   b) 8 m/s for ducting up to 750mm diameter

   c) 10 m/s for ducting larger than 750mm diameter

5) The maximum pressure drop for the critical leg shall be 2 Pa/m. In the event that the pressure losses in the odour ducting is higher than the maximum specified pressure drop, or if negative pressure is expected, special design considerations for the ductwork will be required and shall be included in the submitted proposal to ENGINEER for approval with P.E. endorsement.

6) Unless otherwise approved, the ductwork installed shall be made from FRP, compatible with the corrosive conditions under which it must be operated. Any deviations to the proposed ducting material shall be submitted to ENGINEER for prior approval.

7) All joints in ductwork / manifolds shall be effectively sealed. Gaskets shall be full face and the material shall be compatible with humid and corrosive conditions of operation, and submitted to ENGINEER for approval.

8) Flexible connections shall be provided at the interface of all mechanical equipment items and along the ducting route to accommodate differential movement and prevent vibration transmission.

9) All ductwork shall be provided with flanged connections at its termination points.

10) Ductwork shall be securely fixed to rigid supports which are designed to allow ductwork expansion without damaging the gel coat. All clamps and brackets etc. shall be made of Grade 316 Stainless Steel unless otherwise specified.

11) Ductwork shall be designed to prevent the accumulation of any condensate. Drain points for removal of condensate shall be provided, and shall satisfy the following:

   a) All drain traps shall be fitted with S-bends and provided with visible water traps.

b) All drain points shall be rated for a minimum of 1.5 times the ductwork pressure at the point of installation and be made of materials which resistant to corrosion by the condensate, which may be highly acidic.

12) All necessary access and sampling ports for the connection of pressure gauges, air velocity sensors etc. and for sampling shall be provided. If practicable, access ports shall be positioned in straight length of ductwork, at least 3 ductwork diameters from dampers.

13) All ductwork shall be UV resistant and shall be of a colour approved by PUB prior to installation.

14) All ducting shall be smoke tested to ensure there are no leaks. Furthermore an airflow balance test shall demonstrate that there is no more than 2.5% leakage through the system from the source to point of discharge.

15) Ducting between the extraction points and the fan inlet shall be constructed to withstand the full suction pressure of the fan during blocked conditions (both duct and pre-filter).

(f) Foul Air Fans

(i) Where fitted, centrifugal, axial or mixed flow fans shall comply with the following:

1) Fans shall be secured using anti-vibration mountings.

2) Fans shall be provided with online vibration monitoring on the bearings which are connected to plant PLC and SCADA. Automatic interlocks on the PLC and SCADA shall be provided to automatically shut down fan operation upon detection of any imbalances during operation.

3) Depending on the location of the fan installed, special acoustic enclosures may be required.

4) Terminal units enclosed fans shall incorporate attenuation linings to reduce transmitted noise.

5) A low airflow sensor shall be incorporated to provide an alarm in case of fan failure.

6) To ensure that no hazardous gases are present in the housing, the control system shall ensure that on start-up, the fan runs for a sufficient period to purge the ductwork prior. This period shall not be less than 30 seconds.

7) Positioning of the fans will be dependent on the type of odour treatment technology adopted. The following requirements should be observed unless otherwise specified in the Particular Specifications:

a) For instances where only Bio-Trickling Filters are adopted, the fan(s) are typically positioned upstream of the odour treatment vessels and push air through the equipment.

b) For instances where a dry scrubber system such as an Activated Carbon system is implemented, fan(s) can be positioned both upstream and downstream of the odour treatment scrubbers and push/draw air through the equipment (pre-filter, heater, and scrubbers).

c) For instances where a combined Bio-Trickling Filter with Activated Carbon system is implemented, fans should be positioned between the BTF scrubbers and the AC scrubbers.

d) Odorous air should not be drawn from a Zone 1 hazardous area through a Zone 2 hazardous area.

8) The impeller and shaft of the foul air fans shall be constructed of FRP or Grade 316 Stainless Steel unless otherwise specified in the Particular Specifications.

9) After fabrication the impellers shall be cleaned and Non-Destructive

(ii) The fan housing and pedestal shall satisfy the following requirements:

1) Unless otherwise specified in the Process Specifications, the fan housing, axial fan case, and pedestal shall be constructed from FRP or Grade 316 Stainless Steel and be fully welded. Any perforated sheeting used for sound attenuators (if required) shall be constructed of Grade 316 Stainless Steel.

2) For the Foul Air Fans integral access platform shall be attached to the fan pedestal to allow access to the fan bearing vibration monitors.

3) The fan housing enclosure shall be fitted with a DN25 drain line and isolation ball valve for manual removal of condensate.

(iii) The fan motor shall satisfy the following requirements

1) The selected fan motor shall be capable of continuous reliable operation when the fan is operating at a duty flowrate of 10% greater than that specified in the Particular Specifications;

2) The fan motor shall be wired to terminal boxes located external to the fan casing for ease of maintenance;

(iv) Fan gaskets and sealants shall satisfy the following requirements:

1) All gaskets, regardless of where they are used, should conform to the following:

2) Resistant to UV and other conditions that might reasonably be assumed to exist in the odour control facility, (e.g. high humidity conditions, bird droppings, cleaning chemicals, disinfectant, etc.).

3) If self-adhesive strips are applied, they should maintain their adhesive properties for the design life (25 years) without more than a 20% loss of adhesion compared with new strip.

(v) The fans shall satisfy the following occupational health and safety requirements:

1) Equipment shall be guarded in accordance with local regulations as outlined in the General Specifications for Workmanship Requirements (G1.3), Section G.1.3.37 Machine Guards.

2) Guards shall be strong enough to withstand personnel and other loads during maintenance and inspection activities.

3) Appropriate workplace health and safety warning signs complying with local regulations as outlined in the General Specifications for Workmanship Requirements (G1.3), Section G.1.3.37 Machine Guards shall be fastened to all equipment.

(vi) The fans shall satisfy the following requirements for noise:

1) Tenders are to supply with their tender noise emission data (overall at 1m free field and Octave band) to allow the ENGINEER to determine if dB (A) noise attenuation of the fans is required. Noise testing shall take place off-site.

2) Tenderers are to comply with the noise requirements as outlined in the Particular Specifications.

3) Where acoustic enclosures are to be provided by the Tenderer, they shall be designed, constructed and installed to ensure:

a) Normal fan operation is possible without opening or removal of the enclosure;

b) Quick and easy removal for inspection and maintenance is possible;

c) The enclosures do not impede the flow of cooling air over the fan motor when operating;

d) Be sufficiently robust to withstand a large number (not exceeding annual) of removal and replacement operations during the life of the fan, as well as be suitable for the installed environment.

(vii) Dedicated nameplates manufactured from appropriate corrosion resistant material shall be affixed to each fan casing and motor by means of Grade 316 Stainless Steel screws, engraved in accordance with the general specification

(viii) All items shall be individually labelled prior to packing and delivery. Labels shall include the following information as a minimum:

1) Manufacturer name

2) Contract number

3) Manufacturer's item/part number

(ix) Final agreement on exact label contents shall be in consultation with the ENGINEER

(x) Where items are manufactured for specific mating component parts, they shall all bear individual identification numbers and reference to the mating part identification numbers.

(xi) Liaison with the ENGINEER and timely provision of information are required to ensure installation can be completed in a timely and efficient manner.

(xii) If Grade 316 Stainless Steel fan guards are provided then no Protective Painting is required.

(xiii) The Foul Air Fan impeller shall be fabricated to withstand the stresses incurred during operation at the duty point as specified in the Particular Specifications for each site.

(xiv) The thickness of the casing and impeller material shall be as specified by the manufacturer.

(xv) Fan bearings shall satisfy the following requirements:

1) Bearings shall be mounted out of the air stream.

2) Bearings to have integral temperature monitoring instruments – Grade 316 Stainless Steel RTD probes with loop powered 4-20mA signal converters and connection junction boxes. The instruments and signal converters shall be Intrinsically safe (e.g. ”IA”) and be certified to IEC standards.

3) Fan bearing housings shall be supplied with a clearly marked vibration monitoring stub on each bearing.

