

10	ODOUR CONTROL EQUIPMENT-SCRUBBER TYPE	2
10.1	GENERAL.....	2
10.1.1	Scope	2
10.1.2	References	2
10.1.3	System Description.....	4
10.1.4	Submittals.....	5
10.1.5	Warranty.....	5
10.2	PRODUCTS.....	6
10.2.1	General.....	6
10.2.2	Scrubbers	6
10.2.3	Fans	8
10.2.4	Recirculation Pumps.....	10
10.2.5	Chemical Feed Pumps	10
10.2.6	Chemical Storage Tanks.....	11
10.2.7	Rotameters.....	12
10.2.8	WYE Strainer.....	13
10.2.9	Sump Overflow Trap.....	13
10.2.10	Acid Supply Connection.....	13
10.2.11	Pressure And Vacuum Gauges.....	13
10.2.12	Pressure Switches.....	13
10.2.13	Drench Showers	13
10.2.14	Water Softener	14
10.2.15	Control Panel.....	14
10.2.16	Factory Inspection and Testing.....	14
10.2.17	Spare Parts and Tools	14
10.3	INSTALLATION AND COMMISSIONING.....	15
10.3.1	Installation	15
10.3.2	Site Inspection and Testing.....	15

10 ODOUR CONTROL EQUIPMENT-SCRUBBER TYPE

10.1 GENERAL

10.1.1 Scope

1 This Part specifies the requirements for the design, manufacture, construction, installation testing and commissioning of odour scrubber systems and related auxiliary equipment.

2 Related Sections and Parts are as follows:

This Section

Part 1, General

Section 8, Drainage Works

Section 10, Instrumentation Control and Automation

Section 21, Electrical Works

10.1.2 References

1 The following standards or revised/updated versions and other documents are referred to in this Part:

BS 848-..... Fans for general purposes –

BS 848-1..... Fans for general purposes - Performance testing using standardized airways; (ISO 5801 Fans. Performance testing using standardized airways)

BS 848-2 Fans for general purposes - Methods of noise testing; (ISO 13347-1 Industrial fans — Determination of fan sound power levels under standardized laboratory conditions — Part 1: General overview; ISO 13347-2 Industrial fans — Determination of fan sound power levels under standardized laboratory conditions — Part 2: Reverberant room method; ISO 13347-3 Industrial fans — Determination of fan sound power levels under standardized laboratory conditions — Part 3: Enveloping surface methods; ISO 13347-4 Industrial fans — Determination of fan sound power levels under standardized laboratory conditions — Part 4: Sound intensity method)

BS 848-5..... Fans for general purposes - Guide for mechanical and electrical safety;

BS 970 (ISO 683) Specification for wrought steels for mechanical and allied engineering purposes (ISO 683 - Heat-treatable steels, alloy steels and free-cutting steels)

BS 1646 (ISO 3511) Symbolic representation for process measurement control functions and instrumentation -; (ISO 3511 Industrial process measurement control functions and instrumentation — Symbolic representation —)

BS 2782 (ISO 174, 181, 307, 8618) Methods of testing plastic - ; ISO 1628-2 Plastics — Determination of the viscosity of polymers in dilute solution using capillary viscometers — Part 2: Poly(vinyl chloride) resins; ISO 307 Plastics — Polyamides — Determination of viscosity number; ISO 3251 Paints, varnishes and plastics — Determination of non-volatile-matter content)

- BS 3496 (ISO 1888) Specification for E glass fibre chopped strand mat for reinforcement of polyester and other liquid laminating systems (EN 14118-1 Reinforcement - Specifications for textile glass mats (chopped strand and continuous filament mats) - Part 1: Designation; EN 14118-2 Reinforcement - Specifications for textile glass mats (chopped strand and continuous filament mats) - Part 2: Methods of test and general requirement; EN 14118-3 Reinforcement - Specifications for textile glass mats (chopped strand and continuous filament mats) - Part 3: Specific requirements; ISO 1888 Textile glass — Staple fibres or filaments — Determination of average diameter)
- BS 3532.....Method of specifying unsaturated polyester resin systems
- BS 3749.....Specification for E glass fibre woven roving fabrics for the reinforcement of polyester and epoxy resins systems
- BS 4994 (EN 13923) Specification for design and construction of vessels and tanks in reinforced plastics; (EN 13121-3 GRP tanks and vessels for use above ground - Design and workmanship); (EN 13923 Filament-wound FRP pressure vessels. Materials, design, manufacturing and testing)
- BS 5000 (IEC 60034, IEC 60072) Rotating electrical machines of particular types or for particular applications; (IEC 60034 Rotating electrical machines- ; IEC 60072 Rotating electrical machines - Dimensions and output series -)
- BS 5316-1Specification for acceptance tests for centrifugal, mixed flow and axial pumps - Class C tests; (ISO 9906 Rotodynamic pumps. Hydraulic performance acceptance tests. Grades 1, 2 and 3)
- BS 5316-2Specification for acceptance tests for centrifugal, mixed flow and axial pumps - Class B tests; (ISO 9906 Rotodynamic pumps. Hydraulic performance acceptance tests. Grades 1, 2 and 3)
- BS 5345 (IEC 60079) Code of practice for selection, installation and maintenance of electrical apparatus for use in potentially explosive atmospheres (other than mining applications or explosive processing and manufacture); (IEC 60079- Explosive atmospheres)
- BS 5512, (ISO 281) Method of calculating dynamic load ratings and rating life of rolling bearings; (ISO 281- Rolling bearings — Dynamic load ratings and rating life)
- BS 6105, (ISO 3506) Specification for corrosion-resistant stainless steel fasteners; (ISO 3506- Fasteners — Mechanical properties of corrosion-resistant stainless steel fasteners)
- BS 6339 (ISO 6580) Specification for dimensions of circular flanges for general purpose industrial fans; (ISO 13351 Fans — Dimensions)
- BS 7671,.....Requirements for Electrical Installations. IET Wiring Regulations
- EN 1092.....Flanges and their joints - Circular flanges for pipes, valves, fittings and accessories, PN designated
- EN 13923Filament-wound FRP pressure vessels. Materials, design, manufacturing and testing

