# Biological Odour Control Systems Specification

**ADVICE**

This document provides the Specification for **Biological Odour Control Systems.**

This document must be read in conjunction **in conjunction with relevant QCS 2014 referenced in this document**:

- Qatar Construction Specification (QCS) 2014
    - Section 09 - Part 09: Odour Control Equipment - Carbon Type
    - Section 09 - Part 10: Odour Control Equipment - Scrubber Type
    - Section 09 - Part 22: Ventilation Systems

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| **Circulation:** | **Ashghal Departments, Contractors, Supervision Consultants, Design Consultants**. |
| **Application:** | This Specification applies with immediate effect from the date of issue |

| Rev | Date | Description | Author | Checked | Approved |
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# Contents

# 1. General

## 1.1 Scope

**1.1.1** This Part specifies the requirements for the design, manufacture, construction, installation testing and commissioning of Biological Odour Control Systems involving Bio Scrubbers, Bio trickling Filters or combination of both with or without polishing step with Chemical or Activated carbon for controlling Odour emissions in Foul Sewer Network, Pumping stations & Foul sewage treatment plants.

**1.1.2** Related Sections and Parts are as follows:

This Section

1. Part 1, General.
2. Section 8, Drainage Works.
3. Section 09, Part 09: Odour Control Equipment - Carbon Type.
4. Section 09, Part 10: Odour Control Equipment - Scrubber Type.
5. Section 09, Part 22: Ventilation Systems.
6. Section 10, Instrumentation Control and Automation.
7. Section 21, Electrical Works.

**1.1.3** The Odour Control Supplier shall design, supply, deliver, test and commission the Biological Odour Control odour control system complete with vertical towers, water control panels, nutrient feed system (if required), recirculation system (if required), OCU control panel, fan system, spare parts, instruments, components, accessories and appurtenances. Electrical Control panel shall be as per QCS 2014 Section 21 Part 2 and PLC shall be as per QCS Section 10.

## 1.2 References

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

- BS 848 - Fans for general purposes.
- BS 970 (ISO 683) - Wrought steels for mechanical and allied engineering purposes.
- BS 1646 (ISO 3511) - Symbolic representation for process measurement control functions and instrumentation.
- BS 2782 (ISO 181, 174, 307, 8618) - Methods of testing plastics.
- BS 3496 (ISO 1888) - E glass fibre chopped strand mat for the reinforcement of polyester and epoxy resin systems.
- BS 3532 - Method of specifying unsaturated polyester resin systems.
- BS 3749 - E glass fibre woven roving fabrics for the reinforcement of polyester and epoxy resin systems.
- BS EN 1092 - Circular flanges for pipes valves and fittings.
- BS EN 13121 (4994) - Design and construction of tanks and vessels in reinforced plastics.
- BS 5000 (IEC 34, 72) - Rotating electrical machines of particular types or for particular applications.
- BS 5345 (IEC 79) - Code of practice for selection, installation and maintenance of electrical apparatus for use in potentially explosive atmosphere.
- BS 5512 (ISO 281) - Methods of calculating dynamic load ratings and rating life of rolling bearings.
- BS 6105 (ISO 3506) - Corrosion resistant stainless steel fasteners.
- BS 6339 (ISO 6580) - Dimensions of circular flanges for general purpose industrial fans.
- BS 7671 - Requirements for electrical installations.
- National Fire Protection Association (NFPA) 820 - Standard for Fire Protection in Wastewater Treatment and Collection Facilities, 2020 Edition.
- Air Movement Control Association 99-0401 – Classification for Spark Resistant Construction.
- ASTM E477 - Standard Test Method for Measuring Acoustical and Airflow Performance of Duct Liner Materials and Prefabricated Silencers.
- ASME RTP-1 - Reinforced Thermoset Plastic Corrosion-Resistant Equipment.
- BS EN 13725:2003 Air quality. Determination of odour concentration by Dynamic Olfactometry.
- BS/IEC and Kahramaa standards to be followed for electrical codes.
- All relevant QCS 2014 Sections should be followed.

Where codes, standards and regulations are in conflict, **the more stringent criteria and** requirements shall be applicable.

## 1.3 System Description

**1.3.1** OCU Design Specifications:

The system shall be designed based on $H_2S$ and Odour generation data derived from septicity model of Foul sewer network design and / or from historic data of statistical analysis for mean, 95%ile and maximum inlet concentration. In case no specific design average inlet air quality specifications are available, the following minimum average values shall be used:

Average static concentration of hydrogen sulphide (unless specified otherwise): 500 ppm

- Mercapatans: traces.
- Amines (mono (di/tri): 10ppm.
- Ammonia: 50ppm.
- Sulphide concentration in solution: 50 mg/l.

The system should able to handle short-term peaks of minimum concentration of twice the average concentration.

The minimum number of air changes in the ventilated volume are as provided below:

Table 1: Guidelines for minimum air changes

| Description | Minimum Air Changes per hour |
|---|---|
| **PUMPING STATION** | |
| Pumping station (no man access) | One for local covers<br>12 for pumping stations extracted from close to the sump and process unit |
| Pumping station working area (current practice) | 20 during man access (initiated by light switch) |
| Dry wells ( current practice) | 12 |
| **SEWAGE TREATMENT PLANT** | |
| Balancing tank<br>Inlet works distribution chambers<br>Sewage flow distribution chambers | 6 |
| Screenings Buildings, channels and screens | 10 |
| Grit & FOG units | 10 |
| Sludge storage tanks | 10 |
| Screenings buildings (unrestricted access) | 12 |

For any other areas in the Sewage Treatment Plant, unless otherwise specified in the Project particular requirements, the minimum number of air changer per hour in the ventilated volume shall not be less than 4 (four).

To improve the atmosphere on the above restricted access areas prior to man-entry, the above ventilation rates should be increased to at least 16 air changes per hour, considering full empty volume and the overall design shall ensure that the active ventilated area is always kept at negative pressure.

