13 AERATION EQUIPMENT

13.1 GENERAL

13.1.1 Scope

1 This part specifies the requirement for the design, manufacture, construction, installation, testing and commissioning of equipment to dissolve oxygen into liquids using air.

2 Related Sections and Parts are as follows:

Section 1	General
Section 8	Drainage Works
Section 10	Instrumentation, Control and Automation
Section 13	Building Electrical Works
Section 21	Electrical Works

13.1.2 References

BS 970........................Specification for wrought steels for mechanical and allied engineering purposes; (ISO 683-1 Heat-treatable steels, alloy steels and free-cutting steels — Part 1: Non-alloy steels for quenching and tempering; ISO 683-2 Heat-treatable steels, alloy steels and free-cutting steels — Part 2: Alloy steels for quenching and tempering; ISO 683-3 Heat-treatable steels, alloy steels and free-cutting steels — Part 3: Case-hardening steels; ISO 683-4 Heat-treatable steels, alloy steels and free-cutting steels — Part 4: Free-cutting steels; ISO 683-5 Heat treatable steels, alloy steels and free-cutting steels — Part 5: Nitriding steels; EN 10250-4: Open die steel forgings for general engineering purposes - Stainless steels; EN 10095 Heat resisting steels and nickel alloys; BS PD 970 Wrought steels for mechanical and allied engineering purposes. Requirements for carbon, carbon manganese and alloy hot worked or cold finished steels; EN 10089 Hot rolled steels for quenched and tempered springs. Technical delivery conditions; EN 10277 Bright steel products. Technical delivery conditions; EN 10278 Dimensions and tolerances of bright steel products; EN 10088-1 Stainless steels - List of stainless steels; EN 10088-3 Stainless steels - Technical delivery conditions for semi-finished products, bars, rods, wire, sections and bright products of corrosion resisting steels for general purposes)

EN 10084 ....Case hardening steels - Technical delivery conditions; (ISO 683-3 Heat-treatable steels, alloy steels and free-cutting steels — Part 3: Case-hardening steels)

BS 3170, ...Specification for flexible couplings for power transmission

EN 779, ...Particulate air filters for general ventilation - Determination of the filtration performance; (ISO 16890-1 Air filters for general ventilation — Part 1: Technical specifications, requirements and classification system based upon particulate matter efficiency (ePM); ISO 16890-2 Air filters for general ventilation — Part 2: Measurement of fractional efficiency and air flow resistance; ISO 16890-3 Air filters for general ventilation — Part 3: Determination of the gravimetric efficiency and the air flow resistance versus the mass of test dust captured; ISO 16890-4 Air filters for general ventilation — Part 4: Conditioning method to determine the minimum fractional test efficiency)

List of ‘Approved Suppliers’ prepared by the Public Works Authority

13.1.3 Submittals

1 In addition to the requirements of Part 1 of this Section, the Contractor shall reconfirm the information provided in the Technical Submission Schedules submitted with his Tender.

13.2 PRODUCTS

13.2.1 General

1 The works shall be complete with the appropriate number of air blowers, pipework, fittings, valves, diffusers, control equipment and all the necessary ancillaries to make the plant complete.

2 The aeration devices selected by the Contractor shall be based on achieving maximum oxygen transfer efficiency for the design liquid depth. The minimum oxygenation rate in clean water shall be 2.0 kgO_2/kW.h at 20°C

3 Upon selection of a particular aeration device the Contractor shall provide sufficient test data demonstrating the oxygen transfer efficiency of the aeration device at the design liquid depth. Tests shall have been carried out in accordance with the requirements of the American Civil Association standard “Measurement of Oxygen Transfer in Clean Water” test. If the contractor is unable to provide evidence that their equipment has been tested in this way the Contractor shall undertake an oxygen transfer test in clean water in accordance with the American Civil Association standard at an approved testing laboratory.

4 The sizing and number of aeration devices shall be dependent upon the oxygenation requirements of the process.

5 The Contractor shall supply the Engineer with all supporting design calculations and criteria used to determine the type and size/no. of aeration devices selected for approval.