10.1.3 System Description

1 Performance requirements:

concentration of hydrogen sulphide (unless specified otherwise) : 500 ppm minimum
other contaminants:

Mercaptans	: trace only
Amines (mono (di/tri)	: 10ppm
Ammonia	: 50ppm
Sulphide concentration in solution	: 50 mgl
Number of air changes per hour in ventilated volume	: 4 minimum. More if Contractor deems necessary.
Removal of hydrosulphide gas and ammonia	: 99.8%
Removal of amines	: 95%
Removal of mercaptans	: No requirement

The above criteria are for domestic sewage of a quality normally encountered in Qatar. Highly septic sewage or sewage from industrial sources will need special analysis and the possible addition of a sulphuric acid stage or a separate sodium hydroxide stage.

2 The scrubber shall be the counterflow, packed bed tower type.

3 Sodium hydroxide 20 % w/w (NaOH) and sodium hypochlorite 12 % w/w (NaOCl) are to be used as the scrubbing reagents for removing hydrogen sulphide from the odour source. For some installations with ammonia levels above 30 ppm or other industrial chemicals, addition of a sulphuric acid 20 % w/w (H_2SO_4) stage will be necessary. Operation of the scrubber shall be automatically controlled (with manual override capability) as follows. A single speed fan activated by a manual start/stop push-button switch, draws odorous air through the packed beds of the scrubber. The selected recirculation pump (a standby is to be provided), also activated by a manual start/stop pushbutton switch, circulates scrubber liquors through the packed beds. Sulphuric acid (if used), Sodium hydroxide and sodium hypochlorite are added to the scrubber liquor via metering pumps. Sulphuric acid must be added separately in another stage. These pumps are controlled through set points on analysers for pH for H_2SO_4 and NaOH and Redox (oxidation reduction potential) for NaOCl. Chemical is added until the highest set point on the analyser is reached. The recirculation pumps shall be interlocked with the metering pumps so that in automatic mode, recirculation pump failure will cause shut down of metering pumps. Pressure switches shall initiate change over to the standby Flow switches (rotameters) shall initiate change over to standby on low flow fan.

4 The final control involved in the scrubber is water makeup to replace both "bleed" scrubber liquor and evaporative losses. This is to be achieved with a capacitance type liquid level element and a solenoid valve on the supply line fed from the water softener.

5 Scrubber liquid is bled off continuously so that the potable water added is sufficient to maintain the salts in solution.

6 The odour scrubber system shall be designed for indoor or outdoor installation as shown on the drawings and specified.

7 The chemical storage and feed system shall be designed for outdoor installation.

8 A duplex ion exchange water softener shall be fitted on the potable water supply line, with booster pumps if necessary.

10.1.4 Submittals

- 1 In addition to the requirements of Part 1 of this Section, the Contractor shall provide data and information as described in the following paragraphs.
- 2 Design Data providing the following information:
 - (a) calculations to justify the sizing of the fans, packed bed, pumps and chemical storage tanks
 - (b) calculations as required by BS 4994 category III pertaining to the construction of the scrubber and chemical storage tanks
 - (c) structural calculations for foundations and guy wires or any other external means of support, taking into account wind loadings
 - (d) Calculations regarding consumption and storage requirements of chemicals
 - (e) user certificates.
- 3 Shop Drawings providing the following information:
 - (a) product data
 - (i) fibreglass resin and plastic liner manufacturer's technical data on composition. Characteristics of resin and liner including hydrostatic and burn test
 - (ii) manufacturer's technical data on other equipment used
 - (b) dimensional layout of stack and all equipment used
 - (c) fan test data as BS 848 Parts 1 and 2.
- 4 Instrumentation:
 - (a) complete layout and wiring diagrams of unit control panels.
 - (b) complete process and instrumentation diagrams drawn in accordance with BS 1646
- 5 Samples
 - (a) vessel and duct GRP and liner, packed media.
- 6 Operation and maintenance and instruction manuals including:
 - (a) odour reduction field test report(s) as specified in Part 10.3
 - (b) the documentation in Clauses 2, 3 and 4 above in Part 10.1.4.