4) Fan bearings shall be of the type greased for life and designed for a rated fatigue life of 30,000 hours at the specified duty point

(xvi) Fan vibration mounts shall satisfy the following requirements:

1) Vibration mounts suitable for attachment to a concrete plinth shall be provided as part of the works by the Contractor. The concrete plinth for fan installation shall be excluded from the Contractor’s scope of supply.

2) The vibration isolators shall be rated to dampen the vibration frequencies that may occur during the fans' operating speed range.

3) The fan and motor shall be dynamically balanced and installed on bases designed to accommodate vibration isolators

4) The fan and motor shall contain mountings selected to achieve 95% of vibration isolation efficiency at the normal operating speeds of the equipment;

(g) Exhaust Stack

(i) The Contractor shall provide a self-supporting exhaust stack that will achieve the design requirements as follows as a minimum, and incorporates the requirements as outlined in the Particular Specifications:

1) Suitable for operation under highly humid and corrosive conditions as expected for sewer gas containing high levels of H_2S, VOCs and other constituents typically found in sewer gas.

2) Unless otherwise specified, the exhaust stack diameter shall be sized to accommodate an air velocity of approximately 15-20m/s and up to 25m/s.

3) Unless otherwise specified, the exhaust stack shall terminate at a minimum height of 5m above adjacent buildings.

(ii) The Contractor shall supply the Exhaust Stack with a tundish and a drain line with U-bend water seal to allow for drainage of any accumulated water to the sump.

(iii) The Contractor shall also supply the Exhaust Stack with appropriate sampling points to satisfy the local regulatory authority's requirements for air contaminant sampling.

(iv) The Contractor shall provide the Exhaust Stack with appropriate bolts constructed of Grade 316 Stainless Steel for fastening onto a concrete footing.

(v) The Contractor shall design the Exhaust Stack for adequate stiffness and adequate footing size to limit deflections to a level that shall have no adverse impact on the foundation blots or to any equipment or ducting connected to the stack.

(vi) To mitigate corrosion of a metal exhaust stack, if supplied, an internal lining of PVC can be used.

(vii) The external surface of the exhaust stack shall be painted with UV protection and a colour approved by PUB

(h) Valves and Dampers

(i) The Contractor shall provide valves and dampers for the isolation and control of air flow. Valves and dampers shall be designed to withstand ambient and process conditions with the presence of water and condensate along with highly corrosive and acidic gasses.

(ii) Valves and Dampers shall be constructed from FRP or Grade 316 Stainless Steel which can withstand the corrosive operating conditions and be free of rattles, fluttering or slack movement and capable of adjustment over the necessary range without excessive self-generated noise or the need for special tools.

(iii) All valves and dampers shall be of heavy duty construction and designed to withstand up to 2-3 times the designed air flow and static pressure.

(iv) Where isolation of a process unit, filter or fan is required, butterfly valves shall be used to ensure effective isolation. Dampers will not be acceptable when positive isolation is required.

(v) The Contractor shall fit all extraction points with manually operated and lockable flow control dampers and isolation dampers and ensure the correct extraction flowrate is achieved during commissioning. All ducting going into or out of the odour scrubber vessels shall also be fitted with manually operated and lockable flow control and isolation dampers to ensure good flow distribution across all beds and vessels.

1) The position of the flow control dampers shall be set at commissioning and locked in position for normal operation.

2) Isolation of the relevant extraction point or section of ducting/equipment will be achieved by manual adjustment of the isolation valve.

(vi) Blades shall be without sharp edges and sufficiently rigid to eliminate movement when locked. Blades minimum thickness shall be 1.6 mm.

(vii) Damper bearings shall be oil impregnated sintered bronze ball bearings or engineering plastic sleeve bearings. Where the operating temperature is expected to exceed 50°C, nylon shall not be used. Access for lubrication of bearings shall be provided.

(viii) Spindles shall be Grade 316 stainless steel, securely fixed to damper blades with minimum diameter as follows:

1) Blade diameter < 600 mm = minimum diameter of 10 mm

2) 1200 mm < Blade diameter > 600mm = minimum diameter of 12 mm

(ix) The damper shall be capable of being adjusted and locked in the following blade positions: "Open", "10° to open", "20° to open", "30° to open" and "Closed". The positions shall be clearly and permanently labelled.

(x) All non-return dampers assemblies shall be counterweighted so that it:

1) Offers minimum resistance to air flow, and

2) Closes by gravity.

(xi) For isolating duty and standby fans automated butterfly valves shall be provided in lieu of non-return dampers to ensure no backflow occurs through the standby fan

(i) Access Ports

(i) Access ports shall be provided with facilities to prevent air ingress when not in use and shall be located such that monitoring instruments are easy accessible or visible from ground level.

(ii) Unless specified otherwise, ductwork shall be earthed to prevent build-up of static electricity and have a maximum resistance to earth 10 Ω, in accordance with PD CLC/TR 5040 (Electrostatics code of practices for the avoidance of hazards due to static electricity). Any equipment operating procedures or precautions required to prevent build-up of static electricity shall be listed in the tender submission.

(iii) Resilient seals shall be fitted between all joints in the housing and ductwork to prevent air leakage.

(iv) All fixings and fasteners shall be manufactured from material which is resistant to corrosion and compatible for operation under corrosive conditions and the application environment, such as Grade 316 Stainless Steel.

(v) Where non-return flaps are required to protect the unit from reverse flow, they shall be seated on resilient seals, thereby providing an effective seal against the reverse flow of air. The flaps shall be designed to offer minimum resistance to normal flow.

(j) Access Hatches

(i) Unless otherwise specified, access panels shall have the following minimum clear opening:

1) Personnel access: 900 x 900 mm.

2) Hand access: 200 x 300 mm.

(ii) The panels shall be double thick, deep formed, constructed and insulated to match the duct. Cold bridging shall be minimised. Panel frames shall be rigid, securely attached to the duct, with no part of the panel or frame protruding into the airstream.

(iii) The seals shall be silicone rubber mechanically fixed to either the panel or the frame to ensure an airtight seal when latched in the closed position. For fire rated seals, use woven ceramic fibre material. Latches shall be Wedge type sash latches and there shall be a minimum of two.

(k) Extra Tappings

(i) The following extra tappings shall be provided by the Contractor for the Odour Control Systems:

1) Manometer tappings of minimum DN15 are to be positioned on the inlet air odour duct for the measurement of air pressure, as well as for H_2S and odour sampling. The Contractor shall ensure the tapping points are accessible for measurement;

2) Where ducting or drain lines contain U-bends where water and material may accumulate, tappings of minimum DN25 are to be positioned on each U bend, with a drain line from the tapping to the sump, to allow inspection and flushing of U bends;

3) Tapping on the exhaust stack for odour sampling purposes. This tapping shall be in accordance with the sampling requirements as in the particular specifications. The Contractor shall ensure the tapping points are accessible for measurement without the need for specialist or temporary access equipment;

4) Tapping on ducting for odour sampling purposes and air testing. Such tappings shall be of minimum DN15 or shall be in accordance with the sampling requirements as in particular specification.

5) All tappings shall be fitted with a removable seal/cap where required. Further details of are provided in the P&ID and general arrangement drawings supplied with this document

(l) Flowmeters

(i) An orifice plate type flowmeter shall be provided for measurement of airflow through the odour treatment system.

(ii) The flow meter shall be installed complete with all necessary accessories and ancillaries required to form a complete and functional system. In particular, the flowmeter must satisfy the minimum straight lengths stated in the table below to ensure adequate accuracy of installation.

Parameter	Units	Value
Minimum Upstream Straight Length	-	5 x Pipe Diameter

Parameter	Units	Value
Minimum Downstream Straight Length	-	3 x Pipe Diameter

(m) Pre-Filter

(i) A pre-filter shall be installed within the air intake duct for removal of aerosols and particulates from the incoming airflow to prevent blockage of the media for the following conditions:

1) Where the air is extracted from dusty areas; or

2) Where the air is to be treated through a dry scrubber using adsorption technologies such as Activated Carbon.

(ii) The pre-filter shall:

1) Be supplied with a self-contained sealed and lockable housing

2) Remove greater than 99% removal of water droplets of 4 µm or larger diameter at the design air flow

3) Have a maximum face velocity across the filter of less than 2.0m/s at the design flow rate with all duty units online

4) Be designed for continuous operation in odorous air which can be water saturated and contain corrosive/acidic gasses

5) Be designed for the specified airflow rate as shown in the Particular Specifications

6) Be designed for ease of removal, inspection, and replacement without requiring the use of specialised lifting equipment.