6 The plant shall be controlled by PLC suitable for SCADA and telemetry connection and shall incorporate a Human Machine Interface (HMI) within a dedicated Motor Control Centre (FBA).

7 The Contractor shall design, supply and install the optimum number and configuration of air blowers to give the best whole life cost and maintain the integrity of the process.

8 The Contractor shall provide standby facility at all control valves and shall, insofar as is possible, design and select the valves to be identical to rationalise maintenance.

9 Stainless steel shall be Grade 316 S31 to BS 970-1 (partially replaced by EN 10084) unless otherwise stated.

13.3 SHAFT ROTOR AERATORS

13.3.1 Rotor Aerators

1 The rotor shall be suitably sized for the process requirements up to a maximum of 9 metres in length. The rotor shall be suitable for immersion at depths of 0-300mm

2 The rotor shaft shall be of stainless steel sealed at both ends and suitably strengthened along its length to minimise the effects of torsion.

3 The shaft shall be supported at the drive end and non-drive end by cylindrical roller bearings.

4 Stainless steel aeration blade elements shall be equi-spaced around the circumference and along the length of the drive shaft.

5 In order to minimise the effects of clogging of the aerator, the aeration blades shall be fixed by bolting to the drive shaft only.

6 The aeration blades should be positioned such that pulsating torque transferred to the drive shaft, caused by the action of their immersion in the process liquid, is prevented.

7 The drive unit shall comprise a helical geared reduction gearbox. Design of the rotor/drive unit shall prevent contamination of the drive unit from sludge thrown by the rotor.

8 Splash type lubrication of the gears shall be facilitated by means of an oil bath.

9 Shaft bearings shall be protected against water ingress by the provision of rubber lip seals.

10 Bearings shall be roller or angular contact type, designed for a B10 life expectancy in excess of 100,000 hours.

11 Steel foundation plates shall be provided beneath the drive mechanism suitable for fixing by anchor bolts.

12 Power transmission from the reduction gearbox to the rotor shall be via a flexible coupling. The coupling shall be designed to minimise the transmission of vibration from the rotor to the drive unit. The flexible coupling shall be in accordance with BS 3170.

13 The end of the rotor shaft shall be fitted with a split pattern self aligning bearing assembly.

14 The bearing unit shall consist of a cast iron housing and grease lubricated heavy duty double row roller bearing with lip seals. Locking collars shall be provided.

15 The rotor unit shall be fitted with GRP splash guards which shall be positioned along the full length of the rotor between the top of the rotor and the underside of the walkway.

16 GRP covers shall be provided for the drive unit, bearings and end bearing assembly.

13.3.2 Aeration Tank Baffle

1 An aeration tank baffle shall be provided to direct surface velocities downwards thus maintaining the necessary flow velocities for the depth of tank specified in the contract.

2 The baffle shall cover the full width of the tank and be fabricated from stainless steel.

3 The baffle shall be provided complete with all necessary fixing bolts and brackets.

13.3.3 Vertical Shaft Surface Aerators

1 The aerator shall comprise a central deflector/cone complete with profiled blades. The aerator shall be of all-welded construction. Alternatively the impeller shall be the centrifugal screw type comprising a central shaft to which a spiral vane is fully welded along its length

2 The aerator impeller shall be fabricated from stainless steel.

3 Cross baffles for use with the aerator impeller shall be fabricated from stainless steel and shall be of all-welded construction suitable for bolting to the aeration tank floor.

4 In order to promote mixing of the process liquid and to avoid short circuiting, up-draught tubes shall be fitted below the aerator impeller.

5 Up-draught tubes shall be manufactured from stainless steel or GRP and be suitable for bolting to the tank floor via adjustable mounting brackets.

6 Stainless steel tie rods suitable for bolting to the tank structure shall be provided complete with adjustable turn buckles for alignment of the up draught tube.