10.1.5 Warranty

- 1 In addition to the guarantee requirements of Part 1 of this Section, the Contractor shall ensure that the odour control scrubber equipment manufacturer be responsible for the proper performance and warranty of the odour control system. The system shall be designed and guaranteed to meet the odour removal requirement as outlined in this specification.
- 2 Warranties and guarantees by the suppliers of various components in lieu of single-source responsibility by the scrubber manufacturer will not be accepted. The Contractor shall ensure that the scrubber manufacturer is solely responsible for the warranty.
- 3 The scrubber manufacturer must state in his proposal the guaranteed removal efficiency of the scrubber, based on the gas inlet concentration.

10.2 PRODUCTS

10.2.1 General

- 1 Those items of the scrubbers and fans specified to be constructed of fibre glass reinforced polyester resin shall have approximately 25 % glass reinforcement with a 75 % resin content and conform to the following:
 - (a) the polyester resin shall be ortho and isophthalic polyester vinylester resin to BS 3532
 - (b) reinforcing material shall be a commercial grade of glass fibre water resistant type 'E' chopped strand mat or woven glass fabric to BS 3496 and BS 3749
 - (c) surface finish shall be a gelcoat flow coat isophthalic resin to BS 3532. All drilled, cut or otherwise exposed edges shall be sealed with polyester resin
 - (d) all materials, fabrication procedures, manufacturing tolerances, workmanship, tests, and product quality shall conform to BS 4994
 - (e) the scrubbing towers and chemical storage tanks shall include conductive resin strips behind weld lines, and nozzle fitting joints, to enable a full spark test to be carried out, both in the factory and subsequently on site
 - (f) Each scrubbing tower and chemical storage tank shall have a corrosion resistant welded thermoplastic liner of either PVC-u or polypropylene. If PVC-u is used it shall be annealed after fabrication and welding.

10.2.2 Scrubbers

- 1 The scrubber shall be single or dual stage vertical, counter-current design, packed tower type.
- 2 The scrubber shall contain in the main packed bed a minimum depth of 3 m of nominal 50 mm size filamentous toroidal helix shaped or spherical type packing, having a free volume of 95 %, with 28 m² of surface area per m³ of packing. Packing is to be randomly dumped into the scrubber; structured type packing is not acceptable. Material of construction is to be polypropylene. Pressure drop per metre of packing shall not exceed 15 mm water column.
- 3 The scrubber shall include an entrainment separator/demister, internal spray piping or liquid distribution as recommended by the specialist scrubber packing manufacturer, packing, packing supports, lifting and hold down lugs.
- 4 All liquid handling nozzles, external to the vessel, shall be flanged to NP16. Gas handling nozzles shall be of the dimensions as outlined in BS 6339. Couplings shall be fully flanged, NP16. Minimum projection of nozzles shall be 150 mm.
- 5 Scrubber nozzles and appurtenances shall include:
 - (a) make-up water inlet
 - (b) hydrochloric acid supply connection
 - (c) overflow
 - (d) sump drain
 - (e) scrubber liquor recirculation inlet (to spray header)
 - (f) scrubber liquor recirculation outlet (to pump suction)
 - (g) pH probe mounting
 - (h) Redox probe mounting
 - (i) level sensor mounting connections with stilling well
 - (j) a minimum of three manholes with neoprene gaskets (for servicing spray nozzles, packed bed, and scrubber sump)

