

ACP0004

ODOUR CONTROL UNIT

STANDARD SPECIFICATION

NOTES:

- 1. This Specification is to be used by Designers for all Odour Control Unit projects.**
- 2. The content of this Specification must not be changed or altered.**
- 3. This Specification is not intended to be a stand-alone document. Project specific documents and additional technical clauses must be included with contract documentation.**

TABLE OF CONTENTS

1	GENERAL	6
1.1	Scope	6
1.2	Objective	6
1.3	Purpose.....	6
1.4	Supplier Experience and Quality Assurance.....	6
1.5	New Designs and Innovations.....	7
1.6	Style of this Specification	7
1.7	Responsibilities.....	7
1.7.1	Contractor	7
1.7.2	Principal	8
1.8	Acronyms, Abbreviations and Definitions.....	8
1.9	Reference Documents.....	9
2	DESIGN	13
2.1	Performance Requirements.....	13
2.2	Design Criteria and Concept Design.....	13
2.2.1	General	13
2.2.2	Minimum Requirements	14
2.2.3	Selection of Odour Control Unit Type	15
2.3	General Detailed Design Requirements.....	15
2.3.1	General	15
2.3.2	Quality.....	15
2.3.3	Documentation.....	16
2.3.4	OCU Structure	16
2.3.5	Fibreglass	17
2.3.6	Parts	17
2.3.7	Adhesive, Sealants, and Gaskets.....	17
2.3.8	Inlet Isolation valve.....	18
2.3.9	Intrinsically Safe.....	18
2.3.10	Ductwork.....	18
2.3.11	Vent stack	18
2.3.12	Fans.....	19
2.3.13	Integrity of System	19
2.3.14	Valves & Dampers	20
2.3.15	Air Curtains	20
2.4	Mechanical Works.....	20

2.5	Electrical	20
2.6	Telemetry	21
2.6.1	Networks	21
2.6.2	Wastewater Treatment Plants	21
2.7	Instrumentation & Control	21
2.7.1	Networks	21
2.7.2	Wastewater Treatment Plants/Water Recycling Plants	22
2.8	Access and Auxiliary Services	23
2.9	Civil Related	24
2.9.1	Foundation	24
2.9.2	Drainage	24
2.9.3	Fencing	24
2.10	Facility and Equipment Identification and Labelling	24
2.11	Critical Spares	25
2.12	Operating and Maintenance Manual	25
3	TECHNICAL SPECIFICATIONS – ACTIVATED CARBON TYPE OCU	27
3.1	General	27
3.2	Pre-filter(s)	27
3.3	In-Line Heater/Demister	28
3.4	Adsorber Unit	28
3.5	Monitoring	29
3.6	Control system	29
3.7	Adsorptive Media	30
4	TECHNICAL SPECIFICATIONS – BIOTRICKLING FILTER WITH CARBON POLISHING TYPE OCU	33
4.1	Pre-filter	33
4.2	Biotrickling Filter Unit	33
4.3	Adsorber Unit	34
4.4	Monitoring	35
4.5	Control system	35
4.6	Liquor Recirculation System	36
4.7	Nutrient Dosing System (if required)	36
5	TECHNICAL SPECIFICATIONS – BIOTRICKLING FILTER TYPE OCU	37
5.1	Pre-filter	37
5.2	Biotrickling Filter Unit	37
5.3	Monitoring	38
5.4	Control system	38
5.5	Liquor Recirculation System	39

5.6	Nutrient Dosing System (if required)	39
6	TECHNICAL SPECIFICATIONS – CHEMICAL SCRUBBER TYPE	41
6.1	Chemical Scrubber Unit	41
6.2	Monitoring	42
6.3	Control system	42
6.4	Liquor Recirculation System	43
6.5	Chemical Dosing System	43
7	TECHNICAL SPECIFICATION – MONITORING SYSTEM	44
7.1	Standards & Recognised Practices	44
7.2	On-Line Monitoring System	44
7.2.1	H ₂ S monitors	45
7.2.2	Sampling lines and ports	45
7.2.3	Condensate Trap	45
7.2.4	Sampling Pump	45
7.2.5	Flow Control Valves	45
7.2.6	Flow Meter	46
7.2.7	Manual Sampling Ports	46
7.2.8	Return of Foul Air	46
7.2.9	Analysers	46
7.2.10	Pipework, Tubing and Ancillary Fittings	47
7.2.11	Monitoring cubicle	48
7.3	Calibration	48
8	INSTALLATION	50
8.1	Approval	50
8.2	Installation Practice	50
8.3	Materials and Equipment Inspection	50
9	COMMISSIONING	51
9.1	Pre-Commissioning (Factory Acceptance Test)	51
9.2	Site Commissioning	51
9.3	Performance Testing	52
9.4	Records	54
9.5	Handover	55
10	DOCUMENT CONTROL	56
11	CHANGE HISTORY	57
	Appendix A – ACTIVATED CARBON P&ID	58
	Appendix B – BIOTRICKLING FILTER P&ID	59
	Appendix C – CHEMICAL SCRUBBER P&ID	60

Appendix D – MONITORING SYSTEM P&ID61
Appendix E – TREATED AIR TO STACK P&ID62
Appendix F – BIOTRICKLING FILTER GENERAL ARRANGEMENT63

1 GENERAL

1.1 Scope

This document specifies the design and installation requirements for Odour Control Units (OCUs) in Sydney Water's sewerage network and wastewater treatment plants.

1.2 Objective

The objective of this Standard Specification is to provide designers, manufacturers, and installers of an OCU with Sydney Water's requirements for its design, construction, installation and performance testing.

1.3 Purpose

In the procurement of an OCU, it is intended that this document would be appended to a procurement Contract document for a specific site where it would provide the general requirements for an OCU. Any additions, variations, or one-off requirements for that specific site would be included in the Contract document itself. Unless specifically required otherwise in the Contract document, this Standard Specification shall be complied with.

The contract document shall provide for three hold points in the procurement process as follows:

- Sydney Water shall be provided with design criteria and concept design. The Contractor shall resolve with Sydney Water any issues of concern that Sydney Water may have as a result of its review of this information prior to proceeding with detailed design work.
- Sydney Water shall be provided with the detailed design including details of any deviations from this Standard Specification. The Contractor shall resolve with Sydney Water any issues of concern Sydney Water may have as a result of its review of the detailed design prior to proceeding with ordering and manufacturing of the unit.
- In accordance with Sydney Water's Maintenance Related Clauses for Capital and Operational Projects MEFA0001, Sydney Water shall be provided with all Work as Constructed (WAC) documents, such as detailed drawings, Installation, Commissioning and Start-up instructions including installation and quality checklist, troubleshooting guidelines and Operation and Maintenance (O&M) Manuals.