Design of odour control system and associated equipment should take into account the following expected temperatures:

| | |
|---|---|
| Maximum ambient temperature | **50 ºC** |
| Minimum ambient temperature | **5 ºC** |
| Design ambient temperature | **50 ºC** |
| Maximum metal temperature under the sun | **85 ºC** |
| Maximum ambient humidity | **100 %** |
| Minimum ambient humidity | **20 %** |
| Design ambient humidity | **100 %** |
| Design Sewage Temperature | **20 ºC – 40 ºC** |
| Foul air vented to an OCU | **10 ºC to 50 ºC** |

### 1.3.2 Performance requirements

Unless otherwise specified in project particular requirements, the performance should meet under all climatic conditions.

Biological Odour Control for Bulk primary treatment in combination of polishing treatment for treatment of Odour meeting performance.

Primary Odour Control Unit stage -1 with Biological OCU.

A. Minimum $H_2S$ Removal Requirements:

   For inlet concentrations > 10 ppmv, provide 99% removal.

   For inlet concentrations < 10 ppmv, outlet $H_2S$ concentration shall be < 0.1 ppmv.

   Provide additional removals if required to meet the Guaranteed Performance.

B. Odour Removal Requirements:

   90% removal or <1,500 OU, whichever is more stringent.

   Provide additional removals if required to meet the Guaranteed Performance.

Secondary Polishing Odour Control Unit Stage.

A. Minimum $H_2S$ Removal Requirements:

   For inlet concentrations > 10 ppmv, provide 99% removal.

   For inlet concentrations < 5 ppmv, outlet $H_2S$ concentration shall be < 0.05 ppmv.

   Provide additional removals if required to meet the Guaranteed Performance.

B. Minimum odour removal:

   95 percent removal, minimum.

   Provide additional removals if required to meet the Guaranteed Performance.

Overall Guaranteed Performance of Odour Control System.

A. Hydrogen sulphide concentration shall be less than or equal to 5 ppbv at any point outside the property boundaries of site as 98th percentile of the One (1) hour average concentration.

B. Odour concentration shall be less than or equal to 5 odour units per m3 at the point outside property boundaries site as 98th percentile of the One (1) hour average concentration.

### 1.3.3 System Requirement:

i. The single or multi-stage Biological Odour Control system with or without combination of Bio scrubber and Bio Trickling shall be operated as a vertical counter flow arrangement with a once-through irrigation system.

ii. Co-current flow systems where foul air and irrigation water flows in the same direction are not allowed.

iii. Cross-flow horizontal type configurations are not acceptable.

iv. Systems using a water recirculation system through the reactor vessel shall not be allowed.

v. Single or multi-stage biotrikling filter vessels.

vi. Structured and engineered, synthetic media with engineered flow channels to optimize mass transfer and facilitate the growth of bacteria necessary for biological oxidation of odorous compounds.

vii. Biological Odour Control unit media should be based on synthetic media not organic media used in the Bio OCU and Life of the media and warranty guaranteed for not less than 20 Years.

viii. Biological Odour Control media during the above warranty period should not shrink or swell or compact with varying moisture content of not more than 5 percent of the original bed depth.

ix. Biological Odour Control media during the above warranty period should not experience more than 15 percent increase in head loss across the media at design airflow.

x. The Biological Odour Control design comprises of:

- Engineered flow channels to prevent short-circuiting over the Operational life span.
- Optimize mass transfer of odour compounds to the bacteria.
- Eliminate media plugging.
- Provides consistent performance.
- Minimum High specific surface area (750 m2/m3) helps to develop a high microbial density in the media, thus allowing for the treatment of very high odour loadings.
- Effective organic and inorganic odour removal, thus providing total odour control.
- Long Media Life (life expectancy > 20 yrs).
- EBRT not less than 20 seconds.

xi. Unless otherwise specified in particular specification, the Biological Odour Control shall be designed for 120% of the required capacity. The Biological Odour Control design shall comprise of minimum two identical systems each capable of providing 60% of the overall design air and load requirements such that if one unit fails or taken out for service, the other still provides 60 percent capacity.

xii. The water required for Irrigation of media shall be using TSE based on the compatibility of water quality. Any negative impact on Bio media due to presence of residual disinfectants shall be mitigated with automation facilities providing alarm to operator to initiate measures on concentration exceeding the limits of such residual disinfectants.

xiii. The system should be complete with shower and eye baths, Access covers, Inspection sight glass, facilities for media cleaning, replacement etc.

xiv. The system shall be manufactured of materials compatible for sulphuric acid generated in the process with pH as low as pH 1. The system should consider the neutralization facility, if required to avoid any impact on downstream processes due to draining of highly concentrated irrigation water as sulphuric acid.

xv. The treated air shall be discharged into atmosphere via stack and shall extend above the height of building with required height determined by dispersion modelling using US EPA latest AERMOD dispersion model. All potential existing and future sources of odour in the surrounding areas should be considered.

xvi. The discharge vent from the Odour Control system shall be designed to maximize the air velocity greater than 15 m/s out of the top of the stack to obtain maximum dilution with surrounding air. The discharge vent stack height shall be of minimum 14 m above ground unless otherwise proven that the sensitive areas around the project site is not affected with lower stack height.

xvii. The Biological Odour Control design shall comply to the requirements to Hazardous Area Zone classification.

xviii. To meet the performance guarantee with second stage of treatment considered with Activated Carbon Filter, then a Demister between the Biological unit and Carbon System shall be integrated in the design, to avoid any impairment of the performance of activated Carbon. Secondary Activated Carbon shall have a designed life of 10 years with acceptable regeneration cycles.

### 1.3.4 Process Description

The odour control system shall remove hydrogen sulfide, organic reduced sulfur compounds (RSCs) and other odorous compounds from the foul air stream using biological Odour Control System.