- (k) four GRP tie down lugs or base flange
 - (l) mounting brackets for scrubber recirculation piping
 - (m) stainless steel guy wires as necessary
 - (n) gas sampling points on inlet and outlet to the scrubber. If necessary, both shall be piped using 12 mm piping to a convenient point for use of a hand held hydrogen sulphide monitor.
- 6 The scrubber tower shall be capable of operating at the design flow rate with a maximum static pressure loss of 75 mm water column. The packing depth, recirculation rate, and recirculation solution shall be designed to meet the required efficiency.
 - 7 The scrubber housing and internal structural members shall be fabricated of GRP, and shall be not less than 5 mm thickness. External reinforcing ribs, if required for pressure or vacuum conditions or wind load, shall be suitably designed and installed not more than 1 m apart. Colour shall be white.
 - 8 An internal moisture entrainment separator section shall be furnished with each unit which is to consist of 300 mm deep packed bed. The demister shall be capable of removing not less than 99 % of the entrained moisture of the air exiting the scrubber, consisting of droplets 10 µm and larger.
 - 9 Packing support plates for the main bed shall be manufactured from polypropylene having 40 mm by 40 mm square openings and being 40 mm deep. Packing support plates for the entrainment separator section shall be manufactured from polypropylene, having a minimum 84 percent open area , or same as above. Any internal supports required shall be of the same material as the shell. Support plates are not required for chevron blades.
 - 10 The scrubbing liquid distribution system shall be the spray type of manufacturer's standard design, sized for the flowrates required and taking into varying air delivery rates of +10 %. No liquid distributors shall be permitted. Spray headers shall be placed at the manufacturer's recommended distance above the packing. Material of construction shall be chlorinated polyvinyl chloride (PVC-C), NP16. Spray nozzles shall be spiral design, full cone type, constructed of PVC
 - 11 The scrubber shall be designed with a minimum of 600 mm of shell height between the gas inlet and bottom to act as an integral sump. The sump shall hold a minimum of two minutes supply of scrubbing liquid. The sump shall be furnished with a level sensor as specified herein.
 - 12 No internal wetted metal bolts, or components are permitted. All external bolts and fasteners including anchor bolts and flanged bolts shall be BS 970 316 stainless steel. Stainless steel anchor bolts guy wires and clips shall be provided by the manufacturer.
 - 13 The scrubber shall be supplied with integral mounting lugs and pipe supports for the (PVC-C) scrubber liquor recirculation piping. Mountings shall be designed with consideration for pipe inlet and outlet connections. Pipe supports shall be non-metallic channels and straps.
 - 14 The scrubber shall be equipped with a differential pressure gauge on the inlet and outlet ductwork which shall be installed so that abnormalities that may occur in the scrubber can be visually detected. The scrubber shall have pressure taps located below the main packed bed and above the entrainment separator, and the gauge shall be mounted on a scrubber shell. The differential pressure gauge shall include instrument traps, and valve manifolds to permit testing and zero setting of the gauge. Plastic tubing equipment with PVC condensate traps shall connect the high and low pressure taps. The gauge shall have a 100 mm round face.

- 15 Redox and pH probes for analysing the contents shall be located in the scrubber sumps. The probes and analysers shall provide the chemical feed control as described herein. The probes shall meet the following specifications:
- (a) range : pH probe : 0-14 pH : Redox probe; 0-1000 mV
 - (b) stability : $\pm 0.1\%$ per 24 hours, non-cumulative
 - (c) wetted materials sensor Liquid crystal polymer body
 - (d) accuracy/ sensitivity ± 0.1 pH unit : Redox probe : ± 1 mV
 - (e) temp. limits 65°C
 - (f) pressure rating 0-350 kPa
 - (g) interconnect cable manufacturer's standard
 - (h) each probe shall be supplied with a two wire transmitter and analyser
 - (i) the analyser shall be microprocessor based with a 4 digit display, with dual programmable high/low set points, contacts. Alarm conditions shall be indicated on the instrument by front panel LED's with auxiliary alarm contacts. Automatic or manual temperature compensation shall be selectable, with the option to display the process temperature. A data logging system for high/low signals shall be incorporated. Set-up, alarm and control functions shall be accessible on the front panel
 - (j) each probe shall be provided with a protector or well as recommended by the manufacturer
 - (k) the manufacturer shall supply all necessary hardware and wiring for installation of probe and analyser.
- 16 The sump liquid level sensor shall be a capacitance type liquid level probe with a Teflon coated probe element and integrally mounted cast iron or epoxy coated enclosure. The probe shall be a dual-point sensor, for high and low liquid levels. On low liquid level, an electrically operated solenoid valve shall open and allow scrubber make-up water to flow into sump. The valve shall close when high set point is reached. Low-low level shall simultaneously sound an alarm in the control panel and shut off the recirculation pumps. Probe shall be inserted in type 316 stainless steel stilling wells mounted externally of the scrubber.
- 17 All instrumentation mounted inside the scrubber tower or tanks shall be intrinsically safe.

10.2.3 Fans

- 1 Duty/standby fans shall be provided for each scrubber unit. Each fan shall have a single speed motor with the capacity and power to deliver the required volume of air against the total pressure losses in the air intake, duct collection systems, packed bed, mist eliminator and ductwork to the fan and exiting out of the stack.
- 2 The fan shall be centrifugal, belt-driven type constructed from corrosion resistant fibre glass reinforced plastic or stainless steel, with vibration free mountings. The fan shall be capable of the performance specifications as shown below:
- (a) unit capacity : as required
 - (b) static pressure : 3000 Pa, or as required
 - (c) operating temperature : $0 - 70^{\circ}\text{C}$
 - (d) Motor : high efficiency, 415 V, 3 phase, 50 Hz IP 55; 1500 rpm power as required, rated for zone 2 use with methane gas (BS 5345), to BS 5000, 1500 rpm.