7) Have pre-filter pads of standard replaceable size, the specific size requirements are outlined in the Particular Specifications for each site.

8) Removable, disposable or washable panel filters are preferred. Each pre-filter pad shall be securely located within a non-corroding recessed tray/frame and held in position against a retaining mesh that is situated on the downstream side of the tray/frame.

9) Pre-filter pads shall be securely located within a non-corroding recessed tray/frame and held in position against a retaining mesh that is situated on the downstream side of the tray/frame.

10) The pre-filter tray/frame shall be designed for ease of removal, inspection and replacement.

(iii) The pre-filter housing shall:

1) Have a hinged, air tight lockable access door for inspection, cleaning and replacement of filter pads

2) Have flanged inlet and outlet for ductwork connections

3) Have an isolation damper on the inlet side of the housing so that the housing can be isolated from the foul air stream

4) Have a differential pressure gauge to measure the pressure drop across the pre-filter (i.e. extent of blocking). The differential pressure gauge shall be clearly and permanently marked with the design values for “filters clean” and “filters dirty” conditions

5) Have a DN25 drain line to the sump fitted with a U-bend and water seal. The U-bend shall be made of clear plastic or glass so that visual confirmation of the seal fluid can be undertaken. The duct must contain a tapping on the U-bend for inspection and wash-down if necessary.

6) Have an extra drain line with DN25 ball valve for maintenance purposes

7) Have appropriate signage on access doors reminding to keep door closed

8) Be designed with the appropriate material for continuous operation on ventilation air which can be water saturated and acidic/corrosive

9) Be constructed to withstand the full suction pressure of the fan (blocked duct conditions) so that permanent distortion of materials and breaking of seals does not occur

(iv) Contractors shall provide details of the pre-filter and pre-filter housing in the returnable Technical Schedules accompanying the Particular Specifications.

(n) De-humidifiers/Heaters

(i) De-humidifiers/Heaters are typically required for odour treatment units utilising dry scrubbing adsorption mechanisms such as Activated Carbon (AC). However, the requirement for a dehumidifier will be dependent upon the type of AC media proposed by the Contractor and the tolerance of the proposed AC media towards relative humidity (RH %).

(ii) The Contractor’s submission shall indicate if:

1) A dehumidifier/heater will be required for the specified OCS, with characteristics as written in this section; or

2) The reasoning behind why a dehumidifier/heater is not necessary for the specified OCS, with particular reference to the type of AC media blend proposed.

(iii) Supplied dehumidifiers/heaters shall have the following characteristics:

1) The dehumidifiers/heaters shall be comprised of electric heater element(s) in a suitable housing integrated with the supplied pre-filters;

2) Dehumidifiers/heaters shall maintain relative humidity at <90%RH at the design average air flowrate and preferably <75% RH;

3) Be fitted with a thermostatically controlled heater element with a temperature indicator transmitter on the discharge stream and an integral over temperature protection.

4) Low and high temperature alarms shall be transmitted to the local control panel of the plant at which it is installed, along with associated interlocks

5) Be contained within an insulated self-contained sealed housing with lockable access hatches that is easily opened and closed for inspection and maintenance. The housing shall also have flanged inlet and outlet connections to ductwork and be insulated to minimise heat loss to the surroundings.

(iv) The dehumidifiers/heaters shall be suitably protected in the following manner:

1) Electrically to prevent the housing becoming “live” in case of corrosion of the electric heating elements as well as protecting the elements from over-heating; and

2) Mechanically for OH&S considerations, to protect against personnel being exposed to hot surfaces;

3) The dehumidifiers/heaters shall be fitted with clearly labelled lockable electrical isolation switches mounted on an adjacent wall or purpose supplied pedestal such that the heater elements can be independently isolated electrically for maintenance or repair purposes;

(v) If the dehumidifier/heater is not required, the Contractor shall allow space within the OCS and pre-filter housing to allow a future connection and installation of a dehumidifier/heater within the pre-filter housing upstream of the AC vessel.

(vi) Contractors are to provide details of the dehumidifier/heater and housing in the tender submissions for P.O. approval.

1.29.8 Electrical, Instrumentation and Controls

(o) General

(i) Electrical equipment and instrumentation located within the odour control casing, or ductwork, shall be certified as suitable for use in a Zone 1 hazardous area (potentially explosive atmosphere), Gas Group Ibis, Temperature Class T3.

(ii) Electrical equipment and instrumentation located outside the odour control casing or ductwork shall be certified as suitable for use accordant with the zonal rating of the surrounding area. Fan motors shall, as a minimum, be certified as suitable for use in a Zone 2 hazardous area.

(iii) Control panels shall comply with the Electrical Specification requirements

(iv) Electric motors shall comply with the Electrical Specification requirements

(p) Control Narratives

(i) The equipment supplied shall be controlled in its entirety by a PLC system provided by the Odour Treatment Plant Manufacturer. A detailed Functional Design Specification shall be prepared by the Odour Treatment Plant Manufacturer and submitted for approval by the engineer. prior to commencement of software programming.

(ii) Interlocks between the Treatment Plant/Pump Station Main PLC and the Odour Treatment Plant PLC shall be provided to achieve any required special ventilation modes, e.g. for fire conditions.

(iii) Control Narratives to allow automatic unmanned operation of the Odour Treatment Plant shall be submitted by the Contractor as part of their tender submissions.

(iv) The Contractor shall advise the alarm and interlock settings for the safe and reliable operation of the Odour Treatment Plant and included in the control narrative.

(v) The Control Narrative shall include but not be limited to the following:

1) Controlled starts and stops.

2) Any signals required from upstream equipment.

3) Any safety interlocks required for personnel or equipment protection.

4) Interlocks and alarms required to meet EPA WAA conditions as outlined in the Particular Specifications and includes the following as a minimum:

5) High concentrations of H_2S in discharge air; and

6) High flow alarm.

7) Required equipment failsafe state in the event of power failure.

8) Emergency stop requirements.

9) Alarm requirements, with the following as a minimum:

a) Low flow alarm from the foul air fans;

b) High H_2S concentrations in the treated air stream;

1.29.9 Scrubber Vessel Design Requirements

(a) General

(vi) The performance specifications provided below are for the information of the Contractor. They give general loadings, load combinations and guidelines of features that the Contractor shall incorporate into the final design. Any changes to these features that the Contractor may find necessary in his design work must be approved by engineer.

(vii) If concrete scrubber vessels are proposed, all concrete structures in contact with corrosive odorous gasses and liquids must be provided with protective coatings or liner of suitable quality to prevent corrosion. As a minimum, protective plastic lining from Polyethylene (PE) or Polyuria (PU) shall be provided.

(q) Design Inputs

(i) The Contractor shall be required to complete the structural and mechanical design of each of the FRP vessels, internal support beams (or equivalent), internal media support plates, internal turning vanes and internal distribution pipework (as indicated on the drawings. The Contractor shall make allowance for additional ductwork loading supported by the vessels.

(ii) The vessel diameter shall not exceed 3.6m.

(iii) All spray nozzles shall be flanged with a minimum nozzle size of 50mm NB. They shall be located for easy access and to minimise quantity of piping. Nozzle locations shall match those on attached drawings. Nuts, bolts gaskets to be provided and materials of construction suitable for application.

(iv) No exposed metal items shall come in contact with any process gas and liquid streams.

(v) Certified lifting lugs shall be designed, certified and provided on each vessel segment and any equipment requiring crane assembly / disassembly for maintenance or repair.

(vi) All inlets and discharge ducting connections on each odour scrubber vessel shall be flanged.

(vii) The inlet plenum shall be designed to ensure even airflow distribution through the odour scrubber media.

(viii) Each vessel outlet shall have a design air exit velocity of less than 10m/s for the specified operating airflow as specified in the Technical Data Schedules appended to the Particular Specifications with all units in service (i.e. normal operating conditions).

(ix) Each odour scrubber vessel shall be fitted with a differential pressure indicator transmitter fitted across each bed (or a maximum set of two (2) media beds for multiple beds installed within a single odour scrubber vessel) to assist in identifying blockages and determining if replacement of media is required due to media degradation.

