OMAN WASTEWATER SERVICES COMPANY S.A.O.C

الشركة العمانية لخدمات الصرف الصحي ش.م.ع.م



**OMAN WASTEWATER SERVICES CO. S.A.O.C.**

# TECHNICAL STANDARD SPECIFICATION

# PROCESS EQUIPMENT

# SECTION 02

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# 2 Process Equipment

## 2.01 Settlement Tank Equipments

### 2.01.1 Scope

This specifications defines the requirements for the performance, design, manufacture, construction and testing of equipment for primary and secondary settlement tanks.

### 2.01.2 MATERIALS

a. All reference to stainless steel shall mean stainless steel to BS970 Grade 316 S31 (partially replaced by BS EN 10084) unless otherwise stated.

b. All reference to aluminum shall mean marine grade aluminum milled finished 6063TF alloy to BS EN 12020.

c. All materials shall be protected against corrosion.

### 2.01.3 Scrapers

1 The tank scrapers shall be of the half or full bridge rotating type or fixed bridge type as specified in the Contract Documents.

2 Non retractable tubular steel arms shall connect the scraper blades to the drive. The stainless steel scraper blades shall be fitted with removable heavy duty neoprene rubber or synthetic material hard wearing strips having a minimum shore hardness of 70. They shall be not less than 20mm thick and shall be fastened to the mechanism in such a way that the blades may be reversed. Blades shall be arranged to form a continuous spiral across the floor and vertically up the side wall of the tank. Either the arms or blades shall be hinged to compensate for minor variations in the tank floor and side wall. Slotted holes shall be provided on the scraper rubber blades for adjustment against wear.

3 The two arms of fixed bridge scrapers with any appendages shall be equally balanced statically and be supported for rigidity using stay rods and turn buckles.

4 The scraper and its driving mechanisms shall be designed to allow for longitudinal and vertical movements of the bridge.

### 2.01.4 Bridges

1. The bridge shall be fabricated from structural steelwork to BS4 Part 1: BS449 Part 2: BS EN10029: BS EN10113: BS EN10155 and BS EN10210.
2. Fixed bridges shall span the full width of the tank.
3. Rotating half bridges shall be supported at the centre of the tank using a tripod manufactured from the same material of the bridge. The structure shall be designed to withstand the total loadings induced by the bridge and other forces associated with the bridge and scraper when in operation. The top plate of the support structure shall accommodate the centre bearing assembly and diffuser drum supports.
4. The bridge shall be designed to take a uniform distribution load of 250 kg/m2 in addition to the weight of the scraper assembly.
5. The maximum permissible deflection with this superimposed load shall not be greater than 1/360 of the bridge span. On removal of the load the bridge deflection shall fully recover and return to its original mid span position on either side of the bridge.
6. The bridge design shall include provisions to adequately cope with all torsion moments that it may reasonably be expected to encounter, with a safety factor of 2.0.
7. Fixed bridges shall be constructed with equal mass on both sides of the centre of the tank. At each end provision shall be made in the design of the supports to allow for expansion and contraction resulting from temperature differentials of not less than 10°C beyond the recorded maximum and minimum ambient temperatures in the region.
8. The bridge structure shall have suitably rated open walkway across the full length of the structure and the width shall be 850mm, between hand railings.
9. Hand railing shall be manufactured from marine grade aluminum tubes with standards 1100mm above the walkway for top rail and an intermediate rail 550mm above the walkway.
10. Toe boards 150mm high shall be fitted along both sides of the walkway.
11. Insulation shall be provided as necessary to prevent electrolytic action between dissimilar metals.

### 2.01.5 Drive Units

1. For fixed bridges a motor, flange mounted to a reduction gearbox, shall provide the drive. The motor speed shall not exceed 1500rpm. The motor and gearbox shall be easily accessible for maintenance.
2. Rotating bridges shall be driven by a double-wheeled drive unit mounted on the end carriage. The end carriage shall be fabricated from mild steel and incorporate the trailing rear-driven wheel and the leading driving wheel and shall incorporate guards covering all wheels to protect from the possibility of wheel nip. The driving wheel shall be driven by a motor and gearbox unit. Both wheels shall be polyurethane tyred.
3. For fixed bridge drive units the following shall apply:
    a. A drip tray, with gunmetal drain tap, shall be located under the motor and gearbox reduction unit(s). The drip tray shall be manufactured from stainless steel not less than 2mm thickness.
    b. Any drive required between the reduction gearbox and the scraper shaft shall be by pinions and spur wheels or geared slewing rings as appropriate.
    c. The gearbox may be oil or grease lubricated whilst all other bearings shall be grease lubricated. All grease lubrication pipes shall be manufactured from stainless steel tube and be terminated at a common location on the bridge at a point which affords operational access to enable convenient, safe lubrication and be suitably labeled.
    d. The speed of the scraper assemblies measured at the tank periphery shall be. As follows: Primary tanks 0.75 – 2.5m/min Final tanks 0.3 – 1.5m/min fully variable.
    e. The drive system shall incorporate a loss of rotation monitor and an overload protection device comprising a torque limiting coupling set at the appropriate cut out torque. The device shall incorporate a switch and alarm indication system drawing attention to the fact that the torque limiting device has operated.
    f. The gearbox output mechanism shall be restrained by a torque arm fitted with a weatherproof, strain gauge type torque indicator and electro mechanical overload contacts.
    g. Guards shall be provided fully enclosing the scraper drive mechanisms.

### 2.01.6 ANCILLARY EQUIPMENT

### 2.01.6.1 INLET WELL

1. Inlet well shall be constructed in glass reinforced plastic suitably strengthened (or any other suitable and accepted material) and supported from the bridge so as to be

positioned in the centre of the tank.

2. The well shall be sized to be 10% of the total area of the tank and 2m deep. The top of the inlet well shall project 150mm above TWL.
3. The well skin and flange thicknesses shall be not less than 4mm and 6mm respectively.
4. Two 180° opposed square cut outs with internal baffles above TWL shall be installed in the inlet well to enable the removal of grease and sludge.

### 2.01.6.2 Weir plates and scum boards

1. 'V' notch weir plates shall be supplied for bolting to the tank walls. The weir plate shall have 90o notches equal-spaced around the periphery of the tank and slotted adjustment holes. The spacing and size of "V" notches should be determined by calculation. The maximum discharge per notch should be 30-40m3/day to enable uniform outlet conditions.
2. The weir plate shall be 300mm deep and be fabricated from stain less steel, composite plastic or GRP. The weir plate shall be pre-curved and of minimum thickness 6mm. sealing strips shall be provided for installation between the weir plates and the tank wall to allow for discrepancies in the structure.
3. Brackets shall hold the scum boards securely 500mm from the inside face of the weir wall. The scum boards shall be manufactured from GRP; 300mm deep by 6mm thick pre-curved and shall be positioned so that 100mm of the scum board is above water level.

### 2.01.6.3 Scum Skimmer

A scum skimming arm (trailing scum board) shall be attached to the bridge (for rotary bridge) or to the scraper arm (for fixed bridge) which must maintain contact with the scum board in all positions. The scum arm shall sweep the scum to a scum box at the periphery of the tank which shall automatically discharge the scum via pipe work to a scum/grease trap. The blade shall be fabricated from GRP or stainless steel and shall protrude 100mm above top water level.

### 2.01.6.4 Scum Box

Scum shall be collected in a scum box attached to the tank wall. The scum box shall be fabricated from stainless steel and terminate with a flanged connection. Scum box flush shall be provided suitable for operation from either the bridge or tank periphery.

### 2.01.6.5 Effluent Launder Cleaning

Effluent channel cleaning system should be applied taking in consideration that each part of the launder is reachable. Cleaning system to be approved by the Engineer.

## 2.02 Screening Plant

### 2.02.1 Scope

This specifications defines the requirements for the performance, design, manufacture, construction and testing of equipment for screening equipment.

### 2.02.2 GENERAL

1. Screens shall be complete with all the necessary ancillary equipment and with screenings washing and compacting facilities.
2. 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.
3. In all cases the screens shall be protected by a torque limiting device in addition to the motor overload protection. Rake parking switches shall also be provided and in each case the electrical circuit information for each device shall be provided with drawings for approval. The screening equipment shall not immediately restart on removal of the obstruction but shall be manually reset at the control panel.
4. The screen aperture shall be as stated in the Contract Documents.
5. All moving parts of the screen shall have oil impregnated, sintered bronze or grease lubricated bearings. In the case of the latter, individual stainless steel feed pipes and flexible polyurethane tubes to the bearings shall be fed from a manifold that shall be located in a convenient position outside any guards on the screen. A manual grease feed pumping system shall be incorporated.
6. 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 rake mechanism shall be arranged such that minimum number of moving parts will remain immersed when the screen is in the parking position.
7. The complete headgear shall be enclosed within a removable glass reinforced plastic splash hood and a hinged door shall be provided to give visual inspection of

the screens. The hood shall incorporate air admittance valves.

8. The screen shall be manufactured from stainless steel Grade 316 S31 to BS 970-1(partially replaced by BS EN 10084), unless otherwise stated.
9. Limit of position indication shall be incorporated into the drive mechanism by means of proximity switches protected to IP68.
10. Access**,** Hinged or 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. Where equipment cannot be accessed from floor level, an access platform and walkway shall be supplied and designed in accordance with the requirements of this Specification

### 2.02.3 Hydraulic Capacity

The screen shall be suitably sized to enable satisfactory installation within the Site layout as indicated in the Contract. It shall be designed to handle the flow conditions stipulated with the minimum head loss having particular regard to the total head available.

Screens shall be with adequate standby/ assist facility to cope with 110% of design capacity with one screen out of service. At least one standby screen shall be provided for every three duty screens.

Design approach velocities should be in the order of 0.4 - 0.9 m/s (min-max respectively) depending on the type / design of the screen. The actual capacity and design conditions shall be obtained from the manufacturer.

### 2.02.3 Screenings Collection

Removed screenings shall be washed and dewatered to minimise organic and moisture contents, then automatically transferred to skips or bagging units for disposal. In-line disintegration or maceration with the return of screenings to the flow shall not be permitted.

Hoppers for collecting captured screenings shall be of adequate size to cope with peak loads and shaped to avoid blockages. Hoppers and associated ducting shall be stainless steel to BS 970: 316L, GRP or similar approved materials.

### 2.02.4 Wash water

Water used for screenings removal and washing shall generally be treated final effluent. Where spray nozzles are used they shall be fully enclosed to prevent an aerosol.

Potable water may be used if final effluent is not available. Where the manufacturer's design incorporates screened water as a screenings removal medium, this shall not be used within the screenings washing process.

### 2.02.5 Coarse Screen

This is a term applied to screens with a screening aperture, usually in one direction not less than 25mm. 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.

### 2.02.6 Fine Screens

This is a term applied to screens with a screening aperture, usually in two directions between 3 to 6mm. Unless otherwise stated in this or the Particular Specification, the term 'Fine Screen' shall imply a 6mm, two directions screen. The function of this type of screen is predominantly used for screening Flow to Full Treatment (FFT).

Where Works are subjected to large stones / rocks and/or excessive floating debris, in order to protect the fine inlet screen a stone trap or coarse screen may be positioned upstream of the fine screen. The size of the coarse screen and whether this is manually or mechanically raked will depend upon the volume and / or size of the debris to be removed. Each Works should be considered on an individual basis and in conjunction with the manufacturer's recommendations.

### 2.02.7 Straight Bar Screen

1. The straight bar screen may be vertical or inclined and shall comprise a stationary bar rack or grid which is automatically cleaned by one or more power operated rakes.
2. The screen bars shall be at the centers as specified in the Contract and fabricated from stainless steel to BS 970, Grade 316 S31 (partially replaced by BS EN 10084).
3. The screen may be front or back raked. In the case of reciprocating rake machines, the rakes shall clear the bars on the down stroke and engage positively with screen

bars prior to the upward stroke. A wiper mechanism shall ensure that the rake is cleared of all screenings before continuing its cycle.