- 3 Exhaust fans shall be suitable for continuous 24-hour operation and shall be non-overloading. Each fan shall operate such that no point on the fan curve requires more than the rated motor power.
- 4 The fan housing, flanges and backward curved impellers shall be constructed of flame retardant GRP laminate or stainless steel, capable of resisting continuous fume temperature of 70 °C. The manufacturer shall state the type of resin used and confirm that it will perform satisfactorily under the operating conditions. All interior surfaces exposed to the corrosive air stream shall be resin rich.
- 5 Wheel and shaft assemblies shall be statically and dynamically balanced to a maximum of 0.5 µm displacement prior to assembly and every fan test run prior to shipment.
- 6 Fans shall comply with BS 848 and be provided with the following standard features:
 - (a) drive assembly: belts shall be oil, heat and static resistant type, sized for continuous duty. Shafts shall be constructed of heavy duty steel turned, ground and polished, keyed at both ends
 - (b) bearings: heavy duty, self-aligning, pillow block bearings, with grease fittings
 - (c) shaft seal: a fibreglass and neoprene shaft seal shall be placed where the shaft leaves the housing, along with a viton shaft slinger between the seal and wheel on belt drive units
 - (d) bases: heavy gauge hot rolled steel, epoxy coated
 - (e) the fan shall be provided with the following accessories:
 - (i) flanged and drilled inlet and outlet to BS 6339
 - (ii) drain
 - (iii) access door
 - (iv) vibration isolation system
 - (v) belt and shaft guard as Part 1
 - (vi) earthing as QGEWC (KAHRAMAA) requirements and BS 7671
 - (f) flexible connectors:
 - (i) flexible connectors shall be installed on the fan inlet and outlet to dampen axial, lateral, and vibrational duct movement. Flexible connectors shall be installed at each fan inlet and outlet
 - (ii) the flexible connector shall be resistant to the corrosive gases being processed and shall be able to withstand ± 3750 Pa. The flexible connector shall be minimum 30 mm long.
- 7 Dampers:
 - (a) suitable sized dampers shall be provided as follows:
 - (i) balancing damper between the fan outlet and the scrubber inlet
 - (ii) isolation dampers at each fan inlet and outlet
 - (b) the dampers shall be provided in accordance with the following specifications:
 - (i) the damper shall be flanged and drilled to withstand 3000 Pa
 - (ii) the blade thickness shall be as required by the damper manufacturer
 - (iii) the bearings shall be moulded plastic material
 - (iv) fibreglass axles shall extend full length of blade and 150 mm beyond frame
 - (v) the unit shall be equipped with a full circumference blade seal to limit leakage to less than 1 m³ /m² min at 3000 Pa.

10.2.4 Recirculation Pumps

- 1 Pumps shall be of the direct coupled, single stage, end suction, horizontal, back pullout corrosion resistant, centrifugal type.
- 2 Impellers with integral shaft sleeves shall be balanced semi-open fibre glass reinforced resin polyester or PVC-C.
- 3 The pump casing shall be a resin injected hot press moulded fibre glass reinforced polyester or PVC-C. The casing shall be free standing supported by heavy duty non-metallic feet. Suction and discharge nozzles shall be NP16 flanges.
- 4 The shaft shall be constructed of 316 stainless steel of sufficient diameter to assure rigid support of the impeller to prevent excessive vibration.
- 5 The bearing housing shall be constructed of cast iron, machined with precision pins of tongue-and-groove construction to ensure permanent alignment.
- 6 Bearings shall be of the anti-friction, oil lubricated, ball type and enclosed in a cast iron, oil-tight bearing frame. Bearings shall have a minimum L-10 rating of 20,000 hours under full load continuous 24-hour duty. Bearings shall be oil lubricated. The pump shall be equipped with constant level oiler.
- 7 The shaft seal shall be mechanical, EPDM/carbon/ceramic. Seal water shall be provided if necessary.
- 8 Pumps and motors shall be bolted to a common GRP baseplate. Pumps shall be grouted in place with epoxy grout.
- 9 Pumps shall be directly coupled to the motor with a suitable spacer type coupling and guard.
- 10 Duty/standby change over shall be by means of a low flow switch mounted in the liquor feed.
- 11 Motor:
 - (a) each pump shall be provided with a horizontal squirrel cage induction, totally enclosed fan cooled motor, of sufficient power such that no point on the pump curve requires more than the rated power of the motor furnished
 - (b) each motor shall be suitable for 415 V, 3 phase, 50 Hz continuous 24-hour operation and shall conform to the requirements of Part 1 of this Section and Section 21.