(x) Each odour scrubber vessel shall be installed and mounted such that it is not necessary to disassemble the vessel for access to remove and replace the media in each bed within the vessel.

(r) Vessel Contents and Pressure

(i) Vessel Contents – Foul Air

1) The Contractor shall ensure corrosion resistance of the vessels and internals to the foul air.

(ii) Vessel Contents – Liquid

1) The Contractor shall ensure corrosion resistance of all FRP vessels and internals to the liquid products of reaction which are typically corrosive. This shall include entrained humidity contained within the vessel.

(iii) Pressure

1) The design, operating, and test pressures of the vessels shall satisfy the requirements as outlined below or otherwise specified in the Specifications.

(s) Mechanical Design Requirements

(i) Vessel Attachments:

1) Provide pipe supports integral to tank for any down pipes or pipes supported from the vessel walls. Pipes shall be supported at maximum 1,500mm intervals or more frequently as may be required by the relevant Standard.

(ii) Media Support:

1) Quantity: Sufficient to hold odour scrubber media plus entrained humidity and/or biomass/biofilm growth on the media;

2) Specific media support requirements for odour scrubbers:

a) The media support directly underneath AC media shall where possible contain a minimum of 200mm layer of inert large diameter material (e.g. clay balls, pebbles, or plastic packing) for any potential leachate to be collected and drained;

b) Opening size of media supports shall not allow passage of odour scrubber media or organisms suspended within the odour media but not allow the AC media or other media fall through;

c) Constructed of FRP or other approved corrosion-resistant material. Grade 316 Stainless Steel will not be acceptable for this application;

3) Media support shall be structurally supported to limit the mid-span deflection to (L/125) where (L) is equal to the span length;

(iii) Sampling Ports

1) Each odour scrubber vessel shall be fitted with Odour and H_2S logging and sampling points in the inlet and outlet plenums (i.e. areas of low air velocity of < 0.25m/s) with the following requirements:

a) The sample points shall take the form of hinged lockable access hatches which allow access to the inlet and outlet plenums.

b) The inlet and outlet plenums are to be fitted with hanging hooks for H_2S data logging units which can be reached from outside the vessel without the need for personnel to insert their heads into the access hatches to observe or handle the H_2S data logging units.

c) The hinged access hatches are to have suitable sealing gaskets bonded to the access hatch and be able to be locked.

(iv) Vessel Access Manways:

1) All odour scrubber vessels shall be fitted with removable, lockable lid(s) or cover(s) for maintenance and/or media replacement without the need to physically dismantle the scrubber vessels.

2) The number of sealed manways required are specified in the Particular Specifications and is specific to the proposed scrubber technology and arrangement.

3) Manways physically located on any odour scrubber media beds shall be constructed of same material as the vessel.

4) Manways located in other locations shall be constructed as the same material as the vessel with a blank cover.

5) Means shall be provided for safely lifting the cover into place / removal. All manway covers shall be fitted with 2 Nos. of Grade 316 Stainless Steel lifting lugs and a davit shall be provided if the cover is greater than 16kg weight.

6) Access manways shall be provided to all points in the vessel where maintenance or inspection will be required.

7) Bolts shall be of Grade 316 stainless steel and installed using nickel anti-seize.

(v) Vessel Access Platforms

1) The Contractor shall provide each odour scrubber vessels with access platforms and stairs to allow safe and convenient access for operations and maintenance activities (e.g. calibration, adjustment, media replacement, etc.) and for the inspection of internals (e.g. fire-fighting nozzles and Bio Trickling Filter irrigation spray pattern, instrumentation, media conditions, etc.) via the inspection ports.

1.30 U V System

The details of the components UV disinfectant system shall be as described below:

1.30.1 **Reactor Chamber:**

The reactor chamber, meant to house the other three fundamental components of the UV disinfectant system shall be an enclosed structure made of stainless steel, designed for the required flow rate of the treated effluent.

1.30.2 **Ultraviolet (UV) Lamp:**

The mercury lamp shall be low pressure but high-output UV lamp radiating the germicidal UV-C wavelength as required for disinfection of the treated effluent and it shall be installed in the system in a way as such it may not pronounce a hazard to mankind or Biodiversity.

1.30.3 **The Quartz Sleeve:**

The Lamp, protected with a quartz sleeve, shall be inserted into this long cylindrical tube made of glass to keep it safe, from the flow of water. The UV system will be provided with a self-cleaning system for glass tubes.

1.30.4 **Ballast/ Controller Unit:**

The ballast/control unit shall be of the capacity to maintain the electrical output to the UV lamp such as needed to emit the UV radiation of required intensity. The control unit will be equipped with a feeding cable, switch gear and internal wiring for the system.

Fixing of the unit will be made in the channel in a way such as to facilitate the maximum surface area

of the glass tubes to be in contact with the treated effluent. A regular preventive maintenance, of the UV system, shall be undertaken by the contractor as prescribed by the manufacturer.

1.31Ventilation and Air Conditioning

1.31.1 Ventilation Fans

Axial flow fans shall be used for general ventilation duties. The performance of the fans shall be determined by the Contractor in accordance with BS 848.

Fans shall be of the single stage or multi-stage contra-rotating types. Fan blades shall be of aerofoil section. Blades shall be removable and the pitch angle shall be adjustable.

Each fan shall be provided with insect screens and removable air filters. The Contractor shall be responsible for the complete and proper closure of openings provided by the Civil Contractor for this purposes.

1.31.2 Air Conditioning

Roof mounted packaged air conditioning units where specified shall be thermostatically controlled from the respective MCC and MV rooms. The system shall handle predominantly recirculated air with a controlled quantity of fresh air introduced at the unit. Supply and return air distribution ducts shall be located in the ceiling serving supply and return air grilles.

Supply air handling plant shall include sand trap fresh air intake louver, insect screen, filter, fan and thermal insulated distribution ductwork.

External conditions for the calculation of duties for the mechanical services plant shall be with mean monthly maximum and minimum values as detailed elsewhere.

All items of plant and equipment for building services shall be designed to operate without malfunction up to a maximum ambient condition of 55^{o}C dry bulb and a minimum ambient condition of 1^{o}C dry bulb with instances of 100% relative humidity.

The air conditioning system shall be capable of maintaining internal conditions in the respective buildings within the following bands:

23 +/- 1^{o} C dry bulb

40% - 55% relative humidity

The air conditioning shall be arranged to introduce a fresh air quantity equivalent to 5% of the total air volume handled. The system shall maintain a positive pressure internally of 6 mm water gauge. The grills and differences shall be arranged in such a way that a uniform air supply is maintained throughout the air-conditioned areas. The supply and return air ducting system installation shall be in accordance with DW/144 and all testing to follow DW 143 and CIBSE Guides.

The Contractor shall be responsible for the complete and proper closure of the openings provided by the Civil Contractor for Air Conditioning and Ventilation purposes.

The refrigerant used in air conditioning plant shall be Freon Grade R407C or R410A.

Condensate water shall be piped from air conditioning units to the condensate pipes as shown on the drawings.

External ducting shall be protected by field applied jackets manufactured from aluminum alloy 0.9 mm thick, corrugated finish and having an integrally bonded moisture barrier over entire surface in contact with insulation of the duct.

Final connections to the diffuser shall be by flexible ducting of maximum length 1 metre.

Volume control dampers shall be provided at readily accessible locations, at all branches, and where necessary to adjust the flow to achieve satisfactory distribution.

Unless restricted by the dimensions of the ducting, duct access panels shall be minimum 450 x 300mm.

Fire dampers compliant with BS 476, and 2 hour rated, shall be provided.

Extract grills and diffusers shall be anodised aluminium, to match the existing finish.

Where required, fibreglass insulation shall be minimum thickness 50mm, and secured to the ducting with non-corrosive metal pins.

Where incorporated in air conditioning units any copper parts shall be coated with ACAD/HERESITE for protection against corrosion.

1.32Handrailing, Walkways, Flooring and Ladders

1.32.1 General

The Contractor shall design and install handrailing, walkways, flooring and ladders as indicated in outline on the Drawings. The detailed design of handrailing, walkways, flooring and ladders shall take into account access to items of plant requiring regular maintenance. Any item requiring maintenance shall be provided with permanent access and associated flooring and handrailing.