1.4 Supplier Experience and Quality Assurance

The Supplier shall have at least 5 years' experience in the design, fabrication, and supply of odour control systems similar to the type specified for this project.

The Supplier shall have in place a dedicated quality system that conforms to ISO-9000/ ISO-9001. The Supplier's Quality Assurance systems shall demonstrate traceability of materials back to the original equipment and material provider. Work procedures shall be provided by the Supplier which comply with the original equipment provider's equipment warranty conditions.

The Supplier shall provide a list of three (3) air treatment installations associated with the removal of hydrogen sulphide and other typical organic municipal wastewater odours for which they have been responsible. The list shall include contact names, telephone numbers, system capacity (flow rates in m³/hr, removal efficiency of system in terms of odour and H₂S (ppm_v in/out, % removal), and length of operation for each installation. Installations shall be of comparable size to the type specified for this project.

The Supplier shall have a local representation and the Supplier's place of business shall be open for inspection by the Purchaser upon request.

1.5 New Designs and Innovations

This document specifies the minimum requirements for the Works. The Contractor may wish to produce their own alternative design that will comply with these minimum requirements.

Any alternative materials, designs, methods of assembly, and processes that do not comply with specific requirements of this Specification, or are not mentioned in it, but give equivalent or improved performance outcomes to those specified, are not necessarily prohibited.

Written approval from Sydney Water must be obtained for any deviation from this Specification prior to ordering and manufacture of equipment affected by such deviation.

1.6 Style of this Specification

This document is written in the directive style. Where an obligation is given and it is not stated who is to undertake these obligations, they are to be undertaken by the Contractor.

Where a submission, request, proposal is required and it is not stated who the recipient shall be, it is to be provided to Sydney Water representative for approval.

1.7 Responsibilities

Responsibilities relating to the contractual terms and conditions, including financial matters, and site issues are covered in the Head Contract documents. Specific responsibilities are noted in this document, but they do not necessarily describe all the activities required for the Works.

1.7.1 Contractor

The Contractor shall be fully responsible for the detailed design, and construction to fully comply with the requirements in this document and provide a complete functional OCU, which meets all the necessary Standards, Codes of Practice, Industry Standards, and all statutory and regulatory requirements. Where necessary, relevant Dangerous Goods Regulations shall be complied with. The complete systems shall include all pipework, fittings, fans, filters, instruments, and controls, from the point of foul air extraction to the point of treated air exhaust unless otherwise specified by Sydney Water.

In addition, the Contractor shall provide the following, but not limited to:

- Additional equipment as may be necessary for the operation and maintenance of the particular odour treatment system being provided, or as recommended by Sydney Water, the supplier and regulatory bodies.
- Stairs, ladders and walkways, where appropriate, to allow ease of access for changing of media, access sampling points and monitoring equipment, and all storage tanks and equipment. All such stairs, ladders and walkways shall be constructed of appropriate corrosion resistant materials.
- Safety facilities such as safety shower, eyewash station, fire extinguishers, and so on.

- Tags, labels, signs, and other markings, for all these systems which clearly indicate the individual system, chemical contents, hazards, warnings, asset numbers and any other pertinent information in accordance with the requirements of the relevant Standards, Codes of Practice and statutory authorities, and Sydney Water's Maintenance Management System (MAXIMO).
- O&M Manuals, Unit Process Guidelines (UPGs), Standard Operating Procedures (SOPs), WAC drawings, copies of Programmable Logic Controller (PLC) software programs and any other documents necessary for the optimal operation and maintenance of the OCU.
- Any additional items/equipment requested by Sydney Water.

1.7.2 Principal

The Principal (Sydney Water), through its appointed representative/consultant, shall be responsible to provide input from the various internal stakeholders for the development of both the concept and detailed design required by this Specification. They shall include, but not be limited to:

- This document;
- The concept purpose of the OCU (for example, ventilate sewer pumping station wet well, ventilate one of two sewers feeding the draw off point);
- Location of the OCU;
- OCU expected equipment life term at the location (fixed or temporary);
- Current and estimated future operational parameters, such as catchment population and development staging, sewage characteristics, flow levels, and gas level monitoring data as defined in the needs specification.

1.8 Acronyms, Abbreviations and Definitions

ASTM	American Society for Testing and Materials
CASANZ	Clean Air Society of Australia & New Zealand
dBA	Decibels, the unit of measurement for loudness, weighted for the human ear frequency range
EBRT	Empty Bed Residence Time (seconds) of the gas
H ₂ S	Hydrogen Sulphide
HSS	Hydraulic System Services
GPO	General Purpose Outlet, a connection point to access 240 V AC power
Gravity sewer system	Sewer system laid on a grade that allows flow due to gravity alone
IICATS	Integrated Instrumentation, Control, Automation, and Telemetry Systems
LEL	Lower Explosive Limit, the lowest concentration (percentage) of a gas or a vapour in air capable of producing a flash of fire in presence of an ignition source (arc, flame, heat). LEL concentrations vary greatly between combustible gases. At 20 degrees Celsius the LEL of methane is 5.1 % by volume.
MAXIMO	Sydney Water's Maintenance Management System
MSDS	Material Safety Data Sheet
Pressure sewer system	Sewer system that uses pumping units to generate flow

O&M	Operation and Maintenance
OCU	Odour Control Unit
OU	Odour Units (measurement) as defined in AS/NZS 4323.3
P&ID	Process and Instrumentation Diagrams
PLC	Programmable Logic Controller
ppm _v	Air pollutant concentration, in parts per million by volume
RCD	Residual Current Detector, (safety switch)
RPZ	Reduced Pressure Zone, a backflow prevention device for the protection of drinking water supply
RTU	Remote Terminal Unit
SAP	Standard Administration Procedure
SCADA	Supervisory Control And Data Acquisition, control system design standards for SWC designers, consultants and contractors to use in order to ensure the uniformity and consistency of control system projects in SWC facilities.
SOP	Standard Operating Procedure, a set of step-by-step instructions to help workers carry out complex routine operations
SPS	Sewage Pumping Station
SWC	Sydney Water Corporation
UPG	Unit Process Guideline, a document that describes in detail the operation and maintenance philosophy of the unit.
VSD	Variable Speed Drive, a device for controlling the speed of an electric motor by changing the alternating current frequency
WAC	Work As Constructed
WSAA	Water Services Association of Australia
Wet well	A section of pressure sewer system where sewer is collected prior to being pumped
WRP	Water Recycling Plant
WWTP	Wastewater Treatment Plant

1.9 Reference Documents

The following documents are referred to in this Specification.