10.2.5 Chemical Feed Pumps

- 1 Duty and standby dosing pump shall be provided. The pumps shall be of the hydraulically balanced double diaphragm type, wherein a measuring piston reciprocates within a cylinder and causes hydraulic oil to deflect a flat diaphragm. The diaphragm shall be supported throughout the entire pumping stroke. The hydraulic oil system shall include a means to automatically relieve excess hydraulic pressure, makeup oil and bleed-off vapours. Mechanically operated devices are not acceptable. The chemical metering head shall include a diaphragm cavity moulded into the head material, or have other intrinsic design features to prevent diaphragm damage during restricted inlet conditions. The pump shall have a flow-through liquid path from bottom to top. The diaphragm shall be capable of sealing under full head bolt torque limits without stressing the diaphragm. Pump heads shall be polypropylene and diaphragms PTFE.
- 2 The metered liquid shall enter the metering head at the bottom and exit at the top through alumina-ceramic disk or ball type check valves. These may be gravity seating or spring loaded to meet service conditions. Valve assemblies shall be replaceable without threading. Valve seats, shall be of Viton, gaskets shall be PTFE.

- 3 The pump mechanism shall have flooded lubrication using a common oil with the hydraulic system. It shall not contain auxiliary lubricator mechanisms. The pump mechanism shall be sealed from direct contact with the outside atmosphere and shall be suitable for operation in ambient conditions of 55 °C without the use of heating or cooling devices. Manual capacity adjustments between 0 and 100 % shall be accomplished while the pump is idle, or operating, by simply changing the piston stroke length. A minimum of 400 adjustment increments shall be available. Stroke adjustments shall provide positive, repeatable settings within ± 0.25 % over the entire pumping range. Pump delivery shall be repeatable within ± 1 % accuracy over a 10 to 1 range.
- 4 Pump bearings shall be heavy duty ball or tapered roller type designed for an L10 life of at least 50,000 hours in accordance with BS 5512.
- 5 Each pump shall have an integral pressure relief valve to prevent damage to the pump or piping in the event of a downstream pipe blockage.
- 6 Pumps shall be capable of operating continuously with liquids at 40° C.
- 7 Each pump specified herein shall be driven by a squirrel cage induction motor suitable for operation on a 240 V, single phase, 50 Hz power supply, and meeting the requirements for electrical motors as specified in Part 1 of this Section and Section 21. Motors shall be direct coupled to the pumps, with flexible couplings.
- 8 Each pump discharge shall include a back pressure valve designed to create a constant back pressure without chatter or cycling. Parts in contact with the pumped liquid shall be suitable for use with H₂SO₄, NaOH and NaOCl as specified herein. A PTFE diaphragm shall seal the spring and bonnet from the product. The diaphragm shall seal on a replaceable seat and shall ensure tight shutoff at zero flow.

10.2.6 Chemical Storage Tanks

- 1 The storage tanks shall be of lined laminated construction, designed and fabricated in accordance with BS 4994 category III, and shall provide safe, sound, and leak-proof storage at atmospheric pressure for the specified liquids. Lamination thickness specified in the standards shall be considered minimum thicknesses.
- 2 Tanks shall be constructed of a welded PVDF, PVC-u or polypropylene liner and contact-moulded translucent reinforced plastic resin. As a minimum, tank construction shall consist of a 50 µm resin-rich exterior mat, a middle layer mat to develop the necessary strength, and a 250 to 300 µm resin-rich nexus veil interior and a minimum 3 mm thick plastic liner.
- 3 Tanks, anchors, and supports shall be designed for exterior installation that shall withstand a horizontal wind load without movement or damage. Tanks shall also be designed for a concentrated dead load at the top of the tank of 500 kg. Tanks shall include hold-down anchors. Anchors shall be designed to hold the tank against an uplift pressure of 2 m of water column. Tanks shall be designed for pneumatic tanker loading.
- 4 Factory-applied insulation shall be provided for all storage tanks. Insulation shall be 50 mm thick and shall provide a maximum coefficient of thermal conductivity (K Value) of 0.4 kg.cal/h/m²/°C. Insulation shall be protected by an additional fibreglass laminate built up to a minimum thickness of 0.4 mm. This protective laminate shall include expansion joints spaced to preclude damage due to thermal expansion. A lip shall be provided at each joint to prevent moisture from entering. The exterior laminate shall also include a pigmented protective gel coat in a colour to be selected by the Engineer. Loose insulation shall be packed into the gusset around the pipe neck at each tank nozzle, and shall be taped to provide a weatherproof seal.

- 5 A permanently attached encapsulated paper or stainless steel tag shall be affixed to the outside laminate covering the insulation. This label shall contain the following information:
 - (a) manufacturer
 - (b) corrosion-resistant liner
 - (c) type of liner reinforcement
 - (d) chemical to be stored
 - (i) concentration
 - (ii) maximum specific gravity
 - (iii) maximum temperature
 - (e) exterior resin
 - (f) tank capacity
 - (g) date of manufacture.
- 6 The tanks shall include the fittings and appurtenances shown on the drawings and described herein:
 - (a) hinged, top-mounted access manway (800 mm diameter) with non-slip walkway and 316 stainless steel ladder cage, and handrailing
 - (b) conical gusseted, flanged connections for fill, inlet, outlet, drain, vent and overflow. All shall be minimum 75 mm diameter. The overflow shall be piped into the tank bund to prevent splashing. Connections shall be located as shown on the Drawings. Flange face and bolting shall be in accordance with NP 16
 - (c) low level probes shall be fitted in each tank to stop the dosing pumps in the event of low level being detected. Suitable gasketed covers shall be provided for these probes
 - (d) screened vent. The vent shall be sized for release of air during tanker offloading
 - (e) anchor and lifting lugs
 - (f) A visual cat and mouse type liquid level gauge shall be provided on each tank, or alternatively a hand operated pneumatic bubbler.
- 7 Tanks shall be segregated in bunds. Bunds shall have individual capacities equal to 1.1 times the tank full volume. Alternatively tanks of a proprietary design with integral bunds may be provided.