7 The drive shaft shall be fully welded construction manufactured from steel tube and plate.

8 The drive shaft shall be connected to the reduction gearbox via a fixed coupling.

9 The drive unit shall comprise a helical geared reduction gearbox.

10 The drive unit shall be fitted with a 3 phase high efficiency motor complying with the requirements of Section 21.

11 Where specified by the contract the drive motors shall be suitable for variable speeds via frequency invertors.

13.3.4 Floating Aeration Devices

1 Where specified vertical shaft type aerators shall be mounted on a floating raft.

2 The raft shall be manufactured from stainless steel box section. The structure shall be suitably braced for rigidity and interconnections between cross members shall be demountable

3 The raft shall be supported in the process media by use of suitably sized Polyethelene drum buoyancy aids, or equal approved by the Engineer, which shall be bolted to the raft framework.

4 The raft assembly shall be restrained within the tank structure by means of a minimum of three stainless steel guy ropes complete with turnbuckles.

13.4 SUBMERSIBLE AERATION DEVICES

1 The aerator shall comprise the following:

(a) Submersible Motor
(b) Impeller
(c) Venturi and / or Diffuser
(d) Air Inlet pipe
(e) Base Support

2 The submersible motor shall be in accordance with Section 21 of this specification.

3 The impeller shall be a turbine type manufactured from stainless steel and suitably profiled to promote agitation of the media.

4 Where specified by the Contract agitation of the process media shall be by use of a submersible centrifugal pump which shall be in accordance with Part 3 of this Section 9.

5 The diffuser assembly shall be manufactured from corrosion resistant materials and be rigidly secured to the drive assembly frame.

6 The diffuser profile shall ensure uniform distribution of the aerated liquid.

13.5 AIR BLOWERS OR COMPRESSORS

13.5.1 General

1 Air blowers or compressors shall comply with Part 14 of this Section 9.

13.6 AIR PIPEWORK

13.6.1 Intake Ducting

1 The air supply to the blowers will be provided from the air inside the blower room. Individual air intake ducting shall be supplied for each blower for this purpose.

2 The ducting shall be of stainless steel Grade 316 S31 to BS 970-1 (Partially replaced by EN 10084) supported from the blower room floor and shall include two filters (1 No.coarse and 1No.fine), silencer and air intake.

3 The combined efficiency for particle removal by the two filters shall suit the requirements of the blowers and the aeration diffusers selected, but shall not be less than EU4. The filters shall be of the pad or dry pocket type. The filter enclosures shall be fabricated from stainless steel and shall be designed for ease of access to the filter elements for inspection/replacement without dismantling the ductwork.

4 The silencer shall ensure that the noise level described for the blowers shall not exceed 75dBA at one metre. It can be a separately mounted unit or mounted on the common baseplate with the blower assembly. The casing shall be fabricated from stainless steel Grade 316 S31 to BS 970-1 (partially replaced by EN 10084), and shall be approved by the Engineer. Only reflective or reactive type silencers are to be used. Absorptive or dissipative silencers shall not be used.

5 The blower room air intakes shall be mounted directly to the wall and shall comprise a fixed blade weather and sand trap louvre complete with bird screen. The louvre shall be designed to exclude rain and sand from entering the building. The intake shall be fabricated from stainless steel Grade 316 S31 to BS 970-1 (partially replaced by EN 10084), or a suitable non-corroding material as approved by the Engineer.

6 Filters shall be tested in accordance with EN 779 at the manufacturer's works.

13.6.2 Discharge Pipework

1 Each blower shall be provided with individual discharge pipework, which shall be connected to a common manifold. The discharge pipes shall be supported from the blower plant room floor.

2 Discharge pipework shall be stainless steel Grade 316 S31 to BS 970-1 (partially replaced by EN 10084). The supports shall be of steel galvanised after fabrication.

3 Each discharge pipe shall be provided with a suitably sized blow-off valve, non-return valve and isolation valve.

4 The blow-off valve shall be an actuated butterfly valve and shall be fitted with an exhaust silencer. The discharge from the silencer shall be at least 2 metres above floor level and shall be directed vertically upward or mounted in the horizontal plane. The silencer shall ensure that the noise level of the exhaust does not exceed the level described for the blowers.