4. The cleaning rake shall be jam proof type, chain driven, suitable for either front or back cleaning, and shall be formed of stainless steel with teeth of adequate length and section bolted on for easy replacement.
5. Chain driven screens shall be provided with chain tensioners and have provision for manual adjustment in the event of chain stretching.
6. Tracked rake carriages shall also be provided with wheel adjustment so that engagement in the channels of the track can be optimized.

### 2.02.8 Step Screen

1. Step screens shall not be permanently secured to the screen chamber walls. Location fixings shall be positioned at coping level for ease of access.
2. Screens to be housed in enclosed structures shall be manufactured in sections to facilitate removal from the chamber making due allowance for the maximum height available.
3. Where the size of the screen permits, the screen may be hinged such that it can be tilted out of the chamber for maintenance purposes.
4. 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.
5. 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.
6. The screen shall be designed to prevent blockage at the base by grit or stones and shall be constructed of stainless steel Grade 316 S31 to BS 970-1 (partially replaced by BS EN 10084).

### 2.02.9 Rotating Bar Interceptors

The rotating bar interceptor screen shall prevent large solid objects entering the protected area. All other screenings shall be induced to pass through the screen by the rotating action of the bars.

The screen shall consist of a grille of large diameter rotating vertical tubes with either 50 to 100mm clear spaces between tubes. The tubes shall be mounted into a substantial steel framework.

Rotation of individual bars shall be achieved by independent hydraulic motor units capable of being submerged without damage.

The hydraulic motor units shall be driven by a hydraulic power pack. The hydraulic power pack shall incorporate an oil reservoir tank, oil level gauge, oil thermometer, motor driven gear type oil pump and control valves to allow time-controlled rotation and reversal of the bars. In the event of one or more bars stalling then the remaining bars shall continue to operate. It shall be mounted adjacent to the power pack and incorporate indication of oil pump overload, screen bar stalled, oil filter high pressure drop, high oil temperature, low oil pressure and low oil flow.

The Contractor shall include for all necessary hydraulic pipe work, valves and fittings between the hydraulic units and the power pack. Hydraulic hoses shall be in accordance with BS 4586. Steel hydraulic pipes shall be in accordance with BS 778.

### 2.02.10 Brush Screen

1. The screen shall comprise perforated stainless steel Grade 316 S31 to BS 970-1 (partially replaced by BS EN 10084), or molded polyurethane panels with 6mm apertures. .
2. The rotating brush shall incorporate adjustment arrangements to optimize brush effectiveness and reduce brush wear. Brush adjusters shall be fitted with locknuts, stiff nuts or stop retainers to prevent disengagement of the brush resulting in consequent damage of the screen plates.
3. The screening panels shall be bolted to the framework using stainless countersunk bolts. Edge clearances shall not be capable of trapping screenings and in any event shall not exceed 5mm.
4. The screen shall be provided with a brush wiper mechanism to ensure the complete removal of screenings from the brush.

## 2.03 Screenings Handling

### 2.03.1 General

If coarse and fine screening is required two separate screens handling systems shall be provided; one for the coarse screens and the other for the fine screens.

The works shall include the provision of all ancillary items of equipment, including but not limited to launder, pipe work and wash water supply.

Launders for the fine screens shall be constructed to allow flows to be directed to all or any of the process units. Launders shall have minimum gradient of 1:40. They shall include transparent covers with quick release catches.

A means to detect blockages in the launders shall be provided. Detection shall be carried out directly upstream (in the launder flow) of each screen. A probe shall be used to measure the depth of launder water in the launders this shall raise an alarm to SCADA on high level and increase the launder flows in accordance with the Control Philosophy.

Centre-less screw conveyors or belt conveyor shall be used to convey the screenings from the coarse screens to their respective screenings handling units. The conveyors shall be fitted with over-torque protection, and an alarm shall be raised on SCADA in case of failure.

Liquors from the dewatering compactors shall be returned to the flow by gravity or pump if necessary. The liquors shall be returned upstream of the screens.

The screenings handling systems shall dewater and clean the screenings to the following specification:

- Dry solids, minimum 50%
- No visible faecal solids
- Volume reduction ratio 6:1

Conveyance water for the launders shall be final effluent. Flows shall be proportional to the number of screens in operation.

Macerator systems shall not be used on the coarse screen system.

### 2.03.2 Screenings Handling - Screw washer type

1. The system shall comprise an inlet section, a washing section and a compaction section.
2. The system shall be suitable for treating screenings that are heavily laden with grit and stones.

3. The system shall be able to pass solids as large as 200mm (cubes), without damage.
4. The rotational speed of the screw shall be no more than 16 RPM.
5. All along the length of travel of the screening there shall be wear parts that are easily replaceable.
6. In the inlet section these shall be polymeric clip on sections (Durolflow or similar approved), in the washing / compacting sections these wear parts shall be steel with a hardness of at least 400 Brinell.
7. The design shall not have dead spots where rags, grit and stones could accumulate.
8. The system shall be suitable for laundered flow or screw conveyors, as appropriate to the Contractor's choice of system.
9. Where liquors are discharged through a perforated trough, the trough plate shall be easily replaceable and cleaned. Underneath the perforated plate any drop out box shall be supplied with a manual wash water connection, for routine flushing.

### 2.03.3 Screenings Handling - Macerator Type

1. Allowance shall be made for the de-rating the macerator pumps for wear and pumping heavily solids laden fluid (as opposed to water).
2. The control system shall be designed to prevent a build up of a mat of floating solids in the tank.
3. Adequate access shall be provided to all parts of the handling system and particular attention shall be given to manual digging out of the macerator tank, removal of floating solids from the top of the tank and maintenance, inspection and removal of the macerators. Lifting gear shall be provided.

### 2.03.4 Screening Trough

1. Screenings shall be discharged from the screens into a screening trough for water borne transfer to the washer/compactors. The trough shall be made of minimum 6 mm thickness stainless steel Grade 316 S31 to BS 970-1 (partially replaced by BS EN 10084) plate with bolted removable access cover sections.
2. Water for flushing the screenings from the screen discharge collection point to the washer/compactor shall be 6mm screened sewage, treated sewage effluent or potable water as specified in the Contract. Screened sewage shall only be used with the approval of the Engineer and the Contractor shall take all necessary measures to eliminate odor release and to treat any odors that are released.

3. The trough shall be supplied with two 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.

### 2.03.5 Belt Conveyor

Belt Conveyors shall be of 3-ply standard endless conveyor belting (joints to be vulcanized), reinforced with fabric between plies of width 800mm and a thickness of 20mm (upper ply-contact surface 7mm, middle ply 8mm and bottom ply 5mm thickness). This conveyor shall be incorporated with SS side plates, doctor blades, trough and stainless steel return idlers, adjustable tail pulley and a motorized head pulley permitting rotation in both directions. The conveyor shall be mounted on stainless steel frame work.

### 2.03.6 Covered Skip Containers

1. Covered skips shall be suitably sized and fabricated from steel sheets of sufficient thickness to withstand full volume of screenings or grit loading and the stresses of movement and dumping of the screenings and grit.
2. The shape and dimensions of the skip containers shall be compatible with the configuration of the screenings and grit dewaters so that discharge to the skip containers occurs without spillage. The skips shall have a nominal length of 3.6m, nominal width of 1.8m and nominal liquids capacity of 3.6m.
3. Skip containers shall have rubberized castor wheels, with a minimum wheel diameter 150mm.
4. Skip containers shall be epoxy coated with a minimum of at least 3 epoxy coats.
5. Covered skips shall be interchangeable between the screens and grit removal applications.
6. Skips shall be subject to a 5 year replacement guarantee under regular use by the OWSC, provided that the skips are not subjected to misuse.

## 2.04 Grit/Sand Removal

### 2.04.1 General

1. Grit/sand removal equipment shall comprise one or more fully integrated units designed to remove 90% of grit/sand particles of diameter 0.1mm and above and with a specific gravity equal to or greater than 2,650 kg/$m^3$.

2. Grit/sand removal efficiency shall be maintained under all flow conditions to the maximum design flow specified.
3. The grit/sand shall be separated, washed and dewatered prior to transfer to a skip for disposal.
4. Grit/sand removal equipment shall be selected from the following table, to suit the size of works and conditions.

### 2.04.2 Grit Removal Equipment Selection

| Preferred type of Grit/Sand Removal Plant | Size of Sewage Treatment Works Population equivalent (PE)* | |
|---|---|---|
| | <2000 | >2000 |
| Spiral flow aerated channel | | X |
| Cross flow detritus tank | | X |
| Constant velocity channel | X | X |
| Vortex or hydro-dynamic grit separators | X | X |
| Grit/sand trap | X | |

* 1 PE = 60g BOD/day

All equipment shall be of weatherproof construction and suitable for continuous operation. Hand railing shall be provided around tanks and along the sides of bridges.

### 2.04.3 Spiral Flow Aerated Channel

Spiral flow grit removal plant shall comprise a horizontal rectangular channel into which air is introduced at the base, perpendicular to the flow. Spiral flow is induced by passing continuous flow of air through a row of fine bubble diffusers set at low level on one side of the channel. Grit is deposited in a series of hoppers located below the air diffusers. Flow leaves the channel over an adjustable horizontal weir set at top water level. The spiral velocity must be controlled to avoid carry over of grit and excessive deposition of organics.

Grit is removed from the hoppers in suspension via a carrier water stream and is pumped to grit classifiers at high level for separation and discharge to a skip.

The following criteria shall be adopted for sizing the mechanical plant:

- Forward velocity of sewage through channel 0.1 m/s max;

- Transverse velocity of spiral 0.3 m/s max;
- Channel width to depth ratio 1.5:1;
- Detention time (at peak flow) 2-3 minutes;
- Air supply requirement 0.3 m3/minute/m length of channel (min).

### 2.04.4 Cross flow Detritus Tanks

Cross flow detritus tanks shall comprise an approach channel, circular detention tank with inlet deflector plates to ensure an even flow distribution across the tank, and a rotating collector mechanism which transfers the grit from the tank floor to a collection hopper at the base of a classifier. The grit is cleaned and classified prior to discharge for disposal. Organic material is returned to the sewage flow for downstream treatment.

Inlet deflectors shall comprise an adjustable pre-cast concrete aerofoil section pivoting on a stainless steel spindle retained in bearing housings cast into the concrete structure.

### 2.04.5 Constant Velocity Channels

Constant velocity channels shall be of a parabolic nature and shall be sized for the full range of design flows. Channel length shall be twice the design length based on a particle diameter of 0.2mm.

Channel level shall be controlled by a standing wave flume.

Grit settling out on the channel floor shall generally be removed by a travelling suction dredger equipped with airlift or suction lift pumps or other proprietary equipment.

The grit shall be separated and transferred to a grit classifier or conveyor for disposal.

It may be possible in some instances to remove the grit from the constant velocity channel directly by means of direct suction by vacuum tanker.

### 2.04.6 Vortex Grit Separator

The grit separator shall consist of a grit removal chamber with the inlet and outlet separated by not less than 270º of the chamber periphery. The upper part of the chamber shall have a diameter larger than the lower chamber. The chamber walls at the transition section shall slope to allow grit to settle to the base of the lower chamber.

A grit removal device consisting of a vertical rotating hollow tube and demountable impeller shall be fitted centrally in the chamber. The impeller shall be fitted with blades which shall create an upward flow in the central zone of the upper chamber, whilst leaving the outer annulus of the upper chamber quiescent to allow grit settlement.

### 2.04.7 Hydro Dynamic Grit Separator

The grit separator shall be similar to a vortex device, consisting of a grit removal chamber positioned above a grit collection and transfer chamber.

Grit shall be removed by gravity through a constant flow device or by purpose designed grit pumps.

| | Scraper/Drive | | Separator | Collectors | | | Combined collectors/classifiers | |
|---|---|---|---|---|---|---|---|---|
| | Travelling Bridge | Fixed Bridge | Vortex | Gravity | Air Lift | Grit Pump | Reciprocating rake classifier | Screw classifier |
| Spiral Flow | X | | | | X | X | | X |
| Cross Flow Detritus Tank | | X | | | | | X | X |
| Constant Velocity Channel | X | | | | X | X | | |
| Vortex Grit Separators | | X | X | | | X | | X |
| Grit Trap | | X | | | X | | | X |
| Hydro-dynamic Grit Separator | | | X | X | | X | | X |

## 2.05 Bridges for Grit/sand Removal Plant

### 2.05.1 Fixed Bridges

Fixed bridges shall be provided generally in accordance with this specification, for detritus tanks, vortex separators and grit traps.