10.2.7 Rotameters

- 1 General. Rotameters shall be provided as shown on the drawings and specified herein. Rotameters shall include a plastic housing or frame. Rotameters shall include a flow indicator suitable for indoor installations. All wetted parts and fittings shall be 316 stainless steel, except O-rings. Meters shall have a minimum rangeability of 10:1 and 2% accuracy.
- 2 Make-up Water. Rotameters shall include a dial flow indicator, 316L or plastic, suitable for high pressure, high temperature flow indication. The metering float shall be magnetically coupled to an indicator housed in a fully gasketed, reinforced fibreglass case. Glass case shall be easily removable for cleaning. Accuracy shall be plus or minus 5 % of full scale. A stainless steel control valve shall be provided for precise regulation of liquid flow rate.
- 3 Seal Water (if used) and recirculation pump rotameters shall be armoured purge meter type with magnetically coupled indicator used for low flow, high pressure, and high temperature. Accuracy shall be plus or minus 10 % of measuring flow rate. Rotameter shall include a 12 mm stainless steel needle valve.

10.2.8 WYE Strainer

- 1 Wye strainer shall be installed on the potable water, recirculation and dosing pump feeds,. Strainers shall have a PVC body with type 316 stainless or PVC strainers with 0.8 mm perforations.

10.2.9 Sump Overflow Trap

- 1 A trap shall be provided on the scrubber sump overflow line to prevent air inflow through the scrubber.

10.2.10 Acid Supply Connection

- 1 The scrubber shall be equipped with a nozzle for addition of a dilute acid solution to the sump. A 50 mm PVC ball valve and 50 by 100 mm funnel shall be installed for this.

10.2.11 Pressure And Vacuum Gauges

- 1 General. Pressure gauges shall be of the stem-mounting type.
- 2 Construction. Gauges shall be of the bourdon tube or bellows type with 270 ° clockwise pointer travel. Dials shall be white with black numerals. Dial size shall be 100 mm. Panel mounted gauges shall have round bezels for flush mounting and rear connection, others shall have a stem-mounting bottom connection. Connections for all gauges shall be male 12 mm threaded with square wrench flats. Wetted parts shall be compatible with the process fluid. Cases shall be impact resistant plastic. Accuracy shall be ± 0.5 % of span.
- 3 Chemical Seal. The gauge shall be furnished with a diaphragm seal. The diaphragm seal shall have a 316 stainless steel (minimum) top and bottom housing and a 316 stainless steel diaphragm welded to the top housing. When the process fluid is not compatible with 316 stainless steel, the manufacturer shall provide a diaphragm seal compatible with the process fluid. The process connection shall be a 20 mm threaded connection with a flushing connection. The fill fluid shall be silicone.

10.2.12 Pressure Switches

- 1 Pressure switches shall be operated by a brass bourdon tube actuating a switch. Switches shall be single pole double throw, rated at 4 A, 240 V a.c., 50 Hz / 30 V d.c. 2A and have deadband adjustable up to 100 % of switch range. The adjustable operating range shall be 1 mPa, with calibrated dials and two pointers indicating set and reset points. Enclosures shall be IP 65.
- 2 Pressure switches shall be fitted in the dosing and potable water booster pump lines to effect change over from duty to standby pumps.
- 3 A pressure drop transmitter shall be fitted in the ducting to effect change over from duty to standby fans.

10.2.13 Drench Showers

- 1 One or more drench showers shall be provided by the chemical storage tanks, as specified.
- 2 Showers shall be operated by a walk-on platform with stainless steel operating linkages and a stainless steel stay open valve which locks open.
- 3 The shower deluge shall be provided by gravity from a tank mounted above the shower with an in-line or tank mounted thermostatically operated heater, fitted with 30 mA RCD protection.
- 4 The shower shall incorporate an emergency eye/face wash fountain with a flexible hose
- 5 The shower shall be complete with a light and emergency shower/eye wash signs.

10.2.14 Water Softener

- 1 These shall be dual cylinder water softeners, rated for continuous output with an integral meter initiated water power regeneration. The softener shall use a fine bead resin bed in conjunction with a brine solution. The softener shall be rated for 28 days use without the salt storage being replenished.
- 2 A water storage break tank shall be provided to feed the softeners via duty/standby water booster pumps.