1.32.2 Handrailing

Heavy duty aluminium tubular handrailing in accordance with BS 4592 shall be provided. The handrailing shall have a hand rail 1100 mm above the floor or walkway and an intermediate rail 550 mm above the floor or walkway. Handrailing shall be to the approval of the Engineer.

Handrailing (including toe plate) shall be manufactured from aluminium with an anodised finish.

A 150 mm deep aluminium kick strip shall be provided with all handrailing clipped to the handrail standards. Drilling of the handrail standards shall not be permitted. The kick strip shall be discontinuous to a width of 25 mm across concrete joints where plastic inserts or some other approved system shall be used to close the nominal gaps.

1.32.3 Walkways, stairways and platforms

Walkways, stairways and platforms shall comply with BS5395 Part 3.

Standard structural hot dip galvanised mild steel to BS EN ISO 1461: 1999 or marine grade aluminium sections shall be used.

Allowance shall be made for the fitting of equipotential bonding conductors with any lugs welded or holes drilled prior to galvanising.

Walkways shall have an effective width of not less than those stated in BS 5395. Open mesh flooring shall comply with BS 4592. Toe plates of not less than 150mm height shall be provided on all walkways. Floor panels shall be sized to not exceed 25kg for single person lift or, where there is adequate space for movement around the panel (as detailed in the Manual handling Operations Regulations 1992), 35kg for a two person lift.

Stairway inclination shall be between 30deg and 42deg with the 'going' of stair treads not less than 250mm and landings situated after not more than 16 risers in any one flight.

Floor loading shall be as detailed in Table 3 of BS 5395 but not less than a general duty of 5.0kN/m².

Plating shall be of the non-slip, self draining pattern securely fixed to the supporting structure.

Outdoor stairways shall have open mesh treads.

1.32.4 Ladders

1. Aluminium access ladders

   Aluminium access ladders shall be vertical single rung ladders designed in accordance with BS 5395.

2. GRP Ladders

   GRP ladders shall be of approved design and obtained from an approved manufacturer. They shall comply with BS 4211.

3. Emergency access ladders

   Emergency access ladders shall be designed in accordance with BS 5395. Emergency access ladders shall be manufactured from galvanised mild steel.

1.32.5 Aluminium Flooring

1. Flooring

   Flooring shall be either aluminium chequer plate or aluminium open mesh as indicated on the Drawings. Flooring shall be designed to support a minimum load of 5kN/m² or to the manufacturer's standard specification whichever the greatest. All flooring frames are to be handed to the Civil Contractor, who shall be responsible for building these into the Works. Floor panels shall be designed to be easily lifted and handled by one man.

2. Support Steelwork

   Support steelwork shall be provided to support floor panels wherever necessary. The steelwork shall be designed in accordance with BS 5395. Steelwork shall be hot dip galvanised in accordance with BS EN 1461.

1.33Portable Fire Extinguishers

1.33.1 Description

All apparatus shall be suitable for operation by one person alone and shall be easily recharged. The discharge shall be non-corrosive and free of chemicals prone to give off toxic gases when heated.

Extinguishers shall be of the carbon dioxide or carbon dioxide propelled dry power type and shall be provided in accordance with the table given in Particular Specification Section.

Operating instructions shall be clearly printed on each unit (or adjacent to each unit) in Arabic and English.

A label for test date shall be provided for each extinguisher.

1.33.2 Fire Hose Reels

Fire Hose Reels shall be provided in accordance with the manufacturer’s and relevant authority requirements.

1.34Standby Generator

1.34.1 General

The Contractor shall provide a generator driven by a diesel fuelled engine. The engine and generator shall be primary rated for the full site load at the maximum ambient temperature.

The generator set together with its auxiliary systems shall be installed within the standby generator building.

The set shall be designed, manufactured, tested and certified to be compliant with the relevant BS, ISO and IEC standards.

1.34.2 General Arrangement

The engine, radiator and generator shall be mounted on a common base frame, via anti-vibration mountings.

1.34.3 Noise Level

The noise level as measured 2 meters in any direction from the exterior of the standby generator building at 1 meter above ground level shall not exceed 80 dB(A) when the engine is running at full load. The Contractor shall carry out a test on Site to demonstrate compliance with this requirement.

1.34.4 Generator Controls

The controls for the generator set shall be fitted in a set mounted control panel. The panel shall be mounted on the set via anti-vibration mountings.

The panel shall provide the following controls and instrumentation:

The set shall have three modes of control.

1. Automatic – in automatic mode the generator shall start automatically when a mains failure is detected on the live side of the Motor Control Centre mains incoming circuit breaker.

   If the mains failure lasts for more than 5 seconds the Motor Control Centre mains supply breaker shall trip and a start signal shall be sent to the standby generator system. The generator shall start and when the output volts have stabilised the Motor Control Centre panel incoming standby generator supply breaker shall close.

   The generator shall continue to supply the Motor Control Centre loads until the mains supply is restored and remains stable for more than 30 seconds. After this time the Motor Control Centre incoming standby generator supply breaker shall open and the incoming mains supply breaker shall close. The generator shall continue to run for 10 minutes on no load before shutting down automatically.
2. Test – when test mode is manually selected a mains failure is automatically simulated and the generator runs on load for an hour before automatically changing back to standby mode.
3. Manual – in manual mode the generator is started and stopped manually, there is no automatic changeover or switching of circuit breakers.

The following controls shall be provided:

- Key-operated four position, AUTO – OFF - MANUAL - TEST engine control switch. The set protection shut downs shall operate in all modes of operation.
- Key-operated START – STOP switch, this shall be operable only when the control selector switch is in the MANUAL position.
- Fault reset pushbutton.

- Lamp test button
- Emergency STOP pushbutton – mushroom head, twist-to-release type.
- Engine lubricating oil pressure gauge and low pressure warning light. Alternatively the oil pressure gauge may be mounted on the engine.
- Water temperature gauge.
- Engine hours run indicator.
- Battery charging ammeter.
- Battery voltmeter, selected by pushbutton.
- Engine speed trimming control and tachometer.
- Triple-pole circuit breaker, with thermal and magnetic overload protection set up as appropriate to the rating of the set, and fitted with a 300-mA residual ground leakage current trip unit and tripping circuit.
- Ammeter and selector switch permitting display of the three phase currents.
- Voltmeter and selector switch permitting display of line to line & line to neutral voltages from alternator.
- Digital output voltage frequency meter.
- Output voltage trimmer.
- Control and instrument circuit breakers as appropriate.
- Shutdown facilities and alarm lamps as specified.

Instruments and controls shall be identified by means of appropriate labels. In addition to markings on the ammeter scales, a label shall be fixed to the panel adjacent to the ammeters stating the full load current.

1.34.5 Alternator

The alternator shall be the brushless, self-exciting type with salient rotating poles, damping windings and single end shield bearings. Radio interference suppression to BS EN 55014-1:2001or equivalent shall be provided. Protection shall be built in to the alternator to prevent damage in the event of sustained low speed operation due to an engine control fault. The winding insulation shall be a minimum of Class F.

The output voltage shall be maintained to +or - 2.5% from no load to full load. The alternator and engine shall be suitable for continuous operation at a power factor between unity and 0.8 lagging at full load.

The alternator shall be dust and moisture protected to IP23, or above. The alternator shall be fitted with an anti-condensation heater, which shall be provided with a manual operation switch.

The alternator shall be capable of running at 110% full load for 1 hour every 6 hours in the maximum ambient temperature. It shall be supplied with thermistors in each phase winding, which shall give early warning of the temperature rising above the normal full load operating temperature.

The full load temperature rise of the windings shall be limited to a maximum of 80°C. The thermistor relay shall trip the alternator output circuit breaker. The set shall then be shut down after the preset cooling period has elapsed.

The output from the alternator shall be connected to outgoing terminals via a suitably rated manually operated moulded case circuit breaker. The outgoing terminals shall be located within a separate enclosure. This enclosure shall be fitted with a suitably sized removable gland plate arranged for bottom entry cabling. A separate enclosure with its own gland plate shall be provided for control cables.