American Society for Testing and Materials

ASTM	American Society for Testing and Materials
ASTM D2854	Standard Test Method for Apparent Density of Activated Carbon
ASTM D2862	Standard Test Method for Particle Size Distribution of Granular Activated Carbon
ASTM D3802	Standard Test Method for Ball-Pan Hardness of Activated Carbon

ASTM D6646 Standard Test Method for Determination of Accelerated Hydrogen Sulfide Breakthrough Capacity of Granular and Pelletized Activated Carbon

Australian Standards

AS Australian Standard

AS 1324.2 Air filters for use in general ventilation and air conditioning - Methods of test

AS 1939 Degrees of protection provided by enclosures for electrical equipment (IP Code)

AS 3580.2.1 "Preparation of Reference Test Atmospheres – Permeation Tube Method"

AS 1345 Identification of the contents of pipes, conduits and ducts

AS 4254 Ductwork for air handling systems in buildings

AS 1657 Fixed Platforms, Walkways, Stairways and Ladders – Design, Construction and Installation.

Australian and New Zealand Standards

AS/NZS Australian Standard/New Zealand Standard

AS/NZS 4323.3 Stationary source emissions - Determination of odour concentration by dynamic olfactometry

AS/NZS 3580.2.2 Methods of sampling ambient air - Compressed Gas Method

AS/NZS ISO 9001 Quality Management Systems

AS/NZS 60079 Classification of hazardous areas

European Standards

EN European Standard

EN 13121 GRP Tanks And Vessels For Use Above Ground

WSA 121 Industry Standard for Biofilters for Odour Control

WSA 201 - 2017 Manual for Selection and Application of Protective Coatings

ISO 6141	<u>Gas Analysis – Contents of Certificates for Calibration Gas Mixtures</u>
ISO 6142	<u>Gas Analysis – Preparation of Calibration Gas Mixtures – Part 1</u>
ISO 6143	<u>Gas Analysis – Comparison Methods for Determining and Checking the Composition of Calibration Gas Mixtures</u>

“Air Pollution Measurement Manual” – A Practical Guide to Sampling & Analysis, Volumes 1 & 2, Clean Air Society of Australia and New Zealand (CASANZ)

“Handbook of Air Pollution Analysis”, edit. Roy M. Harrison & Roger Perry. Chapman & Hall, printer/publisher: University Press, Cambridge 1986 ISBN 0412 244101

IEEE Standard 1349 – Guide for application of electric motors, Class 1 Division 2: Hazardous (Classified) locations

Sydney Water Standards

P&ID Drawing for Activated Carbon Unit (SEW1700-S1701)

P&ID Drawing for Chemical Scrubber Unit (SEW1700-S1702)

P&ID Drawing for Biotrickling Filter Unit (SEW1700-S1703)

P&ID Drawing for Monitoring System (SEW1700-S1705)

P&ID Drawing for Treated Air to Stack (SEW1700-S1706)

P&ID Drawing for Biotrickling Filter Unit General Arrangement (SEW1700-S1708)

Deemed To Comply Drawing for Facility Fencing DTC-5000 and 5001

Sydney Water’s Safety in Design Procedure D0000653

Sydney Water’s Asset Commissioning Standard Administration Procedure IMS0035

Sydney Water’s Asset Creation Operational Readiness Standard D0000256

Sydney Water’s Maintenance Related Clauses for Capital and Operational Projects MEFA0001

Sydney Water’s Instrumentation and Control Standards TOG_TS01

Sydney Water’s IICATS Sewer Odour and Corrosion Control Standards TOG_TS08

Sydney Water’s Treatment Plant SCADA Standards

Sydney Water’s Supplement to WSA 201.

Sydney Water’s Technical Specification Part 1 – Civil Works

Sydney Water’s Technical Specification Part 2 – Mechanical Works

Sydney Water’s Technical Specification Part 3 – Electrical Works

Sewerage Code of Australia (Sydney Water Edition) WSA 02-2002-2.2

TG0502 – Classification and Management of Flammable Gas Hazardous Areas
Sydney Water Specification for FRP platforms, walkways, stairs and ladders.
Sydney Water Specification for FRP Chemical Tanks.

2 DESIGN

2.1 Performance Requirements

The OCU shall be designed to:

- Be safe to construct, operate, maintain and decommission in accordance with the Safety in Design Procedure D0000653.
- Provide reliable and effective odour removal to a level specified in the minimum requirements outlined in Section 2.2.2 of this Specification;
- Have a minimum of 20 years' service life, i.e. no major maintenance or renewal required. This does not apply to consumable components such as filter media;
- Comply with all relevant statutory and regulatory requirements, Standards and Codes of Practice including noise;
- Not cause interruption to the normal operation of the Sydney Water sewer system;
- Be capable of automatic operation via connection to Sydney Water's Integrated Instrumentation, Control, Automation, and Telemetry Systems (IICATS) for networks and Supervisory Control and Data Acquisition (SCADA) for treatment plants.

2.2 Design Criteria and Concept Design

2.2.1 General

The designer shall undertake investigations, which may include desktop study, field testing and modelling to determine the specific requirements for the OCU.

Layout details of the sewer system, where the OCU is to be provided, and its surrounds shall be collected and documented. They shall be used for the selection of the optimal locations of extraction and discharge points. All features that may affect the operation and maintenance of the OCU shall be documented and considered in the design

Data for the design of an OCU shall be collected and clearly documented including all calculations and assumptions. It shall be submitted to the Principal's representative for written approval prior to commencement of detail design work.

Due consideration shall be given to changes in network chemical dosing due to unforeseen operational problems and changes in odour loads related to future population projections for the operational life of the OCU.

No OCU shall be placed in a "confined space" such as a below ground pit without written approval from the Principal.

The submitted information shall include, but not be limited to:

- Concept design showing the management of air inflows and extraction point to maximise removal of foul air and minimise the potential of gas escape leading to odour and/or corrosion problems. This means the air inlet shall be of one-way type made of corrosion resistant material (galvanised steel will not be sufficient in this case) located at the furthest point of the space to be ventilated and admitted as close to top water level as possible, with the extraction point as close as possible to location with highest foul air concentration (e.g. riser main discharges or weirs).