The foul air shall enter the system from the bottom of each reactor and flow upward through each of the media layers installed in series. The media bed shall be intermittently irrigated from top of reactor using reclaimed treated sewage effluent (TSE) unless otherwise stated or if the quality of TSE does not permit to use then potable water shall be used. Necessary The water trickles through the media and is collected at the bottom of the reactor. The drain water at the bottom of the reactor vessel shall be piped to a discharge point as designed.

The autotrophic bacteria resident on the lower media layer oxidizes the hydrogen sulphide, as the foul air passes through the upper media layer(s), the resident heterotrophic bacteria will oxidize along with other organic odorous compounds. The airstream is then released to the atmosphere via the exhaust stack at the top of the reactor

Autotrophic bacteria can thrive in an acidic environment, but heterotrophic bacteria can only survive in a pH neutral environment. In order to create and maintain a pH gradient over the reactor, systems using recirculation water through the reactor vessel shall not be allowed.

### 1.3.5 Contractor Responsibility

A. Installation of all Manufacturer supplied equipment components, which includes among others, placement and bolting of all equipment to the concrete pad, connection of ductwork, water piping, drainage piping, and power and control wiring, all in accordance with the Manufacturer's installation instructions.

B. Supply of all odorous air ductwork including flex connectors and damper valves upstream of the blower.

C. Site preparation and clearing.

D. Construction of concrete equipment pad for placement of the Biological Odour Control filter(s) and supply of system anchor bolts.

E. External water piping and drain piping to and from the Biological Odour Control filter(s).

F. Power supply to the electrical control panel, water supply to the water panel, and water drain line from the Biological Odour Control filter(s) drain sump.

G. Installation of any additional items as noted on the contract drawings.

H. Heat tracing and insulation of any air ductwork and/or water pipes as required by this Specification or elsewhere in the Contract Documents.

I. Temporary piping and other installations for start up of the system.

## 1.4 Submittals

**1.4.1** In addition to the requirements of Part 1 of this Section, the Contractor shall provide data and information as described in the following paragraphs.

**1.4.2** Design data providing the following information:

Design submittals involving Air extraction sources, rate of air changes, Air volume for Design, Static and dynamic Inlet Parameters, Historic data, Outlet guaranteed performance, Process Flow Diagram, P&ID, Mass Balance, Detailed calculations, QCS compliance, Process and Automation control philosophy, GA drawings, Layout and Modelling.

a) Calculations to justify the sizing of the fans, packed bed, pumps, TSE/potable water storage tanks and chemical storage tanks.

b) Calculations as required by EN BS 13121 pertaining to the construction of the FRP Biological Odour Control vessel and related equipment.

c) Structural calculations for foundations and guy wires or any other external means of support, taking into account wind loadings.

d) End user certificates.

e) Modelling results, in graphical format, with velocity contour plots at 24" media height over the entire media cross section shall be provided to confirm that the airflow through the media is homogeneous at the average airflow rate. For the purpose of this specification, homogeneous is

defined as being when the upflow velocity over the entire media cross sectional area is equal to the average up flow velocity ± 10%.

f) Calculations that the irrigation system shall distribute the irrigation liquid evenly over the media area/section; Deviations more than ± 7% in flow distribution will not be allowed.

g) Detail bill of material complete with Material of construction.

h) Process and Instrumentation Diagram (P&ID) showing all main equipment components, flow rates and instrumentation.

i) Process control narrative.

j) Equipment offloading and installation instruction with sufficient details to allow the contractor to complete the mechanical and electrical installation of all System components.

k) Information on hazard associated with the system and appropriate safety precautions, including applicable Material Safety Data Sheets (MSDS).

l) Datasheets, specifications and warranty for the media.

**1.4.3** Shop drawings, providing the following information:

a) Make, model, weight and power rating of each equipment assembly.

b) Manufacturer's catalogue/data sheet information, descriptive literature, specifications, and identification of materials of construction.

c) Dimensional layout of OCU System and related equipment.

d) Design calculations for the FRP Biological Odour Control vessels, ladders, and structural members.

e) Process calculations showing calculated values for annual utility, water, and nutrient usage.

f) Fan test data as BS 848 Parts 1 and 2

**1.4.4** Instrumentation:

a) Complete layout and wiring diagrams of unit control panels.

b) Complete process and instrumentation diagrams drawn in accordance with BS 1646.

**c)** Instrument list.

**1.4.5** Operation and maintenance and instruction manuals including:

a) Odour reduction field test report(s) as specified in Part 1.3.

b) The documentation in Clauses 2, 3 and 4 above in Part 1.1.4.

c) As-built dimensional drawings showing plan and elevation views of the System and all applicable connections.

d) As-built Process and Instrumentation Diagrams (P&IDs).

e) Detailed bill of material along with specification of System components and materials of construction. The list to include the make, model number and descriptive literature of all items furnished by the Manufacturer.

f) Performance data for the odor control blower, to include curves showing capacity, pressure, horsepower demand and efficiency over the entire operating range, including blower manufacturer's descriptive literature and blower model number(s).

g) Special precautions for any components or materials associated with the System and its operation that should be subject to particular safety precautions, including MSDS.

h) Manufacturer's Service Department contact information and service order form.

i) Statement of Manufacturer's Warranty.

j) System startup and restart instructions.

k) Detailed information on proper settings and operation of the Automatic Flow Control System.

l) Special maintenance procedures, including recommended weekly, monthly and annual preventative maintenance requirements.

m) Troubleshooting guide.

n) Individual Operation and Maintenance instructions for all major system components.

o) Details of manufacturer's local agent and contact information

## 1.5 Quality Assurance

**1.5.1** Upon completion of the installation, each piece of equipment and each system shall be tested for satisfactory operation without excessive noise, vibration, overheating, etc. All equipment must be adjusted and checked for misalignment, clearances, supports, and adherence to safety standards.

**1.5.2** Qualifications:

I. The Biological Odour Control System manufacturer shall have a valid ISO9001 Certificate and be listed on the ASHGHAL Approved Vendor List.