5 The non-return valve shall be of the wafer check type.

6 Butterfly valves shall be provided for isolation of the individual pipelines. They shall be gearbox driven to suitably limit the rate at which the operator can shut off the valve. The valves shall be capable of being operated with the operator standing at floor level.

13.6.3 Blower Manifold

1 The blower discharge pipework shall tee into the manifold. The manifold shall be installed in the blower plant room and shall be supported from the floor. The manifold shall be sized for the duty blowers operating simultaneously delivering air at their maximum output.

2 A valved tapping shall be provided for the fitting of a pressure transducer for monitoring the pressure within the manifold.

3 If necessary, a silencer shall be installed within the manifold to ensure that the noise level outside the building, transmitted via the pipework, does not exceed 75dB(A). This shall be based on the duty blowers delivering at their normal rated output.

4 The manifold shall be fabricated from stainless steel Grade 316 S31 to BS 970-1 (partially replaced by EN 10084). The supports shall be of steel, galvanised after fabrication.

5 Automatic condensate drain traps shall be installed at any location where water can collect in the discharge pipework/manifold assemblies.

6 The blower manifold and any other above ground air pipework that exceeds 60^0C surface temperature shall be insulated.

13.6.4 Air Supply Main

1 A supply main shall be provided and shall connect the blower house manifold to the distribution pipework. The main shall extend from the blower house to the treatment process units.

2 The supply main shall be sized for the duty blowers operating simultaneously delivering air at their maximum output and the velocity shall not exceed 20 m/s.

3 A dirt pocket with an automatic condensate drain trap shall be installed to collect and drain water at the lowest position on the main. A chamber for access to this condensate drain trap shall be provided.

4 The main shall be laid to an even grade sloping back to the condensate trap.

13.6.5 Distribution Pipework

1 Distribution pipework shall be made from stainless steel Grade 316 S31 to BS 970-1 (partially replaced by EN 10084).

2 Additionally, the gauge of the pipes to which the diffusers are to be fitted shall be sufficient to allow the use of screw fit aeration disc base plates and to withstand local forces generated at the joints by the flow of effluent over the discs.

3 The pipework grid shall be broken down into sections, which shall be indicated on the Contractor's drawings.

4 Coupling seals shall be manufactured from a rubber compound suitable for long-term immersion in aerated effluent. If push-fit connections are used they shall be of a design that inhibits the removal of the spigot piece once inserted into the socket.

5 Pipework shall be fixed to the concrete floor of the process units by means of stainless steel pipe supports fixed by means of stainless steel anchor bolts. Pipe supports shall provide a means of fine adjustment of the level of the aeration grid.

6 Pipework supports shall be sufficiently numerous to support the grids without sagging and to allow the pipework to resist mechanical, hydrodynamic and hydrostatic loads without generating excessive loading in the pipework.

7 The maximum air velocity in any portion of the air distribution pipework shall not exceed 20 m/s. When selecting connections, consideration shall be given to heat, internal and external corrosion, expansion and contraction and resistance to all normal and abnormal forces.

8 Each diffuser array shall be provided with condensate drains and purge pipes which shall be taken above TWL and be accessible from walkways. Protection against siphoning of effluent into the air main shall be provided. Self-sealing diffusers shall not be considered to meet this specific requirement.

13.6.6 Flow Control and Isolation

1 Each aeration zone shall be provided with a flow modulation valve to control the flow of air into each zone as required by the process. The valves shall be of an eccentric plug or iris type with a linear characteristic across their design flow range.

2 Each aeration zone shall be provided with an isolation valve. Valves shall be of a gate or butterfly type.

3 Each aeration zone shall be aerated by a series of arrays of diffusers via a dropper. Each dropper shall have provision for measuring and adjusting the air flow rate to balance the air flows in the correct proportions over the area of the pocket to maintain adequate mixing.

4 The provisions for measuring and adjusting the air flow rate on each dropper shall be linked to the SCADA system to achieve remote monitoring and adjustment of each individual dropper.