### 2.05.2 Travelling Bridges

Generally travelling bridges shall be provided for constant velocity grit channels and spiral aerated grit channels. However, alternative designs for grit removal arrangements for spiral aerated grit channels or constant velocity channels may be considered.

Where bridges are used they can span one or more grit channels to suit the site layout.

### 2.05.3 Cross flow Detritus Tank

The rotating collecting mechanisms shall be suspended from the drive unit by a tubular driving shaft. The drive head shall contain adequately rated radial and thrust bearings to carry all loads imposed by the rotating assembly and substantial accumulation of grit.

A system based on a bottom bearing within the tank will not be acceptable.

The scraper drive mechanism shall incorporate a mechanical overload safety coupling or other similar device to disconnect the drive. A shear pin device will not be acceptable. The overload coupling shall be fitted with a limit switch to stop the drive and initiate an alarm.

### 2.05.4 Vortex Separator

The gear head shall comprise a heavy-duty cast iron base housing the bearing and drive assemblies. The base shall support the slewing ring and the driven gear shall be bolted to the rotating section of the slewing ring. The cover of the gear head shall support the geared motor and shall have a bolted flanged connection for the airlift pipe.

The grit removal device, gear head, motor and blower unit shall be supported from a fixed bridge.

## 2.06 Grit Collecting Mechanisms

### 2.06.2 General

Each system shall make provision for collecting and transporting the grit from the floor of the channel or tank and for classification and discharge to a container for disposal.

Transfer mechanisms shall be designed to remove grit from the tank floor or hoppers. The grit shall be classified by separating out organic material and sewage. Transfer and classification may be combined using a reciprocating rake classifier or screw classifier.

### 2.06.3 Airlift and Air washing

Where an airlift / air wash assembly is required to facilitate grit washing and removal it shall consist of an airlift and discharge pipe delivering to the grit classifier and shall be complete with separate air wash and airlift headers and an actuated 3-way ball valve. The air wash/airlift cycle shall be initiated by an operator adjustable time clock.

The air wash header shall discharge an adequate quantity of air to effect washing of the collected grit.

The air lift shall be designed to remove grit and carrier waster from collection units in the range of 3.5 to 5.0m below ground level. The air supply shall be piped to the point of entry to the uptake pipe. The rate of air flow shall be determined to provide a flow of water into the uptake pipe sufficient to suspend the grit and transport it to a high level classifier.

### 2.06.4 Grit Pumps

Grit pumps shall generally be used for the transfer of grit from the collection sump/hopper to the classifier. Where necessary, carrier water shall be provided to re-suspend the grit and facilitate grit removal, with the return liquor discharge back to treatment. The grit pumps shall operate in conjunction with the classifier unit (where appropriate) on an operator adjustable time clock control.

Grit pumps shall be centrifugal type and specifically designed for the pumping of highly abrasive slurries and shall incorporate, abrasion resistant materials (NiHard

or similar), recessed torque flow impellers and centrifugal shaft sealing in preference to flushed mechanical seals. Suction and discharge isolation valves and a discharge non-return valve shall be provided.

### 2.06.5 Reciprocating Rake Classifier

Rake classifiers shall comprise a reciprocating rake mechanism installed in an inclined concrete channel.

The lower end of the concrete channel shall be connected to the peripheral discharge port which collects grit from the grit scraper. The rake paddles shall contact the deposited grit on the upward stroke of the rake.

An open impeller pump shall wash organic material from the grit particles in the lower part of the channel allowing sufficient time for water to drain off prior to discharge to a skip. The pump shall comprise a suction strainer, an impeller operating in an inlet pipe, motor base plate and drive unit. The reciprocating rake shall comprise a fabricated rake assembly, electrically driven via a speed reduction gearbox and bell crank mechanism complete with balance weights.

### 2.06.6 Screw Classifier

The classifier shall comprise of either a solid shaft helical screw or shaft less screw design, rotating in a fabricated stainless steel trough of 6mm minimum thickness. The trough shall be inclined to enable the grit to be discharged into a skip. The screw shall be supported in upper and lower bearings as appropriate.

The lower bearing shall be of the self aligning type, sealed to prevent the ingress of grit and shall be grease lubricated by an electrically driven variable output automatic lubricator. A deflector plate shall be fitted over the bearing to prevent the grit being discharged on to the bearing. The upper bearing shall be a grease lubricated sealed bearing of the combined thrust and radial type.

The water and organic material shall be returned to the main flow via a flanged pipe. The dewatered grit shall be discharged at high level from a chute into a skip below.

The screw classifier shall be driven by a direct coupled shaft mounted geared motor. The screw shall be guarded by stainless steel covers or equal securely fixed to the top of the trough. The complete classifier unit shall be self supporting and suitable for bolting to prepared foundations.

# 2.07 Sludge Thickening and Dewatering Equipment

## 2.07.2 General

This section shall include sludge thickening and dewatering, in accordance with the following definitions.

- Sludge Thickening - The process during which the water content of the sludge is reduced to make the sludge suitable for subsequent treatment or disposal.
- Sludge Dewatering - The process during which the water content of sludge is reduced to produce a stackable sludge cake for subsequent treatment or disposal.

The plant described below may be designed to achieve thickening or dewatering. Any plant proposed shall clearly identify the purpose for which it is intended, the solids content of the sludge produced, and any preconditioning requirements.

## 2.07.3 Gravity Picket Fence Thickener

Gravity picket fence thickeners shall be operated on a continuous or near continuous basis. The operation shall be completely automatic except for occasional adjustments by the operator and routine cleaning operations.

Sludge shall be fed directly to the thickener on a timed or continuous basis, so that the sludge is in a fresh condition.

The picket fence thickener shall be supported by a fixed bridge and scrapers shall rotate with a peripheral velocity in the order of 3m/min.

The sludge withdrawal pumps shall have a maximum instantaneous withdrawal rate sufficient to draw down the sludge blanket, without causing rat holing of the blanket. The withdrawal rate shall typically be in the range 2 to 4 times the sludge production rate.

The sludge blanket level detector shall be calibrated to monitor the height of the sludge blanket and shall be manually adjusted to obtain optimal thickening. The control algorithm shall maintain the sludge blanket level at a pre-set height. In the event of a failure of the sludge blanket level detector, it shall provide fail safe operation of the thickener by operating the desludging pump(s) for pre-set minimum or maximum periods dependent upon the failed condition of the detector, and raise an alarm to warn the operator of this condition.

Picket fence thickeners for gravity consolidation of sludge shall comprise the following components:

**i) Circular Tanks**

The tank shall be constructed in concrete or steel. When constructed from steel the tank shall comprise glass coated, bolted sectional panels assembled on site and mounted on a concrete plinth.

The base of the tank shall be flat or shall slope to the centre, depending on whether the sludge withdrawal point is peripheral or central.

The drain shall be located so that the tank can be completely drained.

Where the tank is sited outside, it shall be fitted with removable reinforced plastic covers.

Provision shall be made within the design for inspection and maintenance of the weir launder channel and outlet box.

Thickeners within odour controlled sludge buildings may not require covers but this shall be reviewed on a site by site basis and, where necessary, dedicated odour control shall be provided.

Thickeners shall be capable of attaining an underflow of at least 6%DS on a continuous basis. In addition, the surface of the tanks shall be chosen such as the maximum solids loading rates and maximum overflow rates will not exceed 150 kgDS/$m^2$/day and 1.5 m/hr at the maximum sludge inflow rate.

However, consideration should be given to ensuring that the retention time in the tank is not excessive leading to gassing off and potential septicity problems. Calculations supporting the contractor's design should be submitted for comment and acceptance. The provision of dilution water up to 24 to 30 $m^3/m^2$/day may be considered in relation to this requirement. Water from the on-site wash water pumping station shall be used for this purpose

**ii) Picket Fence**

The picket fence shall be fabricated from steel section, suitably protected from corrosion. The unit shall be of the fixed bridge type, modified where necessary to suit the sludge thickening duties.

The unit shall consist of horizontal and diagonal steel beams supporting a number of 50 to 60mm diameter vertical pickets at 300mm spacing, with the pickets either side of the central pivot being positioned so that the pickets describe circles with radii separated by 150mm pitch. Steel ploughs shall be fitted under the fence to guide sludge to the draw off point. Clearance between the ploughs and floor shall

be the minimum distance compatible with the tolerance of the finished floor level, and shall be adjustable.

**iii) Weir**

The weir channel shall be corrosion resistant plastic or GRP, with an upper edge comprising a series of adjustable 'V' notch weir plates. The weir plates shall be corrosion resistant plastic, GRP or stainless steel, fixings shall be stainless steel. The channel shall be attached directly to the wall of the tank with no gap between the outer wall of the channel and the tank wall.

**iv) Scum Scraper and Weir Brush**

The scrapers shall be inclined to direct scum towards the weir or to a scum box where specified, while a combined scraper and brush shall simultaneously remove any scum from the vertical face of the weir.

**v) Sludge Blanket Level Detector**

A sludge blanket level detector shall be provided whose height shall be adjustable and shall be firmly attached to the side of the tank in a vertically mounted plastic tube or on a guide rail.

**vi) Sludge Inlet Diffuser**

Sludge shall be fed into the central area of the tank either to a horizontally mounted disk or to a diffusion chamber, which shall distribute the sludge uniformly in a horizontal direction so as not to disrupt the sludge blanket.

Where a diffusion chamber is used, facilities shall be provided for removal of accumulated scum or grease.

This facility shall be easily accessible from the walkway.

**vii) Sludge Withdrawal System**

Sludge shall be drawn-off either at the tank periphery or from a central sludge hopper, depending on the tank diameter and sludge type. The draw-off shall be flush with or below the tank floor level.

Sludge draw-off shall be by means of positive displacement pumps operating on an operator adjustable time clock control.

### 2.07.4 Plate Presses

The operation of the filter plate press shall be fully automated during a duty cycle. The control systems shall include the press assembly, sludge feed pump, hydraulic press pack and automated control valves, cloth washer, membrane air or water supply (where appropriate), reagent storage, make-up and mixing. A programmable controller shall provide fully automatic operation together with a local pushbutton control station.

Sludge shall be stored in a sludge holding tank equipped with a mixer to maintain a homogeneous mixture of sludge. When initiated by the operator, the press will close and the press feed pump will charge the closed filter press with sludge, polyelectrolyte being dosed to the sludge during the process.

The pump shall charge the press at a high rate until it reaches a pre-set back pressure, when operation of the pump shall change over to a low feed rate at a high pressure. When the upper limit of the pressure is reached the feed of sludge will cease and the compressed air or water system shall operate to achieve secondary pressing by inflating the membranes.

At the end of the cycle the pressure is released from the system, and the plates opened to drop the cake.

After release of the cake automatic washing of the filter cloths shall be initiated by the operator if required.

At the end of the cleaning cycle the press shall be closed up ready for the next cycle.

Filter plate presses for dewatering sewage sludges shall comprise the following main components:

**i) Plate Press**

The plate press shall comprise a side-bar or an overhead beam plate press system, including systems for opening and closing the press, locking the press in a closed condition and compressing the plates to a sufficient pressure to achieve a hydraulic seal between the plates to contain the pressurised sludge during the pressing operation.

The press shall be housed within a building, which shall be on the upper floor of a building if the sludge cake is to drop directly into a truck for disposal off-site or, where it is proposed to provide a sludge cake conveyor, the press may be located at a lower level with sufficient height to allow installation and access for maintenance, of a sludge cake conveyor beneath the press.

The press shall be provided with facilities to contain sludge arising from a core blow out and returning it to the press house drainage system or sludge holding tank.