II. The manufacturer shall have at least five (5) years' experience in the design, fabrication, and supply of Biological Odour Control odour control systems. The system manufacturer should also have a minimum of five (5) years of experience of producing similar systems. They shall show evidence of at least five (5) systems in operation of which at least three (3) in operation in similar climate and conditions of in the Gulf Region with details of End user, Contact Names, Telephone no., Scope of work, System capacity (Flow rate in m3/hr), Inlet and outlet concentration of $H_2S$ and Odour, Duration of operation of each reference. The references (3 No.) shall be of comparable size (bigger or 20% less) to the capacity specified for the project for which the submittal is proposed/made.

III. Any manufacturer whose main business is FRP manufacturing will not be accepted as a supplier for the Biological Odour Control odour control system specified herein.

IV. The Biological Odour Control filter manufacturer is responsible for the coordination with all the equipment suppliers to complete the system inclusive of FRP towers, air blowers, nutrients system, ducts, instrumentations, control and water panels, etc. The biological odour control system manufacturer shall be experienced in the design, manufacturing, installation and operation of Biological Odour Control filters designed to remove hydrogen sulphide and all the organic RSCs from municipal wastewater odour sources.

**1.5.3** Manufacturer's Certifications:

I. Certify that factory test equipment has been calibrated and checked against an approved standard within the last twelve (12) months.

II. Certify that field test equipment has been calibrated and checked against an approved standard within the last twelve (12) months.

## 1.6 Inspections

**1.6.1** The Engineer has the right to reject delivery of any or all pieces of FRP equipment found, upon inspection, to have any or all of the following:

I. Blisters.

II. Chips.

III. Crazing.

IV. Exposed glass.

V. Cracks.

VI. Burned areas.

VII. Dry spots.

VIII. Foreign matter.

IX. Surface porosity.

X. Sharp discontinuity and

XI. Entrapped air at the surface of the laminate.

**1.6.2** The Engineer reserves the right to be present at the fabricator's facility for visual inspection of equipment fabrication.

**1.6.3** Rejection of an item shall require correction of the item as follows:

I. Initial Correction: Field correction by the manufacturer shall be attempted. If the outcome of the field correction is satisfactory to the Engineer then the item shall be considered approved. If the outcome of the field correction is not satisfactory to the Engineer, then the item will remain rejected and shall receive further correction.

II. Further Correction: The item shall be returned to the fabrication facility and either corrected or refabricated. After the item is corrected or refabricated, the item shall be delivered to the site location and the inspection process repeated until satisfactory to the Engineer.

III. Correction of items resulting from inspection rejection shall be provided at no extra cost to the Authority.

**1.6.4** Shipping, Delivery, Storage & Handling.

A. All equipment and materials shall be properly protected such that no damage will occur from the time of shipment until the time of installation.

B. All exposed openings shall be protected to prevent entrance of debris, moisture or water during transportation and storage.

C. Contractor shall be responsible for offloading all shipped equipment and shall inspect all equipment upon arrival. Contractor shall notify the Manufacturer within 24 hours of any damage to equipment or surface finish due to shipping.

D. Contractor shall store all equipment such that, for the duration of the storage period, there will be no deterioration in equipment appearance or performance. Manufacturer shall supply detailed storage instructions, as necessary, at the time of shipment.

## 1.7 Warranty

**1.7.1** The Contractor shall ensure that the Biological Odour Control system 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.

**1.7.2** Warranties and guarantees by the suppliers of various components in lieu of single-source responsibility by the Biological Odour Control system manufacturer will not be accepted. The complete system installation shall be guaranteed individually and collectively by the Contractor & Manufacturer.

**1.7.3** The Biological Odour Control system manufacturer must state in his proposal the guaranteed removal efficiency of the Biological Odour Control system, based on the foul air inlet concentration.

**1.7.4** Biological Odour Control Media Warranty:

a. The Biological Odour Control filter manufacturer shall be the origin producer of the media so as to provide the design performance guarantee and to warrant the structural media against all the defects in material and workmanship for at least twenty (20) years from media delivery.

   In case, the media is sourced from a media manufacturer other than Ashghal approved Biological Odour Control OCU system provider, then the media Quality control and warranty for its operable life of twenty (20) years must be guaranteed jointly by manufacturer of the media and Ashghal approved Biological Odour Control OCU system provider.

   The project Contractor Performance liability and Guarantees shall follow the Contract specification, Latest QCS and Qatar laws

b. The Biological Odour Control media shall be provided with a twenty (20) year warranty, commencing from the date of the Commissioning Certificate.

c. In addition, during the warranty period:

   i. The media shall not shrink or compact by more than Five (5) percent of the original bed depth. Differential pressure drops shall not exceed the maximum limits stated herein at design airflow rates.

   ii. The media shall not degrade or decompose.

   iii. If the media does shrink or compact by more than Five (5) percent of the original bed depth or of the media is found, upon examination by the media supplier, to have degraded or decomposed or to be defective in material or workmanship or both, and the efficiency of the system is affected by that, the media supplier shall either:

      a. add new media or

      b. repair or replace any part of the defective media or

      c. replace the entire media bed(s) at no cost to the Contractor or the Authority.

# 2. PRODUCTS

## 2.1 General

**2.1.1** The Biological Odour Control filter odour control system shall be a once through, multiple stage and packaged FRP designed to meet the performance requirements specified herein. The system shall be designed for continuous and automatic operation and also be capable of manual operation. Air flow through the Biological Odour Control shall be vertical counter-current. Foul air passing through wetted media shall make contact with biomass residing within biofilm attached to the media substrate. Foul air constituents shall be absorbed into the biofilm and be biologically oxidized into non-volatile, soluble by products.