13.7 AIR DIFFUSERS

13.7.1 General

1 The size and number of diffusers selected shall provide the necessary oxygen required by the process.

2 Particular attention should be paid to the number of diffusers selected in order to avoid "dead" areas within the aeration zone.

3 The diffusers shall be evenly spaced along the floor of each tank and shall provide an air flow rate of not less than 2.2 m^3/hr per m^2 of tank surface area

4 Manufacturers test certificates shall be provided clearly stating the required air flow rate necessary to achieve even flow distribution through the diffuser.

13.7.2 Fine Bubble Air Diffusers

1 Diffusers shall be installed on the distribution pipework. Diffuser holders shall be manufactured from materials compatible with the distribution pipework. The diffusers shall be selected for long service with a minimum replacement period of 10 years. Diffusers that can be cleaned in situ will be preferred.

2 The materials of the diffuser shall be non-biological and resistant to sewage and its by-products and the membrane shall be manufactured from EPDM. The membrane perforations shall be formed such that tearing of the material is minimised. The diffusers shall be fitted with either integral non-return valves, or similar system, which are capable of automatically sealing and preventing water ingress into the air piping if the air pressure falls.

3 The maximum air flow rate through each diffuser shall not exceed the rated design flow for the diffuser or 175m^3/hr of air at standard conditions per m^2 of effective membrane area, whichever is the lower.

13.7.3 Tubular Membrane Diffusers

1 The aerator shall consist of the following:

(a) Membrane holder complete with air distribution holes.
(b) Membrane
(c) Clamping rings

2 The membrane holder shall be manufactured from stainless steel.

3 The membrane properties shall be as 13.7.2.2 above.

4 The membrane holder shall incorporate an integral check valve to prevent backflow of process media into the diffuser grid pipework.

5 The membrane holder shall be fixed to the distribution pipework via a threaded nipple or via threaded pipe adaptors and stainless steel tie rods complete with stainless steel nuts bolts and washers.

6 The membrane shall be retained to the holder via stainless steel clamping rings.

7 The diffuser shall be suitable for operating at flow rates of 1.0 to 15.0 m^3/hr.

13.7.4 Plate Membrane Diffusers

1 The size and number of aeration devices selected shall provide the necessary oxygen required by the process.

2 The aerator shall consist of the following:

(a) Diffuser trough
(b) Membrane
(c) Stiffening plate
(d) Seal
(e) Retaining Clamps

3 The diffuser trough shall be fabricated from stainless steel plate. The trough shall comprise suitable brackets for bolting the diffuser assembly to the delivery pipework.

4 The membrane properties shall be as 13.7.2.2 above.

5 The membrane shall be supported by means of a stainless steel stiffening plate which shall contain air distribution holes to uniformly distribute the air across the area of the membrane.

6 The distribution holes shall be positioned relative to the membrane perforations such that backflow of the process media during loss of air supply is inhibited.

7 The membrane assembly shall be sealed into the diffuser trough by means of a profiled rubber gasket.

8 The membrane assembly shall be retained in the diffuser trough by means of stainless steel clamps. The number of clamps shall be dependent upon the length of the diffuser. The clamps shall be equi-spaced along the length of the diffuser.

9 The diffuser shall be suitable for operating at flow rates from 1.0 to 25.0m^3/hr.

13.7.5 Coarse Bubble Air Diffusers

1 The air diffuser consists of two simple parts, the diffuser body assembly and the flexible check diaphragm. Both parts are molded together so no separation can occur. During aeration, the diaphragm rises allowing the air to exit through the orifice of the disk body. When the air stops, the diaphragm is instantly seated against the diffuser body by the pressure of the liquid, preventing backflow and clogging. The formation of the air check diaphragm will allow double shear of the discharged air from the orifice, along with assisting in reducing the requirements of maintaining each diffuser level for proper air distribution. The air diffuser material shall be adequate to prevent plugging and resist brittleness or growing of the diaphragm through absorption of chemical components in the liquids.