1.34.6 Diesel Engine

The engine shall be of the diesel fuel powered internal combustion type, continuously rated, with the engine flexibly coupled to the alternator.

The engine shall be governed within the following limits during running:

-SO 3046 equivalent

The engine speed shall not exceed 1800 rpm.

Automatic shutdown facilities shall be provided to operate in the event of low lubricating oil pressure, high cooling water temperatures or high engine speed. In addition a fusible link emergency fire shut down system shall be provided within the generator enclosure, complete with wires, pulleys and fusible link. An emergency stop button shall also be provided on the exterior of the enclosure.

The engine shall be provided with fuel and lubricating oil filters, air cleaner and exhaust silencer. The set shall be supplied with the correct quantity and grade of lubricating oil.

1.34.7 Fuel tanks

1. General: The fuel tank shall be constructed in accordance with BS 799 Part 5 with seams fillet welded both internally and externally. Welding personnel shall be qualified to the required British Standard. Prior to dispatch from works the tank shall be cleaned internally and externally.
2. Daily Service Tank: A day tank with a storage capacity for 8 hours of operation at full load shall be provided. The pipework between the day tank and the diesel engine shall be copper.

   When deriving the usable fuel capacity of the tank, allowance shall be made for usage and for collection of debris in the bottom of the tank.

   The tank shall be provided with the following fittings and connection points:

   - Filling point pipe
   - Drain Cock
   - Access point for dip tape.
   - 100mm diameter level gauge graduated “empty”, ”¼ full”, ”½ full”, ”¾ full” and full”, adjacent to the filling point.
   - A fuel oil tank low level switch shall be provided to give a low level alarm on the engine control panel. Once this low level is indicated the provisions shall be made to trip the engine.

Hand operated pumps shall be provided to transfer the fuel from the bulk storage tank to the day tank.

3. Bulk Storage Tank: A bulk storage tank shall be designed for a storage capacity for five days running at full load or as otherwise stated in the particular specifications. The tanks shall be complete with the inlet pipe work, outlet pipe work, drain valves, vent pipes, lifting eyes, support feet, earthing boss and local level indicator with local audible high level alarm and alarm accept button. The level indication shall be transmitted to the instrument panel and shall be available for the connection to telemetry outside. The tank shall be bunded with the bund capacity of 110% of the bulk storage tank volume..

   The pipework from the bulk storage tank and the day tank shall be carbon steel as per BS EN 10217 or equivalent with a minimum wall thickness of 2.9mm.The joints in the pipework shall be minimum and flanged to PN 10 specification.

1.34.8 Engine Protection

The engine shall be provided with suitable engine protection systems which will shut the engine down automatically in the event of a fault or abnormal operating conditions.

The engine shall be fitted with an over speed trip which shall cut off the fuel supply when the engine speed rises above 120% of the normal running speed.

In the event of a shutdown occurring due to a fault condition arising, the relevant fault lamp shall remain illuminated and restarting shall be inhibited until some reset action has been taken.

1.34.9 Starting

An electric starting system utilising heavy-duty lead-acid batteries shall be supplied. An engine driven alternator and control unit shall be fitted for automatically recharging the starting batteries when the set is running.

A minimum of three sequential attempts to start from cold over a six minute period and a maximum of 6 starts per day shall be possible without the assistance of a supply of mains electricity. The starting system shall be fully recharged within 12 hours of continuous engine operation following the most arduous of the above starting sequences.

If the engine fails to start after three sequential attempts the start sequence shall be locked out and a “Failed to Start” alarm condition indicated.

1.34.10 Exhaust and Silencer System

The engine shall be fitted with an exhaust and silencer system. The exhaust shall terminate outside of the building above roof level. Within the building the exhaust shall be suitably lagged and finished with polished stainless steel cladding. Exhaust pipes shall be supported on rollers or pipe hangers. The exhaust pipework shall be connected to the engine via a bellows type expansion joint on the manifold flange. The exhaust pipework shall be fabricated from a minimum of 3/16” thick 316 grade stainless steel.

Insulation shall be fitted to those parts of the exhaust system within the generator enclosure or elsewhere, that are likely to come into contact with operatives.

1.34.11 Cooling System

The engine cooling system shall consist of a forced air cooled radiator utilising an engine driven cooling fan. The exhaust air shall be discharged directly to the outside of the building via ductwork. The incoming air will be taken from outside of the building and first pass over the alternator before passing over the engine and radiator.

The Contractor shall be responsible for the design and provision of adequate cooling facilities for the alternator, engine and radiator, taking into account the high ambient temperatures of the location. This shall include the provision of a noise attenuated intake and exhaust baffles and corrosion resistant ducting required within or external to the enclosure.

The Contractor shall submit calculations to demonstrate that adequate cooling of the generating set shall be achieved under all conditions up to the maximum ambient temperature.

The Contractor shall ensure that hot air produced by the engine running continuously at full load shall be satisfactorily dissipated with no risk of short circuit to the cooling air inlet.

1.35Painting and Protection

1.35.1 General

This Specification shall apply to the Protection, Painting and Surface Treatment of the Plant to be supplied under this Contract.

The preparation, application and conditions for work shall comply with the recommendations of IS: 1447 (Part I), BS 5493 and BS 6150 or if the protection is of a special nature, in accordance with the manufacturer's directions.

Paints, primers and undercoats shall be obtained from the same manufacturer and except where a definite time is specified between mixing and application, shall be ready mixed for use. They shall be compatible with one another.

Paints shall be delivered in sealed containers bearing the manufacturer's name, batch number, etc. and shall carry a label giving details of quality and instructions for use.

Test plates carrying finishes from the actual coating used may be required by the Engineer for inspection and test purposes.

To facilitate inspection, no consecutive coats of paint shall be of the same shade except in the case of white.

Priming to two mating surfaces shall be applied prior to assembly.

All items of Plant shall be delivered to Site with the shop paint finish applied unless specified otherwise. A further coat of final finish paint shall be applied at Site, of sufficient thickness to produce a uniform colour and appearance. Such painting shall be carried out within one month of successful acceptance trials for the Plant.

All paint thicknesses shall be checked using an alkometer or equivalent instrument, supplied by the Contractor, for each layer of paint, to the reasonable satisfaction of the Engineer.

All buried steel pipes and fittings shall be coated and unwrapped with hot or cold applied, self-adhesive, polyethylene in accordance with AWWA C214 or equivalent Standard.

Cast iron or mild steel parts to be built into concrete shall remain unpainted. Immediately before it is cast in-situ, it shall be made perfectly free from dirt, scale, loose rust, paint, oil limewash or any other coating.

No blast cleaning or painting shall be applied to corrosion resistant Materials such as stainless steels. Ni-resist cast iron, bronze and other metals used for seals, bearings, lighting fitting etc.

Machined surfaces such as gear teeth shall be coated with a thick layer of grease. Other mechanical surfaces such as shaft ends or other bright parts shall be coated with two coats of an anti-rust solution which can be removed easily when required. Permanently bolted mechanical interfaces such as flanges shall be coated with a thin coat of anti-rust compound before assembly.

1.35.2 Standards

Reference Standard	**Description**
BS 5493 or BS 6750 or equivalent iron and	Code of practice for protective coating of steel structures against corrosion
IS 1477 (Part – 1)	Code of Practice for Painting of Ferrous Metals in Buildings – Pretreatment
IS 1477 (Part – 2)	Code of Practice for Painting of Ferrous Metals in Buildings - Painting
BS 729, ISO 1459, 1460, 1461& 4921 1224 articles	Hot dip galvanised coatings on iron and steel
BS 4921, BS EN 12540:2000 or equivalent articles	Sherardized coatings on iron and steel
IS 2074	Ready Mixed Paint, Air Drying, Red Oxide Zinc Chrome, and Priming - Specification.
BS 7079/ BS EN ISO 8502-8/SIS055900	Rust grades for steel surfaces and preparation grades prior to protective coating. RAL Colours for Ready Mixed Paints and Enamels

1.35.3 Non Toxicity

Coatings used for any part of the plant in contact with potable water shall be non-toxic, non-carcinogenic, not impart taste, odour, colour or turbidity to the water or foster microbial growth. To avoid the possibility of the presence of the carcinogenic polyaromatic hydrocarbons, bituminous paints and coatings must be manufactured from petroleum or asphaltic bitumen and not from coal tar bitumen.