**ii) Filter Plates**

The filter plates shall be of the membrane type manufactured from polypropylene or moulded rubber with a steel insert and shall be provided with ports and channels to permit the feed of sludge to the cavity between the plates. The plates shall be membrane type suitable for air or water inflation.

**iii) Filter Cloths**

Filter cloths shall be provided to suit the filter press and shall be selected to provide a high solids capture, good filtrate porosity, low frequency of blinding and clean discharge of cake.

The filter cloth shall be resistant to wear, chemical or microbial attack and shall not be subject to creasing or shrinkage.

Cloths which shall be of synthetic material shall be barrel necked to facilitate changing.

**iv) Sludge Loading Pumps**

The sludge loading pumps shall be variable speed positive displacement pumps capable of operating in the low pressure/high speed mode and also in the high pressure / low speed mode to suit the loading cycle and operating pressures of the press.

The pump shall also provide the means of mixing polyelectrolyte with the sludge prior to transferring the sludge to the press.

**v) Cloth Washing System**

An integral automatic cloth washing system shall be provided to wash the filter cloths at the end of the pressing cycle following discharge of the cake for disposal.

When the cloths require washing the operations shall be initiated manually. The cloth washer shall be attached to the plate separator mechanism and wash the cloth surfaces on both sides of the plate as it is being moved.

A system shall be provided to collect the washings for subsequent treatment and disposal.

**vi) Cake Discharge System**

The sludge cake shall be discharged by gravity, this being achieved after plate separation by the plate separator. Visual inspection and access to the cloth surfaces shall be provided.

Sludge cake break wires shall be provided beneath the press discharge chamber.

The cake shall be guided on to the collection system (truck, skip or cake conveyor) by a hopper with flexible skirt to prevent cake from splashing outside the collection system

Drip trays shall be provided beneath the press, draining to the filtrate collection or press house drainage system. Prior to cake discharge the trays shall be retracted to a vertical position by hydraulic power. The trays shall relocate beneath the press during feeding and pressing.

**vii) Safety Guard**

The press shall be protected on both sides by an infra-red scanning light curtain which shall inhibit the press cycle and sound an alarm in the event of the curtain being broken.

## 2.07.5 Belt Thickeners and Presses

Belt thickeners and belt presses can be used to thicken sludge and to dewater sludge respectively to produce a thickened sludge or a sludge cake. In both cases 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 content.

Odour released from the sludge undergoing treatment in the belt thickeners or presses shall be contained and controlled. Belt thickeners and presses need to be enclosed to contain the odour. The enclosure shall be vented to atmosphere via an odour collection and treatment system.

Operation of the belt thickener/press shall be fully automated. The control system shall include the thickener /press assembly, and associated equipment comprising sludge feed, polyelectrolyte make-up and dosing system, flocculation tank and thickened sludge/cake transfer system.

Operation of the thickener/press 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 / cake transfer system resulting in an accumulation of sludge or cake in the collection hopper.

**i) Sludge Feed and Distribution System**

The belt thickener shall be provided with a sludge feed and distribution system which shall receive conditioned sludge from the flocculation tank and distribute it evenly across the full usable width of the filter belt.

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.

**ii) 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.

**iii) Sludge Discharge/Collection System**

Sludge reaching the end of the thickening section shall be removed from the belt by a scraper mechanism and discharged to a 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.

**iv) Filtrate Collection System**

The filtrate from the belt and the washwater shall be collected and delivered to the main filtrate sump for recycling or for transfer to subsequent treatment and disposal.

### 2.07.6 Belt Presses Sludge Feed and Distribution System

Generally as that for belt thickeners given above.

### 2.07.7 Dual Belt System

The dual belt system shall comprise two continuous filter belts carried by a series of rollers around which the belts are driven by a motor powered roller, the speed of which is controlled by a variable speed gearbox.

The upper surface of the top belt shall provide a gravity drainage section. The two belts shall converge and pass between a series of rollers. This shall provide the pressurised dewatering section. The pressure applied shall be selected to produce the cake solids content required for subsequent treatment or disposal.

The rollers shall be supported on a stainless steel framework, and the tension of the belts around the rollers shall be maintained by an automatic tensioning and tracking system, controlled by signals from a PLC in response to signals from the belt sensors. Alarms shall be provided to indicate belt slippage or tracking out of limits.

The belt material shall be woven polyester.

### 2.07.8 Sludge Cake Discharge System

At the discharge end of the press, where the belts separate a scraper shall be provided to remove the sludge cake from the belt and discharge the cake via a chute into a hopper. The hopper shall feed the sludge cake to a cake conveyor for transport to subsequent treatment or disposal.

### 2.07.9 Filtrate Collection System

The filtrate produced and the washwater shall be collected and delivered to the main filtrate sump for recycling or for transfer to subsequent treatment and disposal.

### 2.07.10 Belt Washing System

Depending upon the application, belt washing using anything other than potable water may not be permitted, particularly with reference to sludge cake and disposal thereof. Reference shall be made to the Particular Specification prior to specifying any other medium.

A belt washing system shall be provided for each belt to clean accumulated solids from the surfaces. The washing system shall comprise jets of high pressure washwater which shall remove residual sludge particles.

The nozzles shall be provided with remote operated cleaning mechanisms to allow cleaning of the nozzles without disassembly or interruption of operation. The washwater shall be collected and directed to the washwater/filtrate collection sump.

The washwater system shall be provided with facilities to recycle a proportion of the final effluent for use as washwater. A mains service water connection shall also be provided permitting operation on final effluent and / or mains water. The washwater system shall be designed to use washwater containing at least 200mg/l suspended solids.

### 2.07.11 Decanter Centrifuge

The centrifuge shall comprise a conical cylindrical bowl and screw feed (scroll) horizontally mounted in bearings on a support frame.

Machines shall be designed to achieve minimum energy consumption.

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 or other approved material. The leading faces of the scroll shall be protected by the application of a suitable hard coated material against abrasive wear. The whole rotating assembly shall be enclosed by a carbon steel fabricated casing incorporating a centrate discharge hopper and outlet pipe and solids hopper which shall discharge the de-watered 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 and scroll bearings shall be arranged for lubrication by an external lubrication system. Greasing nipples shall be arranged together as a battery, wherever practicable. 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 position feed tube and dispersed to the bowl through an inlet chamber.

The bowl shall be provided with an adjustable 360° peripheral weir at its cylindrical end to control the depth of the centrate in the rotor.

The fixed outer casing of the rotor shall be designed to collect the centrate and dewatered sludge discharged from the rotor. Baffles within the casing shall direct

the separated phases to the relevant discharge points and prevent cross-contamination. Both the centrate and dewatered sludge shall discharge by gravity via funnels and hoppers to the collection system, for transfer to subsequent treatment or disposal.

The centrifuge shall be mounted on heavy duty vibration isolators, located between the machine and the supporting steelwork or foundations, to damp vibrations and to prevent vibration transmission. Two axes, vibration monitors shall be provided to stop the centrifuge automatically when excessive vibration is detected.

Flexible connections shall be provided on the sludge feed system and the centrate collection system at the centrifuge. The cake discharge system shall incorporate flexible chutes.

**i) Variable Speed Drive (If fitted)**

A variable speed drive shall be provided to accelerate the rotor to operational speed and maintain that speed during the centrifuges duty period. The bowl drive shall be electric or hydraulic and shall be coupled to the drive shaft by a multiple `V' belt drive.

**ii) Differential Scroll Drive**

The scroll 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 controlled automatically with a manual override facility so that the moisture content of the dewatered sludge can be adjusted as required.

## 2.08 Aeration Equipment

### 2.08.1 Aerators

Aerators shall be selected to suit each particular application and shall provide clean air to satisfy the respiratory oxygen demand of the microbiological population and maintain the mixed liquor suspended solids (MLSS) in an agitated state of suspension.

#### 2.08.1.1 Air Diffusers

The air diffusion system shall be of the fine bubble type (2-3mm) provided by flexible membrane diffusers which shall enable airflow to be varied to match the demand and improve energy efficiency. The diffusers shall also be able to resist the ingress of the tank contents when the air supply is reduced or failed.

The diffusers shall be specifically designed for municipal sludge application and provide satisfactory service for at least 10 years. Where membrane diffusers are used, they must be able to maintain their elasticity, original aperture size and have a low record of tearing over long periods of service.

The membranes shall be supported on rigid base plates and be self-sealing or employ a self-sealing device on 100% turndown of air flow.

The diffusers shall be grouped to allow removal / replacement and orientated to permit a number of zones per lane length for differential air distribution.

Pipework shall be securely fixed to the concrete floors and walls.

Account shall be taken of the following:-

- air flow rate per diffuser, range to match the incoming demand;
- location distribution and density of diffusers across the tank floors;
- feeder pipework, distribution pipework, drains, purging of the system;
- flow control valves;
- compressors output characteristics;
- standby provisions;
- Control, optimisation and energy conservation.

Due to the depth of the tanks air compressors will be necessary to deliver the process air and overcome the hydrostatic head.

All compressors shall generally be configured on a duty/assist/standby basis. The duty / assist combinations shall be capable of providing sufficient process air to satisfy the peak demand and to cater for low load periods.



### 2.08.2 Surface Aeration (fixed bridge)

#### 2.08.2.1 Aerator Cone

The aerator shall be all welded mild steel construction complete with a statically balanced horizontal rotating disc and suitable number of vertical aeration blades. The aerator cone shall be suitable for operation when completely, semi, or non-immersed.

### 2.08.2.2 Drive Shaft

The aerator drive shaft shall be of all welded construction fabricated from mild steel circular hollow section and plate. The shaft shall comply with the Code of Practice for fatigue for a life of at least 200,000 hours running and the Contractor shall be required to submit calculations to verify his design.

All welds shall be fully welded in accordance with BS 4870 (1981).

### 2.08.2.3 Aerator Shaft Assembly

The relative position of the gearbox base plate and aerator to the support platform shall be such that the upper flange of the aerator shaft can be uncoupled from the gearbox output shaft to permit the aerator shaft and aerator to be restrained at the support platform level without draining down the tank and erecting scaffolding below the support platform.

All stub shafts, bolts, nuts and fixings which may require disconnection for repair or maintenance shall have a high degree of corrosion resistance.

### 2.08.2.4 Drive Plate

The aerator and the drive unit shall be suspended and supported from a drive plate located centrally above the tank. The Contractor shall include for the provision of suitable vibration mountings to isolate harmonic forces from the civil structure. The Contractor shall include four drive jacking bolts to adjust the aerator cone height by +/- 100 mm from the nominal design top water level.

### 2.08.2.5 Drive Unit

Each surface aerator shall be coupled to a continuously rated, heavy duty, totally enclosed, and oil tight speed reduction gearbox. The drive unit mounting arrangement shall allow removal of the drive unit whilst the aeration cone remains in place.

The gearbox shall be of the helical double reduction type and shall include an oil level sight glass, low speed shaft coupling, motor lantern housing and flexible high speed shaft coupling. The service factor of the complete gearbox will be a minimum of 3. The gearbox shall have adequate oil capacity to avoid frequent attention and the sight glass shall be equipped with a level indicator with maximum and minimum levels clearly marked.

The drive motor, which shall comply with this specification and protected to IP 65.

The vertical aerators may be used in conjunction with a vertical cruciform to prevent rotation of the tank or ditch contents. Throughout the length of the lane the vertical aerators are to rotate in opposite directions to prevent or reduce short circuiting of the activated sludge.

### 2.08.3 Horizontal Aeration Rotors

Each rotor unit is to be of robust construction and comprise a series of bladed elements circumferentially mounted. The rotor drum is to be hermetically sealed and the whole statically balanced and due allowance shall be made for corrosion.

All stub shafts, bolts, nuts and fixings which may require disconnection for repair or maintenance shall have a high degree of corrosion resistance. The rotor is to be supported by means of grease lubricated split roller bearings, the housings of which shall be made watertight including the use of spring loaded lip shaft seals and thus be suitable for severe splashing or submerged applications.