Irrigation water shall be provided for maintaining adequate moisture and pH levels within the media. Irrigation system also should be able of "unclogging" the media, at an eventual higher flow rate. This shall be accomplished by once-through irrigation system. All necessary valves and piping shall be provided to allow for once-through operation. Irrigation system shall distribute the irrigation liquid evenly over the media section by the use of an one spray nozzle system. A nutrient feed system shall be provided as backup in case TSE becomes unavailable or is proven to be insufficient with regards to nutrient addition. Potable water shall be utilized for irrigation water in case TSE is unavailable.

**2.1.2** 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 isophtalic and/or 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 isophtalic 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 EN13121.

e) Each Biological Odour Control filter unit shall include the following:

i. Flanged inlet connection.

ii. Multiple stage, vertical tower.

iii. Structured, synthetic and coiled Biological Odour Control media.

iv. Nozzle type liquid distributor.

v. Stairs and platforms.

vi. Piping, valves, and fittings as required for the system to operate as described herein.

vii. Nutrient feed system with a nutrient feed pump.

viii. All other equipment and accessories necessary to provide a complete and properly operating system.

## 2.2 Biological Odour Control Vessel

**2.2.1** Each Biological Odour Control filter vessel shall operate as a vertical, counter-current flow type, fibreglass-reinforced plastic vessel consisting of media, liquid distributor, and internals.

**2.2.2** For design purposes, the maximum hydrostatic water level in each tower shall be to the bottom of the air inlet.

**2.2.3** The tower shall include all supports required for the tower internals, including media support plate(s). Supports for tower internals shall be of fiberglass construction. These supports shall be furnished and installed by the manufacturer.

**2.2.4** Biological Odour Control vessel shall be:

a. Freestanding tower, including media and top distribution irrigation system.

b. Designed to support the required number of media layers/lifts and treatment stages.

c. Cylindrical shaped with upflow air passage and countercurrent liquid flow.

d. Complete with flanges, nozzles, manways, lifting lugs, anchor lugs, and other appurtenances.

e. Contact moulded manufactured in accordance with BS EN 13121.

f. Designed for either positive and negative pressure service conditions as specified for the specific system. Any system made of PVC or polypropylene will not be acceptable.

**2.2.5** Each Biological Odour Control filter vessel shall be delivered as a single piece of construction without the requirement for field butt joints. Vessels may be delivered in sections. However, segment connections must be gasketed, provided with mechanical connections of Type 316 S31 stainless steel construction and eliminating any leakages.

**2.2.6** Manways shall conform to BS EN 13121. Access flanges for manways shall be air tight to the pressure equal to or higher than the corresponding fan static pressure and shall be water tight.

**2.2.7** Flanged nozzles, bottom drain nozzle, and threaded full couplings shall be provided as required.

**2.2.8** Ultraviolet absorbers shall be added to surfacing resin to improve weather resistance.

**2.2.9** An ultraviolet stabilizer shall be added to the final coat of resin that also incorporates parafinated wax curing elements (gel coat). Dual protection of ultraviolet stabilizer and gel coat shall be sufficient to withstand long-term extreme sun exposure.

**2.2.10** Colour: Use no dyes, pigments, or colorants, except in the exterior gel coat which shall be coloured white.

**2.2.11** FRP Fabrication: All cut edges, bolt holes, secondary bonds shall be sealed with a resin coat prior to the final resin coat. All voids shall be filled with a resin paste.

**2.2.12** Laminate shall consist of an inner surface (corrosion barrier), an interior layer, and an exterior layer.

**2.2.13** Meet requirements of the mechanical properties and visual acceptance criteria in BS EN 13121.

1. Inner Surface:
   a) Reinforce inner surface with a resin-rich, two ply surfacing veil of 1,5 to 2 mm thick.
   b) The resin content of the inner surface shall be a minimum of 80 percent by weight.
2. Interior Layer:
   a) Construct interior layer of resin reinforced with at least two plies of chopped strand mat. Thickness of interior layer shall be at least 1.5 mm.
   b) The inner surface and interior layer shall be continuous throughout the tank interior.
   c) The resin content of the interior layer shall be a minimum of 75 percent by weight.

d) Glass content of combined inner surface and interior layer shall be 27 percent plus or minus 5 percent.

3. Exterior Layer (structural layer) for Filament Wound Vessels

a) The exterior or structural layer shall be filament wound. Filament winding shall be with continuous strand roving to provide a glass content of 50 to 80 percent.

b) Exterior surface shall of the vessel shall contain resin-rich single ply "C" veil or chopped strand mat.

**2.2.14** Media Support:

1. FRP grating, 30 mm by 30 mm or approved equal.
2. Quantity: Sufficient to hold the amount of media plus weight of biomass and hold-up water under maximum operating conditions.
3. Construct of fibre glass with vinyl ester and/or isophtalic resins or approved equal.
4. Supply manufacturer's instructions for placement and removal of the media support in and out of the tower.

**2.2.15** Stairs and Platforms:

1. Provide stairs and top railing to allow access to inspection nozzles and water distribution piping.
2. Stairs and platforms shall be designed and provided to meet all local requirements.
3. Stairs, platforms, and handrailing shall be constructed of galvanized steel/FRP members with FRP grating and handrailing.

**2.2.16** 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

**2.2.17** The Biological Odour Control vessel shall be supplied with integral mounting lugs and pipe supports for the Biological Odour Control liquor piping. Mountings shall be designed with consideration for pipe inlet and outlet connections. Pipe supports shall be non-metallic channels and straps.

**2.2.18** The Biological Odour Control shall be designed to structurally withstand both Operating gas pressure (Positive or Negative ) with design and Operation preferred with negative operating pressure and any other stresses expected during loading, unloading of the media and need to support at least two people standing on the top typically 200 kg plus the media.

## 2.3 Biological Odour Control Media

**2.3.1** The Biological Odour Control media shall:

a) Be synthetic, engineered and structured coiled media, composed of minimum two layers chemically resistant polypropylene and/or polyethylene;

b) Have a minimum available specific surface area greater than 750 m2/m3 and void opening of more than 96%. Pressure drop shall not exceed 1000 Pascal across the Biofilter system in any design and during normal operation;

a. Media shall not shrink or swell with varying moisture content.

b. Sufficient media to provide contact time specified.