- Current, peak and future quantity of foul gas required to be treated.
- Physical properties of gas such as pressure, temperature, and humidity.
- Current and future level of odorous gas component(s) and fluctuation during different time/season.
- Location of treated gas discharge.
- Assessment of corrosive substances in the gas and surrounding, which may affect the unit.
- Proposed type of OCU including P&ID and recommended spare parts list.
- General site layout concept to allow adequate space around the OCU (including roadway access) for its operation and maintenance, such as the changing of media, and removal of equipment.
- Electrical circuits and control panel layout and submit these drawings to the Principal's representative for review prior to manufacture.

2.2.2 Minimum Requirements

Unless otherwise specified, the minimum requirements of the OCU are specified below.

OCU Minimum Requirements

ITEM	REQUIREMENTS
Outlet concentration as measured at the exit of the OCU or vent stack (if installed).	Hydrogen Sulphide (H ₂ S) ≤ 0.05 ppm _v Mercaptans (Thiols) ≤ 0.02 ppm _v Odour concentration ≤ 500 Odour Units (OU) Or otherwise, at a level that is demonstrated to achieve <u>no</u> odour nuisance at the nearest residence or public space.
Flow rate	Minimum of 6 x airspace/headspace volume per hour for network and minimum of 12 x airspace/headspace for WWTP/WRP. Refer to notes below for examples * or as specified by Sydney Water
Fan(s)	Duty/standby. Centrifugal type with forward or backward curved impellers fitted with a flameproof motor Class 1 Division 2 **
Noise level	Not exceeding 35 dBA measured 1 metre from the OCU, or 5dBA above the surrounding environment noise level measured at the boundary fence whichever is the lower
Discharge vent stack	The discharge vent stack height shall generally comply with the Sewerage Code of Australia for vent stacks (14m above ground level) unless otherwise agreed by the Principal. Typically, the vent stack shall be designed to maximise the air velocity (>15m/s) out of the top of the stack to obtain maximum dilution with the surrounding air.
Removal Rate	Hydrogen sulphide >99%

ITEM	REQUIREMENTS
	Where outlet H ₂ S is below requirements listed above, removal rate is not applicable.

Notes

- * Volume examples:
 - Sewage Pumping Station (SPS) wet well: if the volume of a SPS wet well at the lowest operating level is 10 m³, then the required *minimum* flow rate is 60 m³/hour.
 - Sewer pipeline: if a pipeline has a cross sectional headspace at the low dry weather flow level of 1 m², and a sewer flow velocity of 1m/s (to which the gas velocity must be matched), then the *minimum* required flow rate is:
 (headspace cross sectional area at low peak dry weather flow level) × (gas velocity down sewer)

$$= (1\text{m}^2) \times (1\frac{\text{m}}{\text{s}}) \times (3600\frac{\text{s}}{\text{h}})$$

$$= 3600\frac{\text{m}^3}{\text{h}}$$
- ** In accordance with IEEE Standard 1349

2.2.3 Selection of Odour Control Unit Type

Different types of OCU have different performance characteristics. These shall be considered thoroughly when selecting the type of OCU that will perform best given the type, volume, concentration and variability of the foul air odorous components. Attention shall also be given to operability, installation and maintenance requirements of the unit, particularly in terms of cost, availability of electricity, availability of critical spare parts, media or chemical replacements, requirements for any confined spaces entry, and ease of access.

In particular, soil bed odour systems will not be considered. Chemical Scrubbers shall only be used in treatment plants, and not the networks. This is due to the hazardous nature of the chemicals used.

2.3 General Detailed Design Requirements

2.3.1 General

All materials specified in the design shall be suitable for installation in the proposed environment and be corrosion resistant for at least 20 years' service life. This does not apply to consumable components such as filter media.

To allow easy installation and removal of equipment by lifting devices, suitably designed lifting lugs shall be fitted where necessary. Where the OCU is specified as temporary or moveable, lifting lugs shall be provided on the Unit.

2.3.2 Quality

The OCU system and its components shall be manufactured under a quality management system certified to AS/NZS ISO 9001 – Quality Management Systems.

The contractor shall supply a third-party certification of the manufacturer's quality system stating the scope of certification and the period of validity. All materials and products must have been supplied or manufactured within the period of validity of the certificate.

2.3.3 Documentation

The following information shall as a minimum be submitted with the proposal. The accuracy and completeness of the submission of all the requested data will form part of the tender evaluation. All information shall be submitted in both hard copy originals and as an electronic copy.

- Details of any non-conformances relating to this technical specification.
- Manufacturer's catalogue information including equipment type, model number/designation, operating characteristics and relevant technical product brochures.
- Basic description of proposed OCU system, including process flow description.
- Details of expected odour removal performance and statement of performance guarantees offered.
- The Tenderer's Scope of Supply, including limits of contract and any assumptions made by the Tenderer.
- List of main equipment items, motor list, and instrument list.
- Details of media offered, including media life guarantee.
- Details of instruments proposed.
- Civil/Structural requirements (to be provided by others), e.g. preliminary footprint dimensions, dead weight, operating weight, and dynamic loading criteria.
- Drawings with the proposed layout complete with key dimensions, showing ductwork, access road and access platforms
- P&ID drawings.
- Media, chemical and utility consumption based on design average and maximum conditions.
- Reference lists and relevant case studies demonstrating Supplier's previous experience.
- List of any special tools and lifting devices.

2.3.4 OCU Structure

The odour unit structure/vessel material and finish shall be durable, resistant to corrosion and UV degradation in the proposed environment to achieve the nominated service life. The structure may be constructed from the following:

1. Glass-reinforced plastic (fibreglass); or
2. Stainless steel grade 316; or
3. Any other material, being equivalent to item 1 or 2 in strength and durability.

The OCU structure shall be suitably reinforced and supported to withstand all forces including wind loads, operating pressures (positive or negative), loading and unloading of media, and any other anticipated forces. The magnitude of the imposed actions are to be determined using AS/NZS 1170 using building type with Importance Level 1.

2.3.5 Fibreglass

All fibreglass vessels and components shall be constructed to BS EN13121:2016 and shall consist of an internal corrosion barrier, a structural layer and an outer surface layer, as specified under relevant sections of BS EN13121:2016.

The corrosion barrier shall be constructed from corrosion resistant vinyl ester resin, suitable for the application, and shall comprise a minimum backing layer of 1200gsm of CSM subject to any additional requirement recommended by the resin supplier. All BS4994 QA requirements relating to the liner and its construction shall apply.

The resin and fillers selected for fabrication shall be suitable for the chemical used. The resin used shall have the minimum performance criteria as specified under relevant sections of BS EN13121:2016 including structural requirements, i.e. ductility and strength.