For ease of maintenance stainless steel or copper grease piping shall be brought out from the split roller bearings to suitably mounted greasing points on the Access Bridge. The rotor shall be connected to the gearbox by a flexible coupling. The rotor shall be provided with lifting arrangements.

A splash guard shall be fitted over the rotor and be arranged to give maximum protection to each end bearing.

The splash guard shall be manufactured from glass reinforced plastic or other approved corrosion resistant material.

### 2.08.4 Access Bridge

Where Horizontal Aerators are used each rotor shall be provided with a galvanised steel access bridge spanning the oxidation ditch or aeration basin. The access bridge shall be fitted with galvanised steel self draining flooring; toe plates along each side for safety purposes and double row tubular mesh infilled hand railing along each side of the structure. The Contractor shall include for access steps from finished ground level to the rotor access bridges.

### 2.08.5 Submersible Aerators

When in use, submersible aerators shall stand under their own weight on the floor of the tank in which they are installed. Air shall be induced via a flexible hose and an air turbine into the fluid to produce fine bubbles of a nominal maximum diameter of 5mm.

The motor shall comply with this specification and be suitable for operating submerged at depths of up to 5m.

The supply to include a suitable lifting chain in stainless steel (minimum length 7m) complete with test certificate.

If not already being provided for other equipment such as submersible pumps and / or mixers a portable davit and lifting tackle shall be provided.

#### 2.08.5.1 Aeration Performance

The aerator shall be capable of achieving the required rate of oxygen transfer indicated elsewhere when operating at maximum speed on the variable speed applicators and the normal full load on fixed speed applications. At the lowest operating speed the aerator must also be capable of maintaining the MLSS in suspension.

### 2.08.6 Aeration Testing

The aerator shall be tested on site with clean water in accordance with the ASCE "Standard for the Measurement of Oxygen Transfer in Clean Water" published in 1984.

## 2.09 Sludge Storage

### 2.09.1 General Requirements

Sludge tanks shall be covered and vented. The requirement for tanks to be connected into the odour control system shall be site specific and dependent on whether the works is odour sensitive. Generally odour treatment will be provided.

### 2.09.2 Sludge Storage

This section refers to the following types of sludge holding/storage facilities:-

- Unthickened sludge holding tanks include the following:-
- holding tanks at a satellite works;
- holding tanks for unscreened imported sludge prior to thickening;
- holding tanks prior to thickening (Screened indigenous and imported sludge);
- Thickened sludge holding tanks, refers to sludge that has received thickening either in a gravity thickener or in a mechanical thickener, and include the following:-
- − holding tanks for sludge prior to further treatment or export;
- − holding tanks prior to dewatering;
- Cake storage prior to disposal off site

### 2.09.3 Storage capacity

Holding tanks for unscreened imported sludge shall match the peak import deliveries.

Holding tanks prior to thickening shall match the peak throughput of screened indigenous sludge, all imported sludge and an allowance for the maintenance of the chosen downstream processing.

Storage shall be determined with due regard to operational tankering frequency arrangements. As a guide 4 days storage with 3 days storage as a minimum.

Thickened sludge holding tanks shall be sized in conjunction with the forward treatment capacity whether it is offsite transporting or onsite processing

### 2.09.4 Performance Requirements

Sludge storage facilities shall be designed so that the following is achieved:-

- the sludge holding tanks prior to export shall achieve sufficient storage and provide a degree of gravity thickening;
- the sludge holding tanks upstream of thickening and dewatering shall maintain a homogeneous sludge with the aid of mixing;
- sufficient buffer capacity to service or maintain any downstream processes is provided;
- sufficient covered area/capacity for sludge cake storage and its mechanical handling;
- safe access for tank cleaning is provided;
- optimisation of tanker utilisation (dependant on location and journey time) this requirement shall be agreed with the Asset Manager;
- safe tanker loading un-loading;
- minimising of odour production;
- Odour control.

### 2.09.5 Specific Requirements

Common requirements for all tanks shall be:-

- a minimum freeboard of at least 0.5m shall be provided;
- the minimum floor slope shall be 10°;
- a valved washout drain gravitating to the works drainage system or similar approved discharge shall be provided;
- for tanks in excess of 10m diameter, an access hatch at ground level shall be provided;

- a high level overflow;
- pipework shall be designed to avoid potential blockages and provided with jetting and/or rodding points;
- the tanks shall be sited with due consideration of minimising the lengths of any sludge delivery mains;
- Mixers shall be designed to be removed without the need for man-entry or tank emptying. Where a compressed air mixing system is provided an arrangement for containing displaced odours shall be provided;
- Access shall be provided for routine maintenance. Level probes, mixers, pumps and any other items of plant or instrumentation shall be accessible for maintenance without requiring the use of portable ladders;
- routine maintenance access shall be designed on the basis of single person maintenance;
- All sludge holding tanks shall be covered. At odour sensitive sites, any odours generated shall be contained and treated;
- Where tanks may become liable to negative pressure due to the pumping system sufficient ventilation shall be provided.

Specific additional requirements for holding tanks at sites prior to export, and requiring some gravity thickening shall be:-

- duplication of tanks and the decanting arrangements shall be based on whole life costing;
- supernatant shall be fed back to the works at a controlled rate, with no adverse affect on the wastewater treatment process;
- the design must control odours discharged via the tanker vacuum pump;
- accessible and suitable connections for tankers shall be provided with a sludge outlet at a height, which provides a positive delivery head to the tankers wherever possible;
- where practical, tanker loading points shall be within 3m of the tanks;
- The tanker loading area shall incorporate localised lighting, spillage capture via grill covered channels draining to the works drainage system, and a pressurised wash down (potable water) hose point.

- Specific requirements for cake storage shall be in cake silos, skip marshalling areas or covered cake bays:-

- the facility shall provide sufficient and safe vehicular access for handling the sludge;
- access for taking material off site shall allow vehicles to circulate the storage area;
- there shall be hard standings and bounding to contain all spillage;

- Wheel washing facilities shall be provided where there is an open cake storage area. The area designated for vehicle washing shall be drained in such a way as to return the wash back into the treatment works.

### 2.09.6 Dewatered Sludge Storage

Dewatered sludge is stored on hard standing areas or in sludge silos. Factors which shall be considered during the design of sludge handling and storage facilities include:

- the extent of sludge production;
- the frequency of sludge discharge;
- the interruptions of transfers to final destination, e.g. agricultural land or landfill;
- the impact of sludge liquors on wastewater treatment;
- the rheological characteristics of the sludge;
- the odour and gas emissions;
- The explosion risk.

### 2.09.7 Process Control and Operating Regime

Sludge holding tanks upstream of thickeners and dewaters shall be operated to maintain buffering of variations in sludge quality to minimise the need for operator adjustment to maintain %DS, solids capture and optimise polymer usage.

Each storage tank shall be provided with an ultrasonic level detector. Where an automatic pumped feed system is used to fill the tanks, the ultrasonic level detector shall provide a high level alarm to the control prior to tank overflow and inhibit further pumped discharge into the tank.

Where tanks are provided with a pump suction discharge from the tank, low level pump protection shall be provided. This shall also apply to mixing equipment where dry running would be detrimental to the unit.

### 2.09.8 Standby Requirements for Mechanical Equipment

Suitable arrangements shall be provided to maintain the tank in a homogeneous state at all times.

### 2.09.9 Pipelines

The flow velocity in liquid sludge and sludge liquor pipelines shall not be continuously less than 1 m/s unless measures for the prevention of

sedimentation/encrustation are taken. If the rate of gravity flow is too low then pumping shall be considered.

Systems shall be designed so that regular operations do not require pressure tight isolation of any section. This is to avoid the risk that high or damaging gas pressures could develop in a sealed section.

In sludge pipelines which are connected to permanently filled sludge tanks below the minimum sludge level and which include a frequently operated isolation valve, a second manual valve shall be installed between the reactor and the valve which is frequently operated.

Pipelines and other equipment which are installed in sludge tanks should be corrosion resistant.

### 2.09.9.1 Sludge pumps

Sludge pump selection shall take the following into consideration:

- thickness and viscosity of sludge;
- grit, rag and other gross solids and fibres in sludge;
- incorporation of either, or both, sludge screening and disintegration;
- risk of blockage, abrasion and cavitations;
- pump wear;
- energy efficiency;
- pump duty including suction and delivery heads and flow rate;
- Local and operational conditions e.g. submersed or dry well, available space.

Pump casings with ventilation and dewatering bores should be provided. The leaking water from lubricated glands shall be drained. The circumferential velocity of the rotors of eccentric screw pumps should not exceed 2 m/s during regular operation in order to avoid excessive wear.

## 2.10 Mixing

### 2.10.1 Static Mixer

The mixer, having no moving parts, shall blend and disperse all material capable of flowing by re-directing the flow patterns present in the pipe or channel.

All material in the flow shall be continuously and completely mixed to eliminate radial gradients in temperature, velocity and material composition.

The mixer may use helical or vortex inducing features to promote mixing.

Processes with very low pressure loss requirements shall make use of the vortex inducing design, where practicable.

The degree of mixing shall be measured in terms of Coefficient of Variation (CoV), which is the 'ratio of standard deviation of component concentration to its mean concentration'.

The required CoV is to be achieved by the time the flow reaches the downstream sample take-off point (whether integral or separate) for all flow conditions.

Where stated in the particular specification, mixers shall be provided with connections for dosing points of application and sample points.

Where stated in the particular specification, mixers shall be designed to be installed in sections into an existing pipe or channel.

#### 2.10.1.1 Materials

The mixers have the potential to be used in processes involving pH adjustment, coagulation, disinfection and dechlorination for example. The materials of construction; which may be carbon steel epoxy coated, stainless steel, alloys or plastics, shall be selected to be compatible with the intended service conditions.

### 2.10.2 Submersible Mixers

#### 2.10.2.1 Propeller

Propeller blades and hubs to be designed to shed rags, fibrous matter, etc., which may be contained in the process fluid.

#### 2.10.2.2 Mechanical Seals

Direct drive units, two independent mechanical seals to be provided.

Geared Units, outer seal to be a mechanical seal. Gearbox/motor sealing components to be selected to achieve the stated service interval.

#### 2.10.2.3 Mixer guide/support system

Support system to be designed to withstand all dynamic load conditions with the mixer in operation without transmitting excessive vibration to adjacent structures.

Where the mixer is to be installed in a glass lined steel tank, the mixer support system shall not be fixed to the tank wall. An independent support system shall be provided.

#### 2.10.2.4 Lifting Devices

Lifting system to be designed to ensure mixer can be removed safely without entering the tank.

Mixer to be fitted with a suitable lifting chain and fittings. In case of staged lift, Chain to be fitted with intermediate rings to allow staged lift and a locking device at the free end to allow fixing to the tank rim/access point.

## 2.11 Sludge Aerobic Digestion

### 2.11.1 General Requirements

Aerobic digestion is usually thermophilic and carried out in closed tanks.

The following factors shall be considered for aerobic thermophilic digestion:

- sludge type;
- solids concentration;
- viscosity;
- degree of stabilization;
- need for disinfection;
- temperature and temperature control;
- retention time;
- average and peak loads;
- frequency of feeding;
- dimensions of reactors;
- thermal insulation;
- one- or two-stage processes;
- mixing intensity (W/m3);
- prevention of anaerobic conditions;
- prevention of solids deposition;
- oxygen transfer capacity (kg/h) and oxygen transfer efficiency (kg/kWh);
- foam control and maintenance of aeration during foaming;
- odour control;
- heat recovery and heat balances;
- Accessibility of heat exchanger surfaces for mechanical cleaning.

For thermophilic operation and disinfection, reactors shall be covered and thermally insulated. The sludge feed should have a volatile solids concentration higher than 25 kg/m3 to avoid the need for subsidiary heating.

## 2.12 Composting

### 2.12.1 Composting General

The composting process should achieve

- 20 to 30 percent reduction in VSS
- Faecal coliform reduction to less than 100CFU's per gram dry solids
- Salmonella spp concentrations less than 3CFU's per 4 gds

Composting process to be built on a concrete slab large enough to detain the sludge and bulking agent at the works daily production rate for four complete composting periods, composting and curing time (2 operating compost piles, one built, one spare)

Covered storage should be available for two months volume of product compost.