**2.3.2** Random media like Lava rock, clay ball, cubes, blocks, pall rings, sea shells or any type of organic media shall not be acceptable.

## 2.4 Fans

**2.4.1** Duty / standby fans shall be provided for each Biological Odour Control system. Each fan >5kW shall have a VSD driven 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, Biological Odour Control media, ductwork and dampers to the fans and exiting out of the stack.

**2.4.2** The fan shall be preferably centrifugal direct-driven type constructed from corrosion resistant stainless steel 316, with vibration free mountings. The fan shall be capable of the performance specifications as shown below:

a) unit capacity : as required.

b) static pressure: 1500 Pa, or as required.

c) operating temperature : 0-55oC.

d) Motor : high efficiency, 415 V, 3 phase, 50 Hz IP 55; power and power allowance as required by process requirements and QCS, sized for maximum allowed rotation of the selected fan model at nominal grid voltage and frequency, rated for zone 2, to BS 5000.

**2.4.3** 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.

**2.4.4** The fan housing, flanges and backward curved impellers shall be constructed of flame retardant GRP laminate or stainless steel 316, capable of resisting continuous fume temperature of 550C. 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/stainless steel 316.

**2.4.5** 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 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 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 ± 3000 Pa. The flexible connector shall be minimum 20 mm long.

## 2.5 Dampers

**2.5.1** Suitable sized dampers shall be provided as follows:

i. Balancing damper between the fan outlet and the Biological Odour Control vessel inlet in case of 2 or more Biological Odour Control vessels operating in parallel.

ii. Isolation dampers at each fan inlet.

iii. Non-return valves at each fan outlet.

**2.5.2** The dampers shall be provided in accordance with the following specifications:

iv. The damper shall be flanged and drilled to withstand 3000 Pa.

v. The blade thickness shall be as required by the damper manufacturer.

vi. The bearings shall be moulded plastic material.

vii. Fibreglass or Ss316 axles shall extend full length of blade and 150 mm beyond frame.

viii. The unit shall be equipped with a full circumference blade seal to limit leakage to less than 1 m3 /m2 min at 3000 Pa.

ix. Isolation dampers when required should be watertight.

## 2.6 Booster Pumps

**2.6.1** In case there is no proper TSW or Potable water supply available, the Biological Odour Control system shall be equipped with a booster pumps set to assure a proper water supply for irrigation at the top of the Biological Odour Control vessels.

a) Provide permanent duty/standby booster pumps for supply of Biological Odour Control filter irrigation liquid.

b) Performance: Each pump shall be sized by the Biological Odour Control filter manufacturer to provide the total required flow rate at the system discharge head conditions necessary to deliver the pressure required.

c) Centrifugal Pumps:

1. Close coupled.
2. Seal less or mechanical seal as follows:
    i. Double mechanical seal constructed with carbon and chemical-grade ceramic faces, Type 316 stainless steel metal parts, and Viton secondary seals;
    ii. Seals shall be flushed with non-potable water; and
    iii. Gland shall be furnished with two taps for in and out connections. A third tap shall be provided aligned with drive collar set screws to facilitate assembly. Seal with Viton gasket O-rings.
3. Magnetically driven or direct driven.
4. Casing: SS316 or better grade.
5. Impeller: SS316, or better grade.

d) Baseplate:

i. Pump and motor shop assembled on a common baseplate.

e) Motor:

ii. Connected load shall not exceed the motor nameplate kW rating at any head/flow given point on the pump curve. The motor rating shall follow QCS requirements regarding spare power/capacity.

iii. Each pump shall be provided with an induction motor designed in accordance with current NEMA, ANSI and/or IEEE standards. Motors shall be constant speed. Each motor shall have a 1.15 service factor.

## 2.7 Water Control Panel

**2.7.1** The Water Control (Combi) Panel shall be constructed of UV resisted FRP or SS316 and be mounted on an FRP/316SS panel stand, back-to-back with the ECP (as applicable or as approved by the Engineer).

**2.7.2** The Water Control Panel shall contain a panel heater, valves, motorized ball valves, strainers, instruments and piping for the control of the Biological Odour Control filter water supply system and shall operate from control signals from the Electrical Control Panel (ECP).

**2.7.3** The Water Control Panel shall allow for a single connection to either a potable water source or suitable final effluent plant water source. Non return valves shall be provided to avoid return flow between potable and TSE water if both are connected.

**2.7.4** The Water Control Panel shall house, if applicable, the nutrient feed system.

**2.7.5** The Water Control Panel shall also contain a flexible spray hose with a hand trigger to allow for convenient rinsing of the strainer, filling of the nutrient barrel, and general convenience. A dedicated ball valve shall be provided in front of the spray hose to allow for the operation of the water panel whiles simultaneously allowing for isolation in case of a leak in the hose.

**2.7.6** All piping inside the water control panel shall be with PVC/HDPE/SS316 welded and flanged sections with flanged terminations outside the panel. No glued or threaded sections shall be permitted.

## 2.8 Nutrient Feed System

**2.8.1** The Biological Odour Control system manufacturer shall provide a nutrient feed system to support biological growth in case the available TSE water does not contain sufficient nutrients for that. The nutrient feed system shall contain all tubing and equipment necessary to store and deliver nutrient to the Biological Odour Control system.

**2.8.2** The nutrient solution shall be nonhazardous and nontoxic and so stated on the MSDS sheets.

**2.8.3** The nutrient feed system shall use TSE water or non-potable water (backup) as carrier water.

**2.8.4** The system shall be produced as a package with all necessary tanks, mixing system (for tanks >200ltr), dosing pump, filters, instrumentation and controls to form a stand-alone system.