1.35.4 Lead Based Paint

Lead based paints shall not be used.

1.35.5 Application of Paint

Paint shall not be applied under adverse conditions, i.e., when the steel work temperature is below 4°C, above 50°C, less than 3°C above the dew point or when the relative humidity is above 90%.

The Contractor shall ensure that, for the materials specified, application conditions are in accordance with the Specification and manufacturer's instructions, paint only being applied to surfaces that have been cleaned and prepared in accordance with these instructions.

Where local climatic conditions are such that the specified requirements are difficult to achieve the Contractor shall provide temporary protection.

No manufacturer's name plate identification, vented filler plugs in gearboxes or grease nipples shall be painted over.

The paint dry film thickness shall be measured by the Contractor in the presence of the Engineer by Elcometer.

1.35.6 Colour Coding and Labelling

All pipes and equipment shall be colour coded to a schedule to be agreed with the Engineer before any site painting starts, or earlier if necessary to suit manufacturing procedures. Valves and fittings shall be painted in the same colour as the pipe of which they form a part. Where a pipe enters or leaves a piece of equipment the pipe colour shall extend up to but not including the flange attached to the equipment.

All pipelines shall be identified by stick-on 90 micron thick vinyl film labels showing the name of the material to be carried by the pipeline and an arrow indicating the direction of flow. Letters of titles shall be pre-spaced on carrier tape and the complete title protected by one piece removable liners.

Titles shall be at intervals not less than 8 m, but shall in any case be provided in every space through which the pipe passes. Locations of labels shall be subject to prior approval by the Engineer. Lettering sizes shall be between 16 mm and 75 mm in height depending on the size of the pipe.

Pipes smaller than 22 mm outside diameter shall be labelled by the use of tags instead of labels. Tags shall be made of brass no smaller than 65 mm x 16 mm by 1.5 mm thick, with lettering etched and filled with black enamel.

Titles shall also be provided on all equipment in locations and in sizes to be approved by the Engineer.

1.35.7 Cleaning and Preparing at Place of Manufacture

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

Parts shall be cleaned prior to testing at the manufacturer's works. Parts subject to hydraulic test shall be tested before any surface treatment. After test all surfaces shall be thoroughly cleaned and dried out if necessary by washing with an approved dewatering fluid prior to surface treatment.

Bright parts: Bright parts and bearing surfaces shall be thoroughly polished and protected from corrosion by the application of rust preventive lacquer or high melting-point grease, as approved by

the Engineer, before the parts are packed. A sufficient quantity of the correct solvent for removal of the protective compounds shall be supplied and packed with each particular part.

Embedded parts: Embedded parts or those parts of an assembly which will be embedded in concrete shall be thoroughly de-scaled and cleaned to the satisfaction of the Engineer and before being packed shall be protected by a cement wash or other approved method. No cast iron or steel work shall be bitumen or tar coated where it is to be cast into the concrete and provision shall be made for cleaning off any portions so coated.

Grit or shot blasted parts: Grit or shot blasting shall be carried out in accordance with B.S. 7079 to a standard between `First Quality' and `Second Quality' given in Table 1 after which the maximum amplitude of the surface shall not exceed 0.1 mm.

Cast Iron and Steel pipework: All ungalvanised steel pipework including pump suspension mains, bearing spiders and tunnel tubes shall be prepared internally and externally by grit or shot blasting as specified above and the surfaces primed as specified within four hours of blasting.

1.35.8 Painting and Finishing at Place of Manufacture

This Clause governs the methods for the protective coatings to be applied to structural steel, metalwork and ironwork as corrosion protection systems. The systems designed as specified here shall be applied as specified under Protective Coatings. This specification makes reference to the following standard: BS 5493 "code of practice for the protective coating of iron and steel against corrosion"

The Contractor shall design each protective coating system and shall submit details of each system to the Engineer for approval. Submissions shall where possible be in the agreed format with such additional information and samples as the Contractor may provide or the Engineer may require to enable the system to be assessed.

Protective coating shall be designed in accordance with B.S. 5493 to have a long life, generally of at least 10 years to first maintenance. Protection systems shall be chosen to be easily maintained in the future and to allow non-specialist on-site re-coating where necessary using single part paints.

For the purposes of system design the general environment shall be as specified in B.S. 5493 Table 3 Part 2 `Exterior exposed polluted inland'. Bulkhead gates and stoplogs shall be assumed to be exposed to a Table 3 Part 8 `Non-saline water' environment unless otherwise approved by the Engineer.

Interior spaces shall be considered to be dry in administration areas open to continuous access and damp or immersed in other spaces. The protective coating of components or structures which are continuously or infrequently immersed shall be designed for the more onerous of these two conditions relevant to the protection system used.

All exterior exposed items to be coated shall have a final coat of good appearance of a colour and type as approved by the Engineer.

Protective coating systems shall generally fall into one of the following basic systems;

- Galvanising;
- Galvanising plus painting;
- Multi-coat painting;
- Bitumen enamel;

- Others as proposed by the Contractor and approved by the Engineer.

All painting material shall be applied in strict accordance with the paint manufacturer's instructions.

(a) Plant supplied to site with final coating applied:

Before any steel work is painted the steel must be thoroughly cleaned and an approved anti -rusting priming coat applied so that the possibility of rusting or corrosion taking place is negligible. All surfaces should have not less than two undercoats and two top coats or air drying paint. The undercoats shall be easily distinguishable in shade or colour form the priming and finishing coats. The two final coats shall be in a colour and finish to be advised by the Engineer. The inside surfaces of any cubicles, cabinets etc. where condensation is liable to occur, shall be coated with an approved anti-condensation composition. The Contractor shall ensure that all component sections of a switch board wherever manufactured shall have a finish of uniform texture and an exact colour match.

Chromium plated parts:

Where chromium plating is specified or offered by the manufacturer it shall comply with the requirements of BS 1224 including the following provisions. No blistering of any surfaces will be tolerated. The finished appearance shall be brought. Where the base metal is steel, plating shall be applied in accordance with Table 2 of the above code. Other base metals shall be plated in accordance with Tables 3, 4, 5 as appropriate. For all base metals the service condition number 2 (of the above code) shall be used.

Small bore pipes, valves and fittings etc., which are sited in architecturally finished areas of the station and selected by the Engineer shall be chromium plated. Damage to chromium plating shall be made good before taking over.

Galvanised parts:

All materials to be galvanised shall be of the full dimensions shown on the approved drawings or specified and all punching, cutting, drilling, screw tapping and the removal of burrs shall be completed before the galvanising process begins. Parts to be galvanised shall be shot blasted as specified above. Such parts shall be galvanised not more than four hours after commencement of shot blasting.

All galvanising shall be done by the hot dip-process. No alternative process may be used without the approval of the Engineer. No components shall be galvanised which are likely to come into subsequent contact with oil.

The zinc coating shall be uniform, clean smooth and as free from spangle as possible. In the case of component parts the zinc coating shall weigh not less than 610 g/sq.m of area covered and shall not be less than 0.090 mm in thickness.

Bolts and nuts shall be standardised. The Engineer may select for test as many components to be weighed after pickling, and before and after galvanizing as he may think fit. All galvanised parts shall be protected from injury to the zinc coating due to differential serration and abrasion during the periods of transit, storage and erection. Damaged areas of the coating shall be touched up with an approved zinc-dust paint or other approved flake metallic compound.

Cast iron and steel pipework: (Internal surfaces)

The internal surfaces shall have an approved coating. Where a bitumen based coating is used, it shall be in accordance with Type 2 of BS 4147. Prior to lining, the pipe shall be grit blasted and primed with

an approved primer. The lining shall be in accordance with BS 534. After installation, the internal lining shall be made good and satisfactorily tested with a Holiday detector to 8 kV. The coating shall be suitable for use in contact with drinking water.

Where pipe are to be welded after the protective coatings have been applied the pipe surfaces shall be primed and all other coating stopped 250 mm short of the weld preparation. Collars and filling shall be primed but no other coating applied.

The manufacturer shall supply a sufficient quantity of suitable materials to repair damage occurring during delivery to site and to provide a flush finished internal lining at welded joints. He shall supply sufficient coating to fill in the recesses at internal welds over the previously primed areas. The costs of these materials shall be included in the unit rates for the supply of the pipes and specials.