The concrete slab should be built on a gradual incline, with liquid collection equipment available at the lowest point in order to collect leachate. Leachate should be recycled to the head of the secondary treatment process.

Composting time in each system 5 days initial, high temp (50-55C), 23 days composting, medium temp (45-50C), 28 days maturation, medium temp

Sufficient bulking materials should be available to increase the dry solids of the sludge up to 50%. This should be mixed in with the sludge using suitable proprietary equipment sufficient to meet site requirements

Bulking agents should be removed by passing the final product through a suitable screen. The screen should be sized to meet site requirements and operation of this unit, including maintenance should not present a hazard to site personnel.

### 2.12.2 Moisture Control

Moisture content should not exceed 50% Moisture, nor should it be less than 40% moisture. Online moisture measurement should be measured at suitable points within the pile and fed back into an online system.

Final effluent from the on site tertiary plan should be available through suitable spray diffusers to increase moisture content should the moisture fall below 35%

### 2.12.3 Temperature Control

Temperatures should be maintained between 50 and 55 degrees C during the initial composting phase, reduced to between 45 and 50.

Temperature should be measured at a series of locations in the body of the pile, temperature measurements should be fed back into an online control system

Should temperature increase above the required set point, aeration / windrowing activity should be reduced, should temperature fall below required levels, air flow rates should be increased.

### 2.12.4 Aeration Control

Air containing at least 50% oxygen should be present in all parts of the compost pile. Dissolved oxygen probes should be present suitable locations at set intervals along the windrow, inserted into the body of the pile. These should feedback into a control system.

Should the oxygen measurement fall below 45% then air flow / windrowing activity should be increased until a suitable dissolved oxygen concentration is achieved. Should oxygen concentrations be above 60% then airflow / windrowing should be reduced.

### 2.12.5 Windrow system

The windrow should be wholly enclosed within a suitable accessible structure air extraction via a suitable odour control unit should be utilised. This will aid maintain moisture levels within the local atmosphere

Windrow piles should be of size approximately 2m, width 4.5 m

Windrow machinery should be sufficient to completely turn the windrows 10 times over 15 days. Machinery should be sized sufficiently to be able to surmount the compost pile

### 2.12.6 Aerated static pile system

Design considerations should be for a pile approximately 2.5m high and 3.75m wide

Aeration system should be sized to be able to draw 20 volumes (of the static pile) of air every 15 days in order to maintain aerobic conditions

Aeration pipe work to be perforated disposable plastic pipe installed at the base of the pile.

Odour control measures should be present on vent pipe from air pump

In order to protect the air pumps, a drainage trap should be available for moisture drawn through the static pile; this should be recycled to the head of the secondary treatment process

A one way geo-textile liner to allow air to pass inwards but not allow egress of air or moisture should be used to cover the pile. This will aid moisture retention and reduce odour nuisance.

### 2.12.7 Installation, Commissioning and Testing

The concrete slab base and collection apparatus should be initially tested using clean water.

Sufficient sludge must be collected for composting and a compost run initiated.

In the case of air valves and pipe work, these should be thoroughly tested for air flow and leakage prior to placing the sludge above them.

Following the above procedures, samples of sludge, sludge and bulking agent and final product must be taken from representative locations and analysed at a suitably accredited laboratory for VSS, Faecal Coliforms and Salmonella spp.

This analysis should be performed on all samples for one year after installation and afterwards should be regularly monitored prior to leaving site.

## 2.13 Tertiary Treatment Granular Filters

### 2.13.1 General

The following are types of gravity filters:-

- moving bed filters;
- modular deep bed sand filter;
- Shallow bed filters.

#### 2.13.1.1 Performance Requirements

The filters shall be designed so that the following is achieved:-

- final effluent quality complies with the consented discharge standard;
- continuous service is maintained under a wide range of flows and loads up to FFT;
- blockage of the under drain system and flow distribution system does not occur;
- efficient cleaning of the media is automatically attained;
- Dirty backwash water is returned for treatment without adversely affecting performance of other processes.

#### 2.13.1.2 Design Basis

The following approach shall be adopted in the design:-

- the units shall be designed to treat all flows up to the specified FFT plus any return flows;
- suitable filtration rates shall be used in the design to allow for the expected range of SS
- concentration in the feed to the filters and achieve the required effluent SS concentration; the design parameters shall be based on the Contractor's experience of similar full-scale filters
- operating in similar conditions to that expected on the specific site;

### 2.13.1.3 Specific Requirements

Only a well proven, proprietary packaged, automatically cleaned, low head loss system with low power consumption, with a successful track record in a comparable application, shall be provided.

On down flow filters, sufficient freeboard above the media surface shall be provided to allow for a sufficient build-up of head to maximise the specific solids loading before a backwash is initiated.

The filter plant shall be of modular design.

Moving bed filters are not recommended where the final effluent SS discharge standard of 5 mg/l is to be met.

For filters with static media, number of filters shall be sufficient to ensure that when one filter is taken out of service for backwashing, the loading on the remaining filters does not compromise compliance with the discharge standard.

Final effluent shall be used for backwashing. The method of backwashing will depend on the selected system.

Dirty backwash water should be returned upstream of the PSTs. For filters other than moving bed filters, a balancing tank shall be considered for the dirty backwash water prior to return to the main stream process, so that no hydraulic overloading of any of the process units occurs.

Sand traps shall be provided to retain any media carried with the dirty backwash water before it is discharged to PSTs.

### 2.13.1.4 Process Control and Operation Regime

Backwashing should be initiated on a time basis or by a predetermined inlet level when the head loss across the filter reaches its maximum design level.

Where timer control of backwash pumps or ancillary plant is provided, provision shall be made for operator adjustment to starting frequency and duration of operation.

### 2.13.2 Open Gravity Concrete Filters

The design parameters shall be as given in the Table below:

| **Parameter** | **Requirement** |
|---|---|
| Minimum number of filters | One (1) per process train. |
| Type and material of construction of filter | Open gravity filters constructed in concrete. |
| Maximum filtration rate ($m^3/h$) under all conditions. | 12 $m^3/h$ |
| Level difference between top water level in the filter and the weir overflow level in the filter outlet weir box | 3.5 m |
| Filter media effective size and depth | 1.0 mm mono graded sand 1.2 m depth or 1.4 m depth. Effective size of filter coal, supporting sand and gravel shall be nominated by the Contractor. Minimum air scour rate for sequential or combined air and water backwash |
| Minimum air scour rate for sequential or combined air and water backwash | 60 $m^3/h$ |
| Minimum backwash rate for sequential air and water backwash or combined air/water backwash | Contractor to nominate |
| Filter under drains | Open plenum with nozzles |
| Filter backwash features | Automatic backwash facilities based on filter head loss or elapsed time or filtered water turbidity. Discharge filter water to waste until turbidity of filtered water, as indicated by turbid meter, drops below maximum values guaranteed. |

### 2.13.3 Pressure filters

A minimum of six filter units shall be provided. Pressure vessels shall be sized to provide a maximum filtration velocity of 15m/hr when with two filter units out of service. Each vessel shall be provided with internal collection systems and inlet distribution pipework, which shall be hydraulically sized as required for the flows.

The internal diameters of all under drain pipework shall be a minimum of 150mm.

Maximum perpendicular distances between two feeder pipes shall be 3m. Main collector pipework shall have a slope of 0.5%.

All necessary feed and backwash pumps shall be provided. Air scour blowers shall be provided in acoustic enclosures. Duty and stand by units shall be provided for all pumps and blowers.

Backwash and air scour velocities shall be sufficient to fluidise the media without carryover of solids into the outlet stream.

Filtration media shall be provided with the vessels, for installation at site. The media shall be selected to meet the required solids removal efficiency. It is anticipated that a minimum of three grades of media shall be provide to allow for a gravel support bed.

Automated backwash and air scour operations shall be provided to operate on a timed basis or by measurement of differential pressure across the filtration media. The selection of these modes of operation shall be made by the operator. Inlet, outlet, backwash, drain and air sour valves shall be fully automated. The use of air actuated valves is preferred to electrically actuated units.

Storage of backwash water shall be provided to allow the flows to be balanced prior to return to the head of the wastewater treatment works. The balancing tank shall be provided with agitation to prevent solids deposition. The tank shall also be provided with level transmitter, high level float switch and drain down facilities.

Over pressure relief systems shall be provided where necessary.

Filter vessels shall be fabricated from carbon steel with dished ends. The internal and external surface preparation shall be as follows.

- Shot blast to SA 2.5
- Coating with epoxy resin

The vessels shall be pressure tested to 150% of the design operating pressure for a period of one hour

All instrumentation shall be provided to allow fully automated operation of the sand filters. This shall include but not be limited to flow measurement of the inlet, backwash and air flows along with inlet and outlet pressures. Measurement of the water temperature should also be included.

### 2.13.4 Installation, Commissioning and Testing

#### 2.13.4.1 Filter Valves

Each filter shall be furnished with the following controls and associated piping:

- Inlet distribution device
- Inlet isolation valve
- Backwash outlet valve
- Air scour inlet valve
- Filter outlet and level control valve
- Backwash inlet valve
- An air release valve, if required, shall be piped such that it operates in conjunction with the air scour inlet valve. The release valve shall open when the inlet valve is closed and vice versa. This shall avoid media disturbance when backwash starts, exhausting the residual air in the under drains.
- Filter plenum drainage valve.

#### 2.13.4.2 Filter Control

Flow shall be distributed evenly between operating filters by means of inlet distribution devices.

In open gravity type filters the filter control function shall be a constant level control, that is, the filter outlet control valve and associated equipment shall maintain the operating level of the filter within a span of 300 mm.

The operating span shall be maintained over the full operating range from minimum to maximum head loss across the filter. Pressure monitoring shall be linked to SCADA.

This function shall be checked during demonstration by checking inputs and outputs of the individual components that make up the total control loop and observation during operation combined with the SCADA trends of the filter head loss.

The filtered water outlet of the filters shall be designed so that there is a constant head downstream of the filter outlet valve, that is a level higher than the valve.

The inlet to each filter shall not be submerged but shall have a free fall from the inlet to the operating level of the filter under all conditions.

### 2.13.4.3 Filter arrangement

The filtration plant shall include a filter observation platform from which access to the filter shall be possible from ground level. Each filter shall be operated from a console and the whole area of the filter shall be clearly visible from the operating position. Provide one console for each filter. Safety hand railings for the platform and stairways will be provided, allowing inspection of the filter.

A metal deck roofing and associated steelwork support structure over filter console platform and over the access stairways to the top of the filter block will be constructed.

### 2.13.4.4 Filter Under drains

Provide a system employing a plenum with nozzles suitable for combined air/water backwash. All materials in the under drain system shall be corrosion resistant.

The under drainage system shall provide even distribution of backwash water over the whole area of the filter as well as even collection of filtered water. The system shall provide even distribution of air over the whole area of the filter for satisfactory scouring of the media bed.

The design of the nozzle system shall allow for cushioning of the air inflow surge at blower start-up as well as even distribution of air scouring over the whole floor area.

The underside of the plenum under drains shall be elevated 750 mm above filter shell floor to permit access from one point for each filter. The under drain support system shall provide access to all parts of the plenum from this point. A 600 diameter manhole shall be provided for this purpose.

Disparity between levels of the top of nozzle heads shall not exceed ±3 mm.

Install proprietary nozzles in accordance with the nozzles manufacturer's installation instructions.

Air shall enter the laterals via separate air header pipes mounted on top of the nozzles. At least two air entry points evenly spaced on each lateral shall be provided.

The entire under drain system including nozzles, clear water pipework, filter and clear water tank shall be scrupulously clean before the initial air scour and backwash.

### 2.13.5 Filter Media

#### 2.13.5.1 Filter Gravel

Filter gravel shall be placed in successive layers. Nominate the depth and size of each layer.