## 2.9 Biological Odour Control System Control Panel

**2.9.1** Location and Space.

i. Location: Adjacent to the Biological Odour Control filter units, outside the classified hazardous areas, or inside the MCC control room.

ii. Size control panels to provide adequate space for PLC communications equipment, communications processor equipment and other required components like VSD drives for fan system (if not installed in a separate MCC panel).

**2.9.2** The panel shall be supplied complete with all equipment and accessories, including the following:

a) Booster pump motor starters and indicating lights for the fans, booster pumps, nutrient feed pumps, instrumentation and fan VSD drives (if not installed in a separate MCC panel).

b) Interlocks between booster pumps, fans and automatic spray valves.

c) Selector switches for manual or automatic operation.

d) Annunciators with volt-free contacts for remote signalling, as required in the Project.

e) Specification.

**2.9.3** 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. All electrical Panel shall be as per QCS 2014 Section 21 Part 2.

## 2.10 Instrumentation & Control

**2.10.1** The work of this Section includes complete wiring, termination and testing of electrical and instrumentation components supplied as part of the Biological Odour Control filter system.

**2.10.2** Instrumentation and controls components and work shall meet the requirements of QCS 2014, Section 10, Instrumentation Control and Automation.

**2.10.3** Signal interfaces between each Package Biological Odour Control Filter Control System and the Plant PLC, instrumentation and other equipment shall be possible. Signals and dry contacts of OCU system shall be present for Contractor to connects to Plant SCADA.

**2.10.4** For each Biological Odour Control filter system provide a complete and functional control system which includes, but is not limited to the following major components:

a) Programmable logic controller (PLC), power supplies, I/O modules, and ancillary equipment.

b) Fast Ethernet switch, Ethernet and/or fibre communication hardware.

c) Local control panel (LCP) sized adequately for PLC communications, communications processor and monitor, ethernet switch, VSD drives for fans and pump starters.

d) All the parameters shall be displayed on the Dedicated HMI Panel and connected to SCADA through serial cable.

e) The operational parameters; $H_2S$ inlet / outlet, Inlet Airflow (from the ventilated space), differential pressure & Water Flow shall be logged in the local HMI, data shall be available for display for a minimum for a period of 180 days, with a sampling time of 15 seconds.

**2.10.5** Scale instruments to appropriate engineering units.

**2.10.6** Provide specified instrumentation and any other instrumentation required to meet the design performance requirements for the bio- trickling filter system.

**2.10.7** Provide terminal junction boxes as required to wire equipment of the Biological Odour Control filter system.

**2.10.8** The biological Odour control system shall be designed for unmanned remote operation with allowance for manual operation and provide, as a minimum, the following instrumentation

a) Differential pressure indicator (local and remote) and Transmitter to measure pressure loss across Biological Odour Control tower(s).

b) Airflow meter at inlet to show air flow reading.

c) Water Irrigation Flow indicator for water supply to Biological Odour Control system and pressure indicator 0 to 10bar.

d) Water pressure gauge to measure the pressure in the irrigation line to the spray nozzle.

e) Irrigation water strainer, mesh as per system manufacturer recommendations or at least 10 times less caliber that the nozzles system.

f) Nutrient and Water flow rate measurement for irrigation of the media & transmitters; system should be capable of identify malfunctions or uneven distribution of irrigation flow.

g) pH and electrical conductivity sensor and transmitter.

h) Inlet and Outlet H2S sensors & transmitters for each vessel.

i) Online Chlorine sensors and transmitters for TSE used for Irrigation of Bio media.

j) Level gauge and level sensors for Nutrient dosage tanks.

k) Sight glass to allow visual inspection of vessel.

l) Sampling ports for irrigation water and blow down water.

m) VOC meter at outlet.

n) Additional sensors and monitors based on manufacturer recommendation, like media humidity sensor/s, representative of different areas of the media, or others enhancing the system control and system status overview.

## 2.11 Factory Inspection and Testing

**2.11.1** 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.

**2.11.2** Fiberglass vessels shall be tested as follows:

a) Hydrostatically tested prior to shipment, with water to the air inlet flange of the vessel for a minimum of 4 hours.

**2.11.3** Fans shall be tested as required by BS 848, Parts 1 and 2.

**2.11.4** Al other equipment shall be testes in accordance with the approved manufacture Factory Acceptance Test procedures, pre-approved by the Engineer.

**2.11.5** If the project specific requirements ask for FAT witness by PWA Engineer, particularly for large systems; the supplier shall provide including all costs, for witnessing the FAT for the vessel and fan systems by PWA Engineer. The invitation shall be communicated to PWA one month in advance. The test shall be conducted at the designated location as agreed in the AVL approval procedure.

## 2.12 Spare Parts and Tools

**2.12.1** 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:

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

| Item | Quantity |
|---|---|
| Fan | |
| Complete Centrifugal Fan | (1) |
| Sets of V- belts (if applicable) | (2) |
| Sets of bearing | (2) |
| Shaft seals | (2) (if fitted) |
| Inlet/Outlet flexibles | (1) Set |
| Biological Odour Control Vessel | |
| Spray nozzle | (1) |
| Actuator for spray valve | (1) |
| Dosing pump (if installed) | (1) |
| Strainers | (1) Set |

| | |
|---|---|
| Bio Media | As per manufacturer recommendation |

Booster pump:

| | | |
|---|---|---|
| i) | Impeller | (1) No. |
| ii) | Mechanical seal | (1) set |
| iii) | Bearings | (1) set |

# 3. INSTALLATION AND COMMISSIONING

## 3.1 Installation

**3.1.1** 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.

**3.1.2** The odour control system shall be installed in accordance with manufacturers written instructions, by suitably qualified and experienced personnel.

**3.1.3** Media should be installed by the Manufacturer and certified to meet the specified performance requirements.

The Manufacturer shall provide the Contractor with required clearances, tolerances and limitations, such as smoothness/flatness of concrete pad and shall be available to answer questions prior to and during the installation of the equipment.