13.8 INSTALLATION AND COMMISSIONING

13.8.1 Installation and Commissioning

1 The equipment delivered to Site shall be examined by the Engineer to determine that it is in good condition and in conformance with the approved working drawings and certification. All equipment shall be installed in strict accordance with Part 1 of this Section 9.

13.8.2 Testing

1 Test Procedures shall be in accordance with Part 1 of this Section 9 and the particulars of the Contract.

2 Where specified in the Contract the aeration system shall be tested as follows:

3 The aeration tank shall be cleaned of any contaminants which may inhibit successful testing. The use of synthetic detergents for this purpose is not permitted.

4 The aeration tank shall be filled with the required test volume of potable water/final effluent.

5 The dissolved oxygen monitoring equipment shall be calibrated: at zero D.O. using water de-aerated with sodium sulphite solution; at saturation, with aerated water after prolonged and vigorous aeration; and at 50 % saturation, achieved by vigorously aerating water with a gas containing 10.5% oxygen in nitrogen.

6 Calibration results should show a linear relation between D.O. meter and concentration of D.O. Deviations shall require recalibration, checking of the probe including necessary refurbishment, checking of any temperature compensation. Calibration shall be undertaken under the same temperature conditions as those envisaged within the tank.

7 Multiple probes shall be utilised and distributed evenly throughout the tank.

8 Once the necessary equipment is positioned and the required volume of potable water/final effluent is added to the tank the air saturation equilibrium concentration of D.O. shall be checked. The water temperature shall also be measured.

9 A strong solution of sodium sulphite shall be made in warm water, if possible. The required quantity shall be sufficient to provide 20% excess over the stoichiometric amount required for deoxygenation. The mass of anhydrous sodium sulphite in Kg is therefore: -

$$\frac{\text{Volume of tank x D.O concentration in mg/l (prior to addition of sulphite) x 7.88 x 1.5}}{1000}$$

Note: excessive sodium sulphite addition will result in a longer oxygen uptake.

10 A strong solution of cobalt chloride, to act as a catalyst, should be added to the tank sufficient to give a concentration of 0.5mg/l. The mass required is therefore:

Mass $CoCl_2$ (g) = 2 x tank volume

11 The chemical solutions shall be distributed evenly through the aeration tank. Rapid addition at a single point is not permitted.

12 At the start and end of each test the temperature of the water shall be measured to the nearest 0.1°C and the barometric pressure to the nearest mm of mercury.

13 The aeration equipment shall be activated and the airflow rate, temperature and pressure shall be closely monitored. In the case of mechanical aeration equipment the power drawn shall be monitored.

14 The dissolved oxygen probes shall be connected to a multi channel potentiometer recorder. The increase in dissolved oxygen levels shall be monitored until the air saturation is reached (after approx $6/k_La$ hours). At 90% saturation a sample of liquid shall be taken to examine the quantity of residual cobalt.

15 When the test liquid has reached air saturation level a sample shall be taken and the concentration of dissolved oxygen shall be determined using the modified Winkler method.

16 The recorded concentrations of D.O. and calculated or measured values of saturation concentrations results shall be plotted as graphs of $\log_e$ of D.O. deficit against time for D.O. values from 20 to 80% of the saturation value for each probe. The slopes of these graphs shall be used to calculate separate values of K_La as described by the equation:

$$\log_e \frac{C_s - C_t}{C_s - C_o} = -K_La\ t(\text{min}^{-1})$$

17 The average of the K_La values plotted shall be used to determine the K_La of the aeration system.

18 Cs shall be calculated using the following equation:

$$Cs = \frac{468}{31.6+T}$$

19 Following the determination of K_La and by applying the correction factor the oxygenation capacity of the system shall be calculated using $Oc = K_La.V.Cs$

20 The aerator shall be + or - 10 % of the contractors stated values for oxygenation capacity. If this tolerance is exceeded the Contractor shall provide rectification at his own expense.

21 Where the aeration equipment is a mechanical device the Contractor shall also demonstrate that the minimum velocity across the aeration tank floor of 60mm/s is achieved. If this velocity is not achieved the Contractor shall provide rectification at his own expense

END OF PART