Filter gravel shall be best quality rounded shape quartz, non-calcareous, clean, hard, and durable; from shale, mica, clay, sand, dirt, loam and organic matter of any kind and shall contain no iron or manganese in form or quantity that shall adversely affect the filtered water. The gravel test requirements are as follows:

| Test | Requirement | Test Method |
|---|---|---|
| Specific gravity | > 2.5 | ASTM C127 |
| Gravel shape | < 2% flat, thin, hand picking elongated or angular pieces | AWWA B100 |
| Quartz content | > 95% | Refer to as below |
| Acid solubility | < 5% | AWWA B100 |
| Gravel grading | Refer to as below | ASTM C136 |
| Clay, dust and impurities content | < 0.1 | 100g minimum sample ASTM C117 |

The accuracy of separation into the sizes specified, as determined from samples taken after the material is placed, shall be such that not more than 8% of the material shall be finer or coarser than the nominated size limits. The testing shall be done in accordance with AWWA Standard B100.

#### 2.13.5.2 Filter Sand

Filter sand shall be of the best quality quartz consisting of clean single rounded grains, completely free from mica, clay, dirt, loam, organic matter or foreign substances of any kind.

Filter sand test requirements are as follows:

| Test | Requirement | Test Method |
|---|---|---|
| Specific gravity | 2.60 to 2.70 | ASTM C188<br>Quartz content > 95%<br>Refer to as below |
| Acid solubility | < 1.5% | AWWA B100 |
| Friability | < 0.3% | AS 1141.30, Section 32 |
| Sand grading | Refer to as below | ASTM C136 |
| Clay, dust and impurities content | < 0.1 100 g minimum sample | ASTM C117 |

Finer filter sand shall have a maximum uniformity coefficient of 1.3. Coarse filter sand shall have a maximum uniformity coefficient of 1.45.

Testing for quartz contents of sand and gravel shall be carried out as follows:

(a) By counting quartz particles under microscope;

(b) By mass (based on results of (a) above).

The minimum limit of quartz content in either sand or gravel carried out by methods (a) and (b) as above shall not be less than the specified limit.

### 2.13.6 Preparation for Media Placement

- Thoroughly clean each filter before any filter materials are placed and the filter shall be kept clean throughout placement operations.
- Before any materials are placed, the top elevation of each layer shall be clearly marked by a continuous level line on the internal wall of the filter.
- Filter materials shall be kept clean and stored separately.

#### 2.13.6.1 Placement of Gravel and Sand

Before the installation of filter media, the backwash flow indicator shall be installed and operative to indicate the design backwash rate.

The gravel layers shall be placed carefully to avoid damage to the filter under drain system. The placing of each layer of gravel shall be completed before beginning

the placing of the next layer and the gravel layers shall be completed before the sand layer above is started. Workmen shall not stand or walk directly on the filter material but on boards or plywood that shall sustain their weight without displacing the material. Minimum dimensions of boards to be 600 mm x 1200 mm x 20 mm thick.

Each layer of gravel and sand shall be deposited in a uniform thickness with the top surface screeded and brought to a true level plane. Care shall be exercised in placing each layer of gravel and sand to avoid disturbing the surface of the layer beneath.

Filter material, when shipped in bags, may be placed in the filter by scattering the material directly from the bags.

The elevation of the top surface of each layer shall be checked by filling the filter with water.

After all the gravel is placed, and before the sand is placed, the filter shall be washed for 10 minutes at the design rate.

Sand shall be placed in one layer. Sand layer shall be thoroughly washed and scraped. The top surface for the filter material, after initial washing, shall have an elevation equal to the finished elevation plus the thickness of material to be removed by scraping. At all times, after placement of each layer of gravel or sand, the bed shall be kept free of foreign material. Should any foreign material be found in the bed, it shall be removed by hand, followed by backwashing, before any further layer of media is placed.

After sand layer has been placed, wash water shall be slowly admitted upward through the under drain system until the entire bed is flooded. The wash rate shall be gradually increased to the design backwash rate during the initial wash to remove air from the bed, for a period of 5 minutes.

After the initial wash, a layer of fine material not less than 5 mm thick shall be removed from the surface of the filter by scraping.

The washing and scraping operation shall be repeated as many times as necessary to remove 95% or more of all material passing a 300 micron sieve. Each wash shall be of at least 5 minutes duration.

It shall be noted that after all scraping operations are completed; the top surface of the sand shall be at the finished elevation without the need of adding sand to the filter.

### 2.13.7 Air Scour

Supply and install two (2) air blowers (duty and standby). Each blower shall have the design capacity to provide air scour for one filter. Sequential air scour which is followed by water backwash or combined air and water wash shall be required.

Provide automatic changeover from duty blower to standby blower in the event of duty blower failure.

### 2.13.7.1 Air flow measurement

Provide an indicator for air flow rate local to the blowers. Record the air flow rate on the SCADA.

Measurement shall be by an orifice plate. The orifice plate shall be designed for flow measurement at the operating pressure and temperature. The flow indicator shall be calibrated in FAD. The height above sea level shall also be taken into account when sizing the blower output for FAD conditions.

### 2.13.7.2 Air Blower Type

Each blower shall be of the rotary positive displacement "Roots" type driven by an electric motor directly coupled through a flexible coupling or through a belt pulley drive. The motor, gearbox and blower shall be mounted on a common cast iron or galvanised steel base plate which shall be bolted to a concrete plinth. The speed of the blower shall not exceed 1,500 rpm.

### 2.13.7.3 Air Suction and Delivery

Air blower shall draw air from the atmosphere through a filter-silencer and discharge it through a silencer into the delivery main to the filter where it shall discharge through the under drains.

### 2.13.7.4 Operation Mode

The air blower shall be suitable for both continuous and intermittent operation, and shall be stable in operation.

### 2.13.7.5 Air Delivery

The air delivery shall be completely oil-free.

### 2.13.8 Air Blower System

Each air blower shall be supplied and installed complete with the following equipment:

- 1 suction filter silencer
- 1 outlet silencer
- 1 vacuum indicator
- 1 reflux valve
- 1 pressure gauge (anti-vibration type)
- 1 thermometer
- 1 relief valve
- 1 set anti-vibration mountings

The suction filter shall be for continuous service and shall be readily cleanable.

A visual alarm indicator (400 mm wg maximum vacuum) shall be placed between the air filter and its respective inlet to give warning when the filter requires cleaning.

One pressure gauge and one thermometer of at least 150 mm diameter shall be supplied and fitted on the delivery side of each blower.

### 2.13.8.1 Air Pipe work

Air pipework, header and laterals shall be of PVC Class 12 or ABS Class D.

The air pipework shall include a high level loop rising to level 1 m above the overflow level of the filters. A check valve to prevent the accidental entry of backwash water shall be installed in this line on the filter side between the filter and the loop.

### 2.13.8.2 Soft Start Valve

An air vent to atmosphere for soft start of scour air flow into the filter shall be incorporated in the air pipework located upstream of the primary measuring flow element. The soft start valve shall open on shut-down of the air scour blower and slowly close on start-up over an adjustable time period of 10 to 180 seconds. It shall permit full flow venting. The valve shall either be a Saunders diaphragm type with a pneumatic diaphragm operated spring return to open actuator or a butterfly valve with a pneumatic spring return.

A limit switch positioned on the soft start valve shall prevent the air blower from starting unless the valve is fully open.

Air release valves shall also be provided. For each filter, the air release valve shall be open when the air scour valve is closed and vice-versa. This shall avoid media

disturbance when backwash starts by exhausting the residual air in the under drains.

### 2.13.8.3 Construction Materials For Air Blowers

Each blower casing shall be of close grained cast iron. Construction shall allow for the easy removal of the rotor and shaft.

Rotors shall be of close grained cast iron, accurately machined on all exterior faces. The rotor shall be accurately bored and securely fixed to a high tensile steel shaft. Alternatively, integrally cast impellers and shafts may be approved subject to verification that the operating stresses have been accounted for in the design. The timing gears shall be precision ground hardened steel.

The complete rotor assembly, including half-couplings, shall be statically and dynamically balanced. Each blower shall be equipped with heavy duty bearings, suitable for a minimum of 60,000 hours of operation.

The bearings shall be enclosed in oil-tight housings and shall be lubricated by a splash oiling system.

Each oil-tight housing shall be fitted with a sight window and be separate from the working air chamber.

Air seals shall preferably be of the labyrinth type. Face type seals with a carbon wearing ring may be offered as an alternative.

Oil seals shall preferably be of the synthetic rubber, metal reinforced garter spring type.

Couplings, if used, shall be flexible and of the rubber sheathed pin type with cast iron bodies with a rating of at least 300% in excess of the motor rating.

Suitable metal guards fabricated from 2.5 mm thick galvanised steel expanded metal shall be provided around all exposed moving parts, allowing visual inspection of moving parts without removal of guards.

## 2.13.9 Backwashing

### 2.13.9.1 General

Two pumps (one duty and one standby) shall be provided to pump water from the clear water tank for backwashing. Backwash inlet valves shall be arranged for slow opening if considered essential by the Contractor.

A manually actuated flow trimming valve shall be installed in the backwash line to trim the flow rate.

There shall be a local indicator calibrated in L/s and a local integrator for the backwash flow. Local indicator shall be located so that it can be conveniently and easily observed.

The backwash flow shall also be wired to the SCADA system

#### 2.13.9.2 Backwash Flow Measurement

The accuracy of flow measurement is to be ± 2% and shall be by orifice plate.

#### 2.13.9.3 Filter Head loss Indicator

For each filter a head loss indicator, calibrated in metres, shall be mounted on the filter control console.

#### 2.13.9.4 Backwash Launders

Launders or a broad crested reinforced concrete weir shall be provided in the top of each filter to discharge the wash water to waste. Launders shall be of 316 stainless steel construction. Weirs shall be adjustable with an overall tolerance of ± 2 mm to ensure level overflow. Media loss during backwash shall not occur.

## 2.14 Micro and Ultra Filtration Membrane Systems

A low pressure micro or ultra-filtration membrane is required to treat clarified effluent from the secondary treatment plant to standards suitable for land irrigation under the relevant wastewater to land specification.

The filter should be protected with a pre-filter of pore size no larger than 200um. The pre-filter should be self cleaning and manually removable without interrupting process flows.

A minimum recovery of 50% is required from the membrane array.

Membranes should operate at an average flux of 0.4m3permeate/m2/d (16.67LMH). Sufficient membrane cartridges should be available to maintain the required outlet flow at this flux with 2 cartridges out of service.

Backwashing should be initiated once the trans-membrane pressure reaches design limitations, and defaulted to a set minimum time interval. Chemical cleaning to be initiated once the interval between backwashes is reduced to below 10 minutes or once TMP after backwash is double that of a clean membrane.

Permeate water and air scour should be used for the backwash, which should then be released to drain. All chemicals used for chemical cleaning to be compatible with the membrane material.

Readings from permeate flow meters and pressure sensors to be fed back to an online communications system for online control and monitoring

Membranes should be of a spiral wound or hollow fibre type, the material should not be adversely affected by sewage or its constituent materials. The membranes should be configured using out-in configuration. Maximum acceptable pore size is 0.2um

The performance of the membrane material should not be affected by pH in the region of 3 to 11, nor should performance be affected by temperatures up to 45 degrees Centigrade.

Within these parameters, the membrane array should consistently achieve;

- BOD5 removal 30%
- TSS removal 75%
- Filtrate particle counts at <2um <70/100ml

Membrane cassettes and housings should be resistant to chemicals used in the membrane chemical cleaning process

The contractor shall provide membranes which have been individually factory tested and achieved satisfactory results in both bubble point test (pore size) and forward flow integrity tests.

After installation and commissioning of the whole plant (including primary and secondary treatment), samples to be taken for analysis by an accredited laboratory in accordance with the latest edition of "Standard Methods For The Examination of Water and Wastewater".

## 2.15 Wash water Pumping Stations

The Wash water Pumping Station will provide mains water or disinfected final effluent at various points around the site. The pumping station shall incorporate either fixed or variable speed pumps with an appropriately sized pressure vessel.