All designs shall include an independent third-party design review. The fabricator shall ensure that the FRP vessel is built to the correct requirements in accordance with BSEN13121 including all QA/QC testing and records. In addition, an independent third-party inspector shall be appointed to assess the conformity of the fabrication, testing and QA/QC requirements as required by the specification. The inspector shall be sufficiently competent to conduct the inspection to the nominated specifications and shall be approved by SW. The frequency of inspections shall be agreed with SW and shall comprise a minimum of one inspection.

The materials used for the construction of the OCU and ductwork shall be nominated for approval prior to ordering the materials. Vinyl Ester resin shall be used in both the corrosion barrier, structure and outer surface layer to ensure enhance the corrosion protection throughout the vessel construction.

Any flat fibreglass bearing surfaces shall be protected from point loads by use of suitable compressible insertion material.

The design will allow for the periodic inspection and maintenance of the fibreglass structures in accordance with manufacturer's recommendations to ensure delivery of the required asset life.

Any fibreglass walkways, stairs and ladders shall be designed and installed as per the *Sydney Water Specification for FRP platforms, walkways, stairs and ladders*.

Any FRP Chemical Storage Tanks shall be designed and constructed as per the *Sydney Water Specification for FRP Chemical Tanks*.

2.3.6 Parts

All internal parts that may be in contact with the odorous gas shall be acid resistant, particularly sulphuric acid, and any other chemical used by the OCU.

All bolts, nuts, and washers shall be made from stainless steel grade 316. Potential for galvanic corrosion shall be minimised.

2.3.7 Adhesive, Sealants, and Gaskets

All adhesive, sealants and gaskets shall be resistant to oil, water, and acid (mainly sulphuric acid). They shall be non-supportive of microbial growth and dimensionally stable.

Where applicable, they shall also be resistant to any chemicals used by the OCU.

2.3.8 Inlet Isolation valve

An easily operated positive shut off isolation valve shall be provided on the extraction ductwork to the OCU. This valve is to provide a gas tight isolation of the OCU from the inlet sewer gases for the purpose of carrying out maintenance activities. Lightweight dampers are not acceptable for this duty.

All valve spindles, bearings and ancillary components shall be stainless steel grade 316, and suitable for operation in an atmosphere where saturated air and H₂S gases are present. Any components where galvanizing is used or where copper or brass components are used will not be accepted.

2.3.9 Intrinsically Safe

At some locations, analysis of the sewer gases and upstream users may indicate a risk of high hydrocarbon levels. In this situation, the Contractor shall install a suitable monitoring system and design the unit to prevent ignition of the hydrocarbons when detected. This may take the form of automatic shutdown of the OCU, with an alarm to IICATS (Network) or WWTP/WRP SCADA (Wastewater Treatment Plant), or use of appropriate equipment to prevent potential fire / explosion. The Contractor shall carry out and document a risk assessment in conjunction with relevant Sydney Water personnel to assess the need for a flame arrestor or other such measures, and if required, where it should be located, and to identify any other control measures which may be needed (for example, methane meter, alarms, operational interlocks and so on).

Where it is deemed necessary, a flame arrestor shall be designed and installed so that any liquid condensation shall drain away and not pool.

2.3.10 Ductwork

All ductwork shall be fabricated in fibreglass or stainless-steel grade 316 to the relevant Australian Standards (AS 4254-2012), unless otherwise specified in relevant sections of this Specification.

The design of the ductwork shall prevent the pooling of any liquid. The duct must either rise steadily to the unit or have one high point only, such that any condensate water will flow into the unit or back to the air source (e.g. sewer).

Where necessary the ductwork shall be lagged to ensure sound pressure level at the boundary of the site does not exceed 35 dBA under free field conditions or 5dBA above ambient levels whichever is less. This requires the air velocity typically not higher than 8 m/s.

2.3.11 Vent stack

A vent stack shall be provided to exhaust the treated air vertically from the odour treatment processes unless otherwise specified by the Principal. The vent stack height shall generally comply with the Sewerage Code of Australia for vent stacks (14m above ground level) unless otherwise agreed by the Principal. Typically, the vent stack shall be designed to maximise the air velocity out of the top of the stack to obtain maximum dilution with the surrounding air. The vent stack shall have a minimum exhaust velocity of 15 m/sec which may be obtained using a velocity cone.

It shall be formed from spiral welded stainless steel or fibreglass tubing, and shall be self-supporting (including stainless steel guy wires where necessary).

Detailed design for the vent stack shall be provided to the Principal for written approval, along with calculations, prior to the fabrication of the stack.

2.3.12 Fans

The fan(s) with variable speed drive (VSD) shall provide exhaust ventilation of the odorous source. For network sites, a single fan arrangement with isolation valve for replacement is recommended. For larger critical sites like treatment plants duty/standby with automatic change-over is required. For all systems it is preferred that the fan(s) be installed after the contactor and draw air through the contactor under vacuum in order to remove the risk of gas leaks under pressure. For biotrickling filters combined with activated carbon polishing, it is preferred that the fans be installed after the biotrickling filter and before the activated carbon filter so that the inlet air into the activated carbon is not saturated with water.

The fan(s) shall be selected to provide the designated airflow under the system head pressure. The fan shall be centrifugal with forward or backward curved impellers, and shall be suitable for the required design. Fan performance curves shall be provided with the design documents.

The fan shall be constructed from materials suitable for the environment in which it will operate. Materials of construction and clearances between impeller and fan scroll shall be provided to ensure that at all times; no spark potential is possible within the fan. The fan shall be fitted with a 4-pole flameproof motor to satisfy the requirements of the relevant classification specified by AS/NZS 60079, and shall be sized to be non-overloading over the range of operation.

Where required, the fan shall be lagged and fitted with discharge and inlet silencers. This is to ensure that the sound pressure level at the boundary of the unit does not exceed 35 dBA under free field conditions, or 5dB above ambient levels, whichever is less.

Airflow monitors (one flow switch per fan outlet) shall be provided to indicate whether a fan is running when called to operate. Failure of air flow shall be used to lock out operation of the fan and any duct heater (and any other equipment of concern). The airflow monitor shall be installed on the downstream side of any fan isolation damper valve.

The Contractor shall provide a price for supply and lead time of an additional fan to be held as a critical spare. The Principal reserves the right to choose whether to take up this option or not.

2.3.13 Integrity of System

The complete ductwork system, through the main duct, adsorber inlet and outlet ducts, any bypass duct and stacks, shall be completely gas tight and soap bubble tested at the operating pressure of the OCU. All ductwork and associated ventilation equipment shall be fabricated and installed to the Standards specified in this document.