10.2.15 Control Panel

- 1 A prewired, preassembled electrical control panel shall be provided for the odour control system, as specified in the particular Project Specification
- 2 The panel shall be supplied complete with all equipment and accessories, including the following:
 - (a) motor control switches and indicating lights for the fans, recirculating pumps chemical metering pumps, pH and Redox analyser/controllers
 - (b) interlocks between recirculating pumps, chemical metering pumps, and sump level control. Interlocks between pH and Redox analyser/controllers, chemical metering pumps, and the make-up water solenoid valve and level controls
 - (c) selector switches for manual or automatic operation
 - (d) The panel instruments/instrument loops shall be wired suitable to accept UPS Power
 - (e) an annunciator with volt-free contacts for remote signalling, as required in the Project Specification.
- 3 Additionally the panel construction and components shall meet the requirements of Part 1 of this Section, Section 21 and shall be suitable for connection to 415V 3 phase 50Hz.

10.2.16 Factory Inspection and Testing

- 1 The Contractor shall secure from the equipment manufacturers certification that the following factory tests have been carried out, and submit to the Engineer prior to shipment.
- 2 Fibreglass vessels shall be tested as follows:
 - (a) hydrostatically tested prior to shipment, with water to the top of the vessel for a minimum of 24 hours
 - (b) the water must be contained with no leaks or excessive wall deflection.
- 3 Fans shall be tested as required by BS 848, Parts 1 and 2
- 4 One pump of each size supplied shall be factory tested. Where multiple units are provided, only one of each size and type shall be tested. Dosing pumps shall be tested in accordance with BS 5316 Part 2, recirculation pumps to BS 5316 Part 1.

10.2.17 Spare Parts and Tools

- 1 The Contractor shall provide from the equipment manufacturers all the spare parts and tools required during the commissioning and maintenance periods as specified in Part 1, including those below:
- 2 In addition, sufficient chemicals shall be provided for the complete operation of the odour removal system for 2 years of operation.

- 3 The following spare parts shall be furnished as a minimum requirement, in addition to any additional spare parts required for two years of operation.

<u>Item</u>	<u>Quantity</u>
<u>Fan</u>	
Complete Centrifugal Fan	(1)
Sets of V- belts	(2)
Sets of bearing	(2)
Shaft seals	(2) (if fitted)
<u>Scrubber</u>	
main packing	(100 %) (for 1 bed)
spray nozzles	(1) (set)
moisture separator packing	(5%) (of total)
<u>Dosing pumps</u>	
diaphragms	(8)
Disk check valves and sets	(8)
Pump gaskets and 'O ' rings	(8) (complete sets)
Pumps and motors	(2)
<u>Recirculation Pumps</u>	
Impeller	(2)
Seals	(8)
Pump and motor	(1)

10.3 INSTALLATION AND COMMISSIONING

10.3.1 Installation

- The Contractor shall ensure the supplier of the odour control system furnishes the services on site of a factory trained service technician or engineer. He shall inspect the equipment installation, advise and assist with commissioning, and train the Employer's operations and maintenance personnel.
- The odour control system shall be installed in accordance with manufacturer's written instructions, by suitably qualified and experienced personnel.

10.3.2 Site Inspection and Testing

- Vessel and tank tests. The above water tests shall be repeated on site after installation.
- Fans shall be tested as required by BS 848 Part 1 and shall be installed in accordance with BS 848 Part 5.
- Odour System Test: The Contractor shall test as follows:
 - the odour control system to certify that it meets requirements after completion of the installation
 - all odour shall be testing conducted by the Contractor in the presence of the Engineer
 - the odour control system test shall be conducted after all the air systems are tested and balanced. Separate H₂S tests shall be conducted on each odour control system

- (d) the H₂S tests shall be repeated at the end of the maintenance period with the plant in full operation during the time of year determined by the Employer to have greatest odour problems, using the actual gas levels generated by the pumping stations
- (e) the hydrogen sulphide test shall comprise as follows:
 - (i) hydrogen sulphide (H₂S) concentrations shall be measured using a calibrated portable H₂S analyser
 - (ii) if instructed by the Engineer, bottled H₂S gas shall be used to determine if the specified H₂S performance requirements are met
 - (iii) each test: three sets of samples shall be taken over an 8 h period:
 - each test shall consist of an inlet and outlet H₂S test
 - the supplier shall be responsible for supplying the H₂S for the bottled H₂S testing
 - the three H₂S levels to be tested shall be selected by the Engineer.
- (f) if the odour control system fails to meet the performance criteria, it shall be the Contractor's responsibility to make all the modifications necessary to improve performance at no cost to the Employer. The Contractor shall pay for all additional testing required to verify that performance criteria are being met
- (g) final acceptance of the system will only be possible after successful completion of this testing
- (h) documentation for all the testing shall be submitted to the Engineer.

END OF PART