For mains water systems, the water shall be fed into a break tank(s). There must be a minimum of 150mm between the top water level and the discharge to prevent back syphonage. The flow into the break tank shall be controlled by a float operated isolating valve. The arrangement of the pumps shall be such that there is a flooded suction at all times. It is intended that the pumping station shall be fully automated.

For final effluent systems, ultraviolet disinfection incorporating medium pressure lamps, automatic wipers and UV monitor shall be provided. Multiple lamps or UV units shall be provided to ensure that full disinfection is available during maintenance and lamp replacement without interruption of the wash water supply.

The pumps shall be required to deliver 12 l/sec at 5 bars at any point around the works washwater ring main. The water shall be used for hose down of operational facilities.

The Contractor shall determine the most suitable size, number and combination of pumps to deliver the flow stated. The pumps shall be uniformly sized. One standby pump will be required. Pumps shall be configured in a duty/standby or duty/assist/standby basis.

For fixed speed, hydro pneumatic systems the compressors shall be configured in a duty / standby basis. A minimum of two pressure vessels shall be provided to ensure that inspections and maintenance can be carried out on the system without interruption to the pressurised water system. The pressure vessels shall be sited out of direct sunlight or shall be provided with sun-shields. Pressure vessels shall be constructed to PD 5500 2006 or ASME VIII 2004.

For variable speed systems the surge vessel shall be fitted with a diaphragm and “Schroeder” type valve to enable initial gas charge and top up.

The Washwater Pumping Station shall be located at a suitable location and shall be sub-divided into a wet well and dry well. The wet well shall be covered with a minimum of two access hatches. The dry well shall have a superstructure and a stairway, which leads down to the pumps. The control panel shall be located above the flood level.

All pumps shall be fitted with suction, discharge and non return valves and discharge pressure gauges.

The ring main shall be constructed from ductile iron pipework or polyethylene and shall have sufficient spurs so that water can be delivered at any location around the site on demand. Each spur will have an isolating valve so that the maintenance work can be carried out on any hydrant. The ring main shall also have several cross-links so that sections of the ring main can be isolated for maintenance purposes without affecting the operation in other areas of the site. The water take-off points shall generally be underground fire hydrants of the integral valve and screwed outlet type set in a pre-cast concrete chamber with cast iron cover. The maximum distance between hydrants shall be 80m. The minimum diameter of the main shall be 80mm. The ring main shall have suitable facilities for scouring out the system.

Where individual processes require process water at specific rates and pressures the Contractor shall make other appropriate arrangements in his design to ensure

that the water supplied to the process unit is secure and does not compromise the wash water requirements stated above.

## 2.16 Odour Control and Ventilation

Due to the nature and combination of processes and activities likely to be employed at the waste water treatment works it is important not to treat odour control and ventilation in isolation.

### 2.16.1 Odour Control

Waste water treatment works are perceived by the public to be a source of odours. Some of the odours generated on wastewater treatment works are hazardous to health and therefore area a health and safety risk. To ensure that odours and gases can be controlled in the most efficient and cost effective manner the design and layout of the sewage treatment works should take account of all opportunities to minimise the problem at an early stage of the design. The methodology which should be adopted when designing the waste water treatment works is to:

- consider systems which minimise the production of unpleasant odours;
- restrict the release of unpleasant odours to the atmosphere by containment and treatment;
- Maximise the distance between the vented source of the unpleasant odour and the site boundary.

Odour measurements shall be made by using electronic olfactometry or the analytical measurement of hydrogen sulphide as stated in the Particular Specification.

The efficiency of any odour control system supplied will be determined by continuous readings of hydrogen sulphide concentrations at the inlet and outlet of the system.

The factors which require being determined when designing an odour control system will include:-

a) the Odour Threshold (dilutions) at the inlet

b) the flow rate

c) the total mass of the contaminants

d) the Odour Threshold (dilutions) at the outlet

It should be noted that several factors which can have an effect on odour production include: -

a) nature of sewage

b) increased retention time of the sewage

c) increased saline content

d) increased septicity

e) increases in ambient temperature

f) increases in turbulence

A well-designed odour control system shall be capable of accepting a large variation in the contaminant loads and still maintain the designed Odour Threshold at the outlet.

Odour control systems shall be based on the following technology: -

a) Chemical oxidation

b) Biological oxidation

c) Adsorption onto solids

Odour masking, incineration, ozone and ultraviolet scrubber systems shall not be considered. Although odour control problems will tend to be process specific, it will be the responsibility of the Contractor to propose the most suitable cost effective solution.

It should be noted that due to the possible changes in the characteristics of the sewage with time any system which is supplied must be flexible enough to allow expansion without a total re-design of the odour control system including collection systems.

Where combined technologies were proposed to remove the odour in two stages or more stages. The first stage would be expected to remove the majority of the contaminants by oxidation methods and the second stage would polish the remaining low level of contaminants by adsorption onto solids.

It is intended that the odour control system shall be available for use at all times and therefore should be designed in a duty/standby mode. An allowance shall be made for 100% standby capacity in the extraction fan sets, recirculation pump sets, and adsorption onto solids chambers. In the event of duty pump or fan failures, the standby set shall be commenced automatically.

Each flow stream shall be fitted with variable control dampers, non-return valves, and isolation valves. Main components, which may be exposed to corrosive agents during normal running or otherwise, shall be manufactured from stainless steels grade 316.

The inlet ducts shall be fitted with mesh screen and disposable dust filters.

Where polishing filters are proposed a de-humidifier controlled by a relative humidistat shall be required to ensure that the relative humidity of the air stream is limited to 70 - 80% before delivery to the polishing filter.

Due to the dangers of the formation of Legionella bacteria in warm recirculation water, the use of final effluent as a recirculation fluid in the bio-scrubbers shall not be permitted. However, consideration should be given to using disinfected, final effluent in a once through mode as a wetting agent. The distribution nozzles shall be enclosed and dispersal of aerosols into the atmosphere shall be minimised.

The treated air shall be exhausted through a purpose built exhaust stack. The factors which require being determined when designing an exhaust stack will include: -

a) capacity
b) material
c) noise and vibration
d) shape
e) visible impact of stack and plume
f) temperature
g) access for maintenance
h) sampling
i) lightning protection
j) location of the stack
k) proximity of sensitive receptors
l) boundary odour limits
m) meteorological conditions
n) dispersion modelling
o) turbulence

The noise shall be below 65 dBA at 1.0 metre from the unit.

The working limit of H2S is set at 10ppm. This is the level at which it is deemed not to be harmful to operators exposed for 8 hours a day, 40 hours a week, over a 40 year working life.

### 2.16.2 Ventilation

Due to the variety of operational workspaces on the works, it is likely that no single solution will be possible and the Contractor shall be responsible for selecting the most suitable methods.

The function of the building or enclosure shall determine the level of comfort which is required. Comfort depends on the inter-relationship of the following factors: -

a) air temperature

b) relative humidity

c) mean radiant temperature of the enclosing space

d) ventilation rates

The Contractor shall determine the air temperature and relative humidity for each enclosing space. Generally, humidity will depend on the operational requirements of the equipment and activities undertaken within the enclosing space. Where close control is required de-humidifiers may be required.

The mean radiant temperature of the enclosing space will be determined by the selection of materials and constructional form of the enclosure.

Ventilation rates shall be determined by the following factors: -

a) Occupancy levels

b) Requirement to control heat or remove excessive heat

c) Requirement to avoid contamination with foul air migrating from other areas

d) Requirement to pressurise a particular workspace (positively or negatively)

e) Openings in the enclosing space and frequency of operation

f) Infiltration

Ventilation can be natural draught or forced ventilation provided by mechanical means. Where mechanical ventilation is employed standby systems shall be used with audible and/or visible warnings when abnormal conditions exist.

Prior to discharge to the atmosphere, the exhaust stack shall be designed to ensure that noise shall be below 65 dBA at 1.0metres from the unit.

## 2.17 Disinfection

Disinfection of final effluent shall preferably be by chlorine dosing to give a chlorine residual as detailed in the Particular Specification. Due to the instability of high strength sodium hypochlorite solutions at high ambient temperatures, electrolysis of sea water or brine shall be used to produce a stable (<1%) sodium hypochlorite solution.

Particular attention shall be given to the venting of hydrogen gas to atmosphere and suitable dilution fans and gas detection equipment shall be installed to control and monitor hydrogen levels to below the lower explosive limit (lel).

In remote areas where the installation and maintenance of electro-chlorination equipment or the storage of sodium hypochlorite solution is not appropriate, gas chlorination or ultra-violet disinfection shall be used, as agreed by the Project Manger.

### 2.17.1 Chlorination System - Imported Liquid Chlorine

Imported Liquid chlorine storage and distribution system shall generally comprise:

Bulk storage

- Chlorine - Storage tank minimum volume equivalent to a delivery tanker volume.
- Storage tanks to be located inside and temperature control (12-15 Degrees) Preparation
- Water softener – required if water hardness is above 17mg/l
- Dilution - eductor system for mixing
- Facility to change dilution strengths

Bulk storage

- Chlorine day tanks to be located inside and temperature control (12-15 Degrees)

Transfer/dosing

- Transfer pumps -
- Dosing pumps
- Pipelines

Controls

- Instrumentation
- Fully automated control system with system shut down in the event of malfunction.
- Water softener monitor or sample point

Ancillary Equipment

- Auto/manual flushing system for transfer/dosing pumps and pipelines.
- Wash down facility

Safety Equipment

- All equipment to be suitably protected.
- Dosing lines to be dual contained with catch pots and alarms
- Emergency shower and eye wash bath

Standard items of equipment e.g. storage tanks, transfer/dosing pumps chemical dosing pipelines etc. shall comply with the details provided elsewhere within the specification.

### 2.17.2 Chlorination System – Imported Chlorine Gas

Imported gas chlorine storage and distribution system shall generally comprise:

Bulk storage

- Gas cylinder or drums
- Remote means of opening and closing the cylinders or drums
- Flow control regulators
- Remote shut off facility
- Change over control panel
- Separate storeroom.

Preparation

- Gas flow control units
- Chemical injectors with non return valves
- Motive water supply system
- Separate preparation room

Controls

- Instrumentation

- Fully automated control system with system shut down in the event of malfunction.

Safety Equipment

- Each room shall be equipped with extraction fans.
- Breathing apparatus
- Toxic gas leak alarm and control panels within the store and prep rooms.

### 2.17.3 Chlorination System - On Site Generation of Chlorine (OSEC)

On site generation of chlorine shall be provided by electro chlorination. The plant will generally comprise a minimum of:

Bulk storage

- Salt

Preparation

- Water softener – required if water hardness is above 17mg/l
- Salt saturator
- Electrolyser units
- Transformer/rectifier units

Bulk storage

- Chlorine day tanks

Transfer/dosing

- Transfer pumps
- Dosing pumps
- Pipelines

Controls

- Instrumentation
- Fully automated control system with system shut down in the event of malfunction.
- Water softener monitor or sample point

Ancillary Equipment

- Auto/manual flushing system for transfer/dosing pumps and pipelines.
- Wash down facility

Safety Equipment

- All equipment to be suitably bunded.
- Hydrogen monitor in the electrolyser plant room
- Hydrogen accumulation force ventilation system for the chlorine tanks
- Dosing lines to be dual contained with catch pots and alarms
- Emergency shower and eye wash bath

Standard items of equipment e.g. Silos, storage tanks, transfer/dosing pumps chemical dosing pipelines etc. shall comply with the details provided elsewhere within the specification.

### 2.17.4 UV Disinfectant

UV disinfection may be carried out using either an open channel or in-pipe closed vessel system; which ever system is provided all flows must receive a consistent dose of radiation under continuous operation.

Medium pressure UV lamps with an operating range of wavelengths between 200 – 400nm are required. The UV element must be contained within a quartz sleeve for protection and provided with an auto/manual cleaning system. Where chemical cleaning is provided a safe means of handling, containing, and disposing of the spent chemical is required.

Open channel systems shall be provided with covers to protect personnel from exposure to the UV radiation.

Continuous monitoring of the UV intensity with manual/auto control of the UV output is required.