Any joints, ducts, bends and so on, that do not meet this requirement shall be remade or replaced at no cost to the Principal.

2.3.14 Valves & Dampers

Dampers shall be provided to perform the functions of diverting or modulating the airstream to the OCU as required and as directed by the monitoring and control system. Dampers that are intended for air diversion only shall operate either in the fully open or fully closed position. Dampers used to modulate airflow and for balancing purposes shall be fabricated and installed in accordance with the specified Standards in this document, and to materials standards as specified in these Clauses.

The dampers shall be stainless steel or aluminium multiple curved blade gang operated, single thickness, factory assembled units. Each unit shall be supplied for heavy-duty operation for field assembly and shall operate through 90 degrees of operation, from fully open to fully closed.

All damper spindles, bearings and ancillary components shall be stainless steel, and suitable for operation in an atmosphere where saturated air and H₂S gases are present. Any components where galvanizing is used or where copper or brass components are used shall not be accepted.

All dampers supplied by the Contractor are to meet the following requirements;

- Internal / external seams and body / flange joints are to be fully welded.
- Pressure tested for leaks prior to installation.
- Faulty welds (pinholes), runny (fast), or blob (slow) or cold lap welds/joints are to be ground out and re-welded.
- Installed damper/s with fault welds must be removed and repaired on floor. Repaired damper/s must be retested before installation.
- All welds and surrounding affected metal by welding process must be cleaned and passivated.
- Application of sealant to incomplete welds or faulty welds is not an acceptable practice.

2.3.15 Air Curtains

Where the OCU is ventilating a section of sewer an air curtain(s) may be required in the sewer to minimise any short circuiting and/or to focus the draw of air from one direction, for example at the confluence of sewers where only one sewer requires scrubbing. The need for an air curtain shall form part of the Needs Specification and Concept Design supplied by the Contractor and accepted by the Principal. If required, a suitable air curtain shall be designed, fabricated and installed by the Contractor. All aspects of the Principal's requirements for confined space entry shall be complied with when installing the air curtain(s).

2.4 Mechanical Works

The design and construction of the mechanical works shall be in accordance with the requirements contained in Sydney Water's Technical Specification Part 2 – Mechanical Works, unless otherwise specified in this document.

2.5 Electrical

The design and construction of the electrical works shall be in accordance with the requirements contained in Sydney Water Technical Specification Part 3 – Electrical Works.

All equipment shall be new and suitable for its purpose. They shall comply with the Australian Standards and shall be rated for continuous in-service condition within a switchboard.

All items of equipment shall be designed, manufactured and installed to perform their required functions reliably and efficiently. Considerations shall be made to ensure the designed system and selected equipment could be operated and maintained safely and efficiently. Particular attention shall be given to equipment installed in an adverse environment and/or exposed to weather.

Live equipment and terminals shall be located behind removable covers or doors, and shrouded, to prevent accidental contact when the control panel's front doors are open, including equipment mounted on doors.

Where more than one item of equipment is supplied and installed to perform a particular function, all such items of equipment shall be identical and completely interchangeable.

Sites are subject to power failure. The equipment shall be designed for automatic restart when the power returns.

The Contractor shall develop electrical circuits and control panel layout and submit these drawings to the Principal's representative for review prior to manufacture. The Contractor shall resolve with Sydney Water any issues of concern Sydney Water may have as a result of its review of these drawings prior to proceeding with ordering and manufacture.

All controls will be placed in a free standing painted stainless-steel cubicle as used for Sewage Pumping Stations (IP65 rating to AS 1939).

NOTE: Standard drawing templates for the electrical systems of different types of OCUs are currently being developed.

2.6 Telemetry

2.6.1 Networks

The OCU shall be designed for connection to the Sydney Water telemetry system in accordance with the latest *Sydney Water IICATS Sewer Odour and Corrosion Standards TOG_TS08*.

2.6.2 Wastewater Treatment Plants

The OCU shall be designed for connection to the Sydney Water WWTP/WRP SCADA system in accordance with the latest *Sydney Water Treatment Plant SCADA Standards*.

2.7 Instrumentation & Control

Instrumentation shall not be left exposed to sunlight, the elements, magnetic fields, vibration, or where local indicators are difficult to read, unless written approval is first obtained from the Principal's representative.

2.7.1 Networks

All instrumentation shall comply with Sydney Water's Instrumentation and Control Standards TOG_TS01 (to be read in conjunction with TOG_TS08 for networks). If there is any discrepancy between this document and TOG_TS01/TOG_TS08, it shall be raised to the

Principal's representative at the design phase. The Contractor shall resolve any issues of concern with the Principals Instrumentation and Control Engineer and obtain written approval from the Principal prior to proceeding with ordering and manufacture.

Differential pressure transmitters shall be provided to measure the head loss across both the pre-filters and the OCU media bed. These transmitters shall be calibrated in Pascals and shall have a local display as well as being connected to the IICATS Remote Terminal Unit (RTU) for alarms of high pressure.

Air Flow switches shall be provided for fans installed for OCU operation and be connected to the IICATS RTU for generating a no flow alarm and causing the fan to be shut off automatically.

If a heater is required then temperature transmitters shall be provided on the inlet and outlet of the heater unit. These transmitters shall be calibrated in degrees Celsius (°C) and shall have a local display as well as the outlet transmitter being connected to the IICATS RTU for generating a high alarm and causing the heater to be shut off automatically.

If a flame arrestor or biotrickling filter followed by an activated carbon polishing unit are installed, then additional differential pressure indicators are required.

Hydrogen sulphide meters shall be supplied to monitor the inlet and outlet OCU performance. These meters shall be calibrated in ppm_v H₂S and will have a local display as well as being connected to the IICATS RTU. Refer to Section 7 of this Specification for more detail.

NOTE: Standard P&IDs for the control systems of different types of OCUs are currently being developed to align with the latest TOG_TS08.

2.7.2 Wastewater Treatment Plants/Water Recycling Plants

All instrumentation shall comply with Sydney Water's Instrumentation and Control Standards TOG_TS01 (to be read in conjunction with Sydney Water Treatment Plant SCADA Standards). If there is any discrepancy between this document and the TOG_TS01/SCADA Standards, it shall be raised to the Principal's representative at the design phase. The Contractor shall resolve any issues of concern with the Principals Instrumentation and Control Engineer and obtain written approval from the Principal prior to proceeding with ordering and manufacture.

If local PLC control is required then the Contractor shall comply with the relevant sections of Sydney Water's Treatment Plant SCADA Standards including Appendix J – PLC Hardware.