Machinery- (Internal surfaces) e.g. pumps, valves, strainers, rising and suspension mains of wet well pumps:

As for cast iron and steel pipe work (Internal surfaces) Cast iron and steel parts (External surfaces) immersed in Water:

All ungalvanised metal parts which will be immersed in water shall be cleaned by grit blasting and within four hours of blasting given an approved coating.

Cast iron and steel (External surfaces) in manholes and areas of high humidity.

Ungalvanised metal parts exposed in manholes or areas of high humidity shall be cleaned by grit blasting and given two coats of a black bituminous solution.

(b) Plant forwarded to site for final finishing.

Cast iron and steel parts (External surfaces) outside buildings:

All ungalvanised metal parts which will be exposed to the outside atmosphere shall be cleaned by grit blasting and provided with two coats of an approved primer.

Cast iron and steel parts inside buildings:

All exposed metal surfaces which will not be immersed in water or exposed in areas described above shall be rubbed down, cleaned by grit blasting and within four hours of blasting given one coat of an approved primer before packing.

1.35.9 Painting at Site

Immediately on arrival at the site, all items of plant shall be examined for damage to the paint coat applied at the manufacturer's works, and any damaged portions shall be cleaned down to the bare metal, all rust removed, and the paint coat made good with similar paint.

Steel and cast iron parts received at site shall be provided with adequate number of further coats of coal tar epoxy polyamine coating or Polyurethane coating as specified & approved, to a total dry film thickness of minimum 275 microns including the primer coats. All sharp edges, nuts, bolts and other items difficult to be painted shall receive a brush coat of specified paint before application of each coat of epoxy based coal tar paint giving a total dry film thickness of at least 275 microns. In the case of fabricated steelwork this work shall be done after assembly.

Before painting is commenced the Contractor shall submit for the approval of the Engineer, full details of the paints he proposes to use together with colour charts for the gloss finishes.

After erection, such items which are not finish painted shall be finish painted, items finish painted at the Manufacturer's works shall be touched up for any damaged paint work.

The painting work shall conform to the following requirements:

(a) The surface preparation shall be carried out generally in accordance with IS: 1477 Part I and

IS: 6005

(b) After surface preparation, two coats of primer-red oxide zinc chromate with modified phenolic alkyd base conforming to IS: 2074 shall be applied. Dry film thickness of each coat shall be 25 microns.

(c) For finish painting, after application of primer as in (b) above, two coats of synthetic enamel conforming to IS: 2932 shall be applied. Dry film thickness of each coat shall be 25 microns.

d) Colours shall be selected as per IS: 5

No painting shall be carried out unless the item has been inspected and accepted by Engineer at the Manufacturer's works.

The dry paint film thickness shall be measured by Electrometer or other instruments approved by the Employer. In order to obtain the dry film thickness DFT specified, the Contractor shall ensure that the coverage rate given by the paint manufacturer will enable this thickness to be obtained. Strength of adhesion shall be measured with an adhesion tester and this value shall not be less than 10 kg/cm2.

Painted fabricated steel Work which is to be stored prior to erection shall be kept clear of the ground and shall be laid out or stacked in an orderly manner that will ensure that no. poles of water or dirt can accumulate on the surface. Suitable packings shall be laid between the stacked Materials. Where cover is provided, it shall be ventilated.

The painting procedure shall be submitted in the following format for approval:

(a) Surface Preparation

(b) Reference Standard

(c) Conditions of Work

(d) Type of Materials

(e) Tests and inspection methods and sequence, thickness (DFT)

(f) Colour in final coat

(g) Total thickness of coats (DFT)

(h) Other necessary data and information

1.35.10 Painting Completion

Painting and protective finishes shall be completed prior to issue of the Certificate of Completion of the Works or any part thereof.

1.35.11 Storage

Paint materials shall be stored and applied strictly in accordance with manufacturer's instructions.

1.35.12 Application of Paint

Paint shall not be applied under adverse conditions, i.e., when the steel work temperature is below 4°C, above 50°C, less than 3°C above the dew point or when the relative humidity is above 90%.

The Contractor shall ensure that, for the materials specified, application conditions are in accordance with the Specification and manufacturer's instructions, paint only being applied to surfaces that have been cleaned and prepared in accordance with these instructions.

Where local climatic conditions are such that the specified requirements are difficult to achieve the Contractor shall provide temporary protection.

No manufacturer's name plate identification, vented filler plugs in gearboxes or grease nipples shall be painted over.

The paint dry film thickness shall be measured by the Contractor in the presence of the Engineer by Elcometer.

1.35.13 Colour

All metal protective finishes shall be in a colour approved by the Engineer. Colours shall be selected as per IS: 5.

1.35.14 GRP Covers and Guards

GRP covers and guards shall be pigmented to give the finished colour without painting. Housing wall thickness shall be a minimum of 8mm and stiffened with GRP cross members.

1.35.15 Defects

Defects are defined in BS 2015 Glossary of Paint Terms.

The Contractor shall ensure that coatings are free from defects and adequate in respects for the purpose intended.

The painting system shall be deemed to have failed if:

1. After painting, damage has been caused by handling, impact, abrasion or welding.
2. Any portion of the paint film separates from any other or the parent metal.
3. After painting the total dry film thickness measured by Elcometer is less than that specified.
4. Loss of gloss.
5. Variation of shade.

The Contractor shall make good any defects and shall re-submit failed areas for inspection.

1.35.16 Protective Systems

The following protection systems shall be employed.

		Dry Film Thickness
Surface preparation	Abrasive Blasting to SA 2½	
Pre-treatment	Zinc Rich Epoxy Primer	40 microns
First coat	Epoxy High Build	100 microns
Second coat	Epoxy High Build	100 microns
Third coat	Two Component Polyurethane (Enamel)	50 microns
	TOTAL DRY FILM THICKNESS	290 microns

Steel structure, machinery etc. below water or sewage level.

		Dry Film Thickness
Surface preparation	Abrasive Blasting to SA 2½	
Pre-treatment	None or Shop Primer	
First coat	Two Component Coal Tar Epoxy	100 microns
Second coat	Two Component Coal Tar Epoxy	100 microns
Third coat	Two Component Coal Tar Epoxy	100 microns
	TOTAL DRY FILM THICKNESS	300 microns

Steel exposed to splashes and spillages.

		Dry Film Thickness
Surface preparation	Abrasive sweeping or sanding to provide key for adhesion	
Pre-treatment	Zinc Phosphate Epoxy Primer	40 microns
First coat	Two Component Polyurethane (Enamel)	50 microns
	TOTAL DRY FILM THICKNESS	90 microns

1.36Spare Parts

Spare Parts required to be furnished in the Bid document.

Spares during pre-commissioning trials, commissioning tests/ maintenance, guarantee etc. shall be provided by the Contractor. The spares also include the consumable such as bulbs, fuses, wires, lubricating oil, gaskets, packing seals, etc. The necessary spares shall be brought by the Contractor

prior to the pre-commissioning test so as to avoid the downtime of equipment due to non-availability of them. All these spares have to be provided as required, by Contractor free of cost.

All spare parts shall be new, unused and strictly interchangeable with the parts for which they are intended to be replacements and shall be treated and packed for long storage under the climatic conditions prevailing at the Site. Each space part shall be clearly marked or labeled on the outside of its packing with its description, number and purpose. When more than one spare is packed in a single case or other container, a general description of its contents shall be shown on the outside of such case or container and a detailed list enclosed. All cases, containers and other packages shall be marked and numbered in an approved manner for the purpose of identification. Spares shall be delivered to Site after the completion of erection but before start of commissioning of plant along with technical leaflets and details. Spare parts shall be indicated in the assembly drawing showing clearly the part numbers.

All cases, containers or other packages are liable to be opened for such examination as the Engineer's representative may require and packing shall be designed to facilitate opening and thereafter re-packing. In the event of the some specific spares offered in the Contract being withdrawn from manufacture owing to changes in design of equipment or similar reasons viz., model being obsolete etc., the Contractor shall inform the Employer/ PMC before such withdrawal so that the Employer/ PMC can take timely alternative steps.