Once the installation has been certified by the Manufacturer, the Contractor, with assistance from the Manufacturer, shall start the System to begin the biological acclimation period. This startup period shall take no longer than six (6) weeks but at any point during this startup period, at the discretion and direction of the Manufacturer, the contractor shall switch the system over to normal operation. Any minor re-piping or plumbing required will be clearly detailed in the Manufacturer's installation and startup manual and will be performed by the Contractor.

Any special tools or materials required for this startup/acclimation period shall be provided by the Manufacturer.

After satisfactory start-up and the corresponding switch over to normal operation, the Contractor shall, in the presence of the Engineer, conduct the performance test as detailed in section 4.0 below.

## 3.2 Site Inspection and Testing

**3.2.1** Fans shall be tested as required by BS 848 Part 1 and shall be installed in accordance with BS 848 Part 5.

**3.2.2** H2S System Test: The Contractor shall test as follows:

a) The odour control system to certify that it meets requirements after completion of the Installation.

b) All testing conducted by the Contractor in the presence of the Engineer.

c) The odour control system test shall be conducted after all the air systems are tested and balanced. Separate $H_2S$ tests shall be conducted on each odour control system.

d) The $H_2S$ tests shall be repeated by Contractor 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 flow levels generated by the pumping stations.

e) The hydrogen sulphide test shall comprise as follows:

I. Hydrogen sulphide ($H_2S$) concentrations shall be measured using a calibrated portable $H_2S$ analyser.

II. Each test shall consist of an inlet and outlet $H_2S$ test for a period of 4 hours.

## 3.3 Field Painting & Corrosion Protection

**3.3.1** If painted surfaces are damaged during shipment, off-loading or installation, as long as the damage is surface only and in no way affects the integrity of the equipment or its ability to perform, these blemishes, scratches or other imperfections shall be touched up by the Contractor in accordance with instructions from the Manufacturer. Materials used shall me compatible with the original coating material in quality and color.

# 4. PERFORMANCE TESTING

1 Field performance tests shall be carried out by the Supplier after installation and commissioning of the plant. The Supplier shall undertake performance and systems tests to demonstrate acceptable performance as defined by:

- Successful operation of each item of equipment.
- Overall system operation meets the performance criteria described in this specification, including correct operation in all control modes, e.g. in manual, local, and auto control.
- Inlet gas contaminant removal performance meets the criteria provided in this specification. The Purchaser will give notice in writing of final acceptance to the Supplier following the successful completion of the performance testing.

2 Performance testing shall commence after the manufacturer and Ashghal and/or Engineer have agreed that the system has been satisfactorily started-up and sufficient time has been allowed for the generation of the required bacterial growth.

3 The Purchaser has inspected the plant after commissioning and is satisfied with the installation and its function.

4 All documentation associated with commissioning have been received and approved by the Purchaser.

5 All test equipment used during tests shall have a current calibration certificate (issued within the preceding 12 months) verifying its accuracy.

6 The contractor is to supply all test materials, temporary test equipment, consumables and experienced personnel required to demonstrate compliance with the specification.

7 After the odour control system has been satisfactorily started-up and switched to normal operation, the Contractor shall, in the presence of the Engineer, demonstrate that the system will perform as specified in section 1.1.3 0f this specification, or as per Particular Specification if available.

8 The Contractor shall provide Ashghal or the Engineer with a written test protocol and the performance test may not be conducted until the test protocol has been reviewed and approved by the Engineer. The manufacturer shall be present during the performance test and, at its own discretion, may conduct a parallel performance test as long as they do not interfere with the performance test being conducted by the Contractor.

9 The Contractor shall supply, install and operate all equipment, sensors and instrumentation required to complete the performance test.

## 4.1 $H_2S$ Testing procedure

**4.1.1** Measure airflow into each unit and, if necessary, adjust to the design airflow of +/- 10%. Airflow balancing can be conducted by manufacturer and witnessed by Ashghal or the Engineer. Airflow shall be measured

at the beginning of the test period. The set position on the damper(s) and/or blower VFD(s) will be marked or noted.

a) Measure the pressure drop across each Biological Odour Control filter at beginning of test period.

b) Measure temperature and relative humidity of the inlet, outlet and ambient air.

**4.1.2** Performance test period to begin at a noted time and last for four (4) hours. H2S data from the common inlet location and from the outlet of each odour control system will be measured and logged, at least, once every 10 minutes to demonstrate performance during test period.

a) The inlet H2S data will be logged with a pre-calibrated and approved gas data logger with appropriate range and accuracy for the inlet air stream (0-1000 ppmv & 0.1 ppmv display resolution) as appropriate to match with the system requirement.

b) The outlet H2S data will be logged with a pre-calibrated and approved gas data logger with appropriate range and accuracy for the outlet air stream. (0.0-50.00 ppbv range, 0.1 ppb resolution) as appropriate to match with the system requirement.

## 4.2 $H_2S$ Acceptance criteria:

**4.2.1** The system shall have passed the H2S performance test if the H2S removal efficiency for all the inlet air design H2S concentrations and outlet performance as detailed in section 1.1.3 of this specification.

**4.2.2** 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.

**4.2.3** Final acceptance of the system will only be possible after successful completion of this testing.

**4.2.4** Documentation for all the testing shall be submitted to the Engineer.

## 4.3 $NH_3$ Acceptance criteria:

**4.3.1** The System's NH3 removal efficiency shall be determined by calculating the average inlet NH3 concentration and the average outlet NH3 concentration and using the following formula: NH3 removal efficiency (%) = (1 – (average outlet NH3 concentration/average inlet NH3 concentration)) x 100. The system shall have passed the NH3 performance test if the NH3 removal efficiency is 99.50% or ≤ 0.5ppmv, whichever is greater.

## 4.4 Odour Acceptance Criteria

**4.4.1** The system shall have passed the Odour performance test if the Odour removal efficiency for all the inlet air design H2S concentrations and outlet performance as detailed in section 1.1.3 of this specification.

___End of section_____