Differential pressure transmitters shall be provided to measure the head loss across both the pre-filters and the OCU media bed. These transmitters shall be calibrated in Pascals and shall have a local display as well as being connected to the WWTP/WRP SCADA system for alarms of high pressure.

Flow switches shall be provided for fans installed for OCU operation and be connected to the WWTP/WRP SCADA system for generating a no flow alarm and causing the fan to be shut off automatically.

If a heater is required then temperature transmitters shall be provided on the inlet and outlet of the heater unit. These transmitters shall be calibrated in degrees Celsius (°C) and shall have a local display as well as the outlet transmitter being connected to the WWTP/WRP SCADA system for generating a high alarm and causing the heater to be shut off automatically.

If a flame arrestor or biotrickling filter followed by an activated carbon polishing unit are installed, then additional differential pressure indicators are required.

Hydrogen sulphide meters shall be supplied to monitor the inlet and outlet OCU performance. These meters shall be calibrated in ppm_v H₂S and will have a local display as well as being connected to the WWTP/WRP SCADA system. Refer to Section 7 of this Specification for more detail.

NOTE: Standard P&IDs for the control systems of different types of OCUs are currently being developed to align with the latest TOG_TS08.

2.8 Access and Auxiliary Services

Adequate access shall be provided to allow all expected operational and maintenance activities to be carried out in a safe and efficient manner.

Suitable road access shall be provided for large vehicles required for media and equipment (such as fans, pre-filters or pumps) removal and installation (such as vacuum tankers, HIAB trucks or cranes).

Platform access shall be provided for media removal and replacement. It shall be large enough to hold two people and a pallet of media unless otherwise agreed by the Principal's representative.

Platforms where required shall be supported from the ground rather than from the adsorber and ductwork.

A Residual Current Device (RCD) protected 240V General Purpose Outlet (GPO) for general use shall be provided in close proximity to the OCU.

A water supply with backflow prevention shall be provided in close proximity to the OCU for process use. The Reduced Pressure Zone (RPZ) valve shall be installed in a standard lockable cage.

A safety shower shall be provided in close proximity to the OCU, which is supplied separately from the RPZ protected process water supply. Safety showers are not required for activated carbon type OCUs.

Where a pre-filter is used, suitable cleaning facilities shall be provided.

A suitable lockable location shall be provided beside the OCU to provide storage of plant documentation (such as O&M manuals, Hazard ID list, plant diary, calibration records, and so on)

2.9 Civil Related

The design and construction of the civil works shall be in accordance with the requirements contained in Sydney Water Technical Specification Part 1 – Civil Works, and Sydney Water's Protective Coating Specification WSA 201 and Sydney Water's Supplement to WSA 201. Where necessary, relevant Dangerous Goods Regulations shall be complied with.

2.9.1 Foundation

The OCU shall be located on a concrete slab. The slab shall be constructed on a suitably prepared ground. Its thickness and compressive strength shall be adequate to bear the load of the unit. Rubber mats shall be used for fibreglass tanks.

2.9.2 Drainage

The OCU shall have gravity drainage facilities to remove condensate. The material of construction shall be sulphuric acid resistant. Drains from the heater/demister shall also be heat resistant. The drainage shall be directed to a permissible disposable location, such as a wet well or sewer and no potentially basic/chlorine laden waste streams are to be mixed.

Each drainage point must be from the lowest point in the item being drained. and sufficient drainage points must be supplied to prevent any condensate from collecting in the OCU.

Drains may only be combined for gases of like quality. No drain from downstream of the media bed is to be connected to any drain from upstream of the bed.

All drain discharge points must have a water seal, which can be easily checked/refilled and removed for cleaning by the operator. The diameter of the water trap needs to be minimal 40mm and a height needs to be sufficient to overcome the pressure difference and is typically at least 200mm. Where possible water traps should be shaded to minimise evaporation from water seals.

2.9.3 Fencing

When nominated in the Contract as being required, depending on security risk, a chain-link wire fence shall be supplied and installed as per Sydney Water Standard drawings DTC-5000 and 5001, with a gate at the perimeter of the network OCU area. It shall be at least 2.0 m in height. It shall be located so as not to interfere or restrict operational and maintenance activities.

2.10 Facility and Equipment Identification and Labelling

All equipment shall have a unique identification number. Sydney Water designates unique identification number for all its asset and associated equipment, and Sydney Water will assign these.

The facility and equipment identification and labelling shall be in accordance with Sydney Water's MEFA0001 Maintenance Related Clauses for Capital & Operational Projects (Section 4: Labelling and Identification) and D0000256 Asset Creation Operational Readiness Standard (Section 5.6: Labelling and Identification).

A standard Sydney Water Facility Asset sign shall be mounted on the OCU structure.

2.11 Critical Spares

The Contractor shall provide a list of any critical spares they consider necessary, including the cost of provision and their source, with their detailed design submission. The Principal will review the list and advise those items that the Contractor shall provide under the contract.

2.12 Operating and Maintenance Manual

An Operating and Maintenance (O&M) manual shall be provided for the OCU. An acceptable O&M manual is considered a key requirement for successful contractual handover. It shall be provided in both paper form (2 copies) and electronic form (on CD-R/DVD/USB, in both Word and PDF formats for every component) and equipment FMECAs shall be in Excel format. In addition, editable file copies shall also be provided where created by the Contractor in a format suitable for Sydney Water (for example, Microsoft Word and Excel documents, AutoCAD for drawings and so on).

The manual shall be in accordance with Sydney Water's Maintenance Related Clauses for Capital and Operational Projects MEFA0001 (Section 6: O&M Manuals) and Asset Creation Operational Readiness Standard D0000256 (Section 5.7: Operation and Maintenance Manuals).

The manual shall include, but not limited to:

- Overview of the OCU conceptual design and how it fits into the local management of odour and corrosion control, with reference to general location drawing.
- Detailed description of the unit and its components, process, and performance criteria.
- Detailed P&IDs, complete list of all equipment items (including electrical items) and a cross reference to Sydney Water's asset numbers where relevant.
- Detailed information for each supplied piece of equipment (Manufacturer, supplier, model number and so on).
- A list of suppliers and their current contact details.
- Pump and fan curves where relevant (including any test data).
- Pressure drop data through media and (pre-)filters at design airflows.
- Standard operating instructions covering all routine work requirements (for example, system start up, shut down, routine monitoring, changing of media and so on).
- Process optimisation and troubleshooting guide.
- Where relevant, a copy of the PLC functional description, Input/Output listings, electronic copies of PLC programs, details of the programming software used (including version details) and where it can be obtained.
- Reference listing of all monitoring and alarm signals both locally and transmitted to IICATS (network) or WWTP/WRP SCADA system (Wastewater Treatment Plants). For each alarm, this shall include detail of how the alarm generates (primary device, condition, relevant relays and so on).
- Reference listing of all interlocks and system timers (their values, allowable ranges and where these are set).
- Recommended routine inspection and maintenance schedule including replacement schedule of treatment media.

- List of any recommended spares to be held.
- Instructions on storage, loading/unloading, and MSDS of treatment media and any other chemicals (e.g. nutrients) required.
- A drawing register of all drawings supplied (such as drawing number, title, revision number and so on, grouped by type)
- WAC drawings covering all aspects of the OCU installation
- Complete program settings for all programmable equipment (for example, Differential Pressure Transmitters).
- Supplier equipment manuals for all items provided (including electrical equipment)

3 TECHNICAL SPECIFICATIONS – ACTIVATED CARBON TYPE OCU

A generic P&ID of this system is provided in Appendix A.

3.1 General

The activated carbon adsorption units shall be capable of continuously treating odorous air at 100% relative humidity at specified flow rates.

The units shall be designed to meet the required efficiency. Outlet conditions for the clean air discharge shall meet discharge odorous gas limit concentration (see section 2.2.2).

The activated carbon adsorption system shall be supplied complete with all auxiliary equipment required for system operation. The activated carbon media shall also be supplied, unless Sydney Water has exercised its right to free supply the activated carbon.

The activated carbon filter system shall generally consist of an inlet isolation valve, pre-filter, flame arrestor (where required), heater, activated carbon housing and activated carbon media, extraction fan(s), discharge stack, control equipment panel, and monitoring equipment.

The minimum activated carbon design bed life shall be 24 months based on the agreed maximum gas contaminant loading rate. The bed life is defined as the length of time between replacements of the activated carbon media based on breakthrough of gas contaminants above the target design levels. The Contractor shall submit calculations to the Principal, substantiating the amount of carbon to meet the carbon bed life specified.

The activated carbon adsorption units shall have a minimum empty bed gas residence time (EBRT) of three (3) seconds with the activated carbon media at the maximum design airflow.

Design of the activated carbon adsorption units shall employ methods to prevent caking, solidifying and blooming of the impregnated activated carbon.

The activated carbon adsorption units shall be designed structurally to withstand both the operating gas pressures (whether operating under a vacuum as preferred or under positive pressure) as well as any other stresses that might be expected during loading and unloading of the media (for example, people standing on top with carbon).

3.2 Pre-filter(s)

One easily removable and cleanable pre-filter assembly shall be installed downstream of the inlet isolation valve and upstream of all other OCU equipment. This pre-filter is intended to remove fats, greases, particulate matter and aerosols from the airstream and hence protect the flame arrestor (if required) and the activated carbon media from contamination.

The pre-filter shall be easily obtainable and of the honeycomb type designed to remove particulate matter and shall have a removal efficiency of 96% based on No.3 dust to AS 1324.2, and of corrosion resistant construction materials. The pre-filter design shall be sufficient to provide consistent flow to the unit for a period of one month between cleaning events, whilst not creating a manual handling issue for cleaning.

The filter(s) shall be mounted in a frame and be constructed to prevent bypassing of the filter by inlet air.

One spare set of filter(s) shall be supplied as well as a suitable container and detergents for cleaning the filters on site. The cleaning container must be able to be drained back to the sewer. A suitable container for transporting the filters offsite for cleaning shall also be provided.

The design of the pre-filter shall facilitate easy removal of the pre-filter for cleaning/replacement without creating a source of gas leaks.

The filter housing shall have a graded floor to a drain (minimum 40mm) connected back to the sewer via a visible water seal. The water seal must be able to be easily checked/filled manually. The pre-filter, filter housing and drain shall be resistant to condensate attack.

3.3 In-Line Heater/Demister

In-line duct heating shall be provided on the inlet side of the adsorber unit to ensure that the temperature of the saturated air to the OCU can be raised to achieve reduced humidity to prevent moisture entrainment and optimal adsorption in the activated carbon bed. The capacity of the heater should be sufficient to reduce the relative humidity to less than 70% for the design inlet airflow with a relative humidity of 100% at 20 degrees Celsius. The in-line heater shall be of the black body type, and shall be fitted with over temperature cut out in the event that fan failure or similar prevents air movement over the heater elements. The in-line heater shall not operate unless the fan is running and airflow through the inlet ducting is ensured. Temperature measurement and indicators shall be provided on the inlet and outlet of the heater. These shall be used to switch on/off the heater to maintain a temperature difference between inlet and outlet of about 5 degrees Celsius.

The heater box must be adequately drained to the sewer to ensure the heater elements do not become immersed in condensate. The drain shall be both resistant to condensate attack as well as high temperatures should the heater overheat.

An in-line heater will be provided at all times, even when an activated carbon product is used that is not susceptible to moisture entrainment, and therefore would not require an in-line heater. Alternative activated carbon types that are more cost effective might be used in the future and might require pre-heating.

3.4 Adsorber Unit

The activated carbon vessel, internal components, and structural components shall be made of fibreglass or equivalent corrosion resistant material as specified in section 2.3.4. Where fibreglass is used, the suitability of this material with resins selected for resistance to activated carbon, the products of reaction and the general sewage environment shall be required. The colour of the odour adsorber unit shall be in accordance with WSA 201 and Sydney Water's Supplement to WSA 201.

The effective volume of the activated carbon vessel will be such that 20% extra bed depth can be added if necessary in the future when additional activated carbon is required or when a different type (e.g. lower density) of activated carbon will be used.

The design shall include lockable access hatches for loading and removal of spent carbon, and for inspection of any other ancillary equipment. The hatches shall be of sufficient size to allow both removal of carbon by suction hose through the top, and by manual shovelling

through the side. The hatches shall allow the easy removal of any internal components such as screens for maintenance purposes.

The adsorber and associated ductwork shall be designed to minimise pressure drop, prevent any short circuiting of gas flow, and provide easy access for maintenance.

3.5 Monitoring

Monitoring systems shall be provided, as detailed in Section 2.7 of this Specification. Three additional permanent sampling ports shall be provided on the adsorber, each at increasing depths across the activated carbon media bed (for example, at 25%, 50% and 75% of the bed depth). These shall be terminated in 12mm full bore stainless steel ball valves and be designed to withdraw a representative gas sample at that depth without blockage or escape of the carbon media.

3.6 Control system

The activated carbon system shall be designed for unmanned remote operation fully automated with allowance for manual operation.

The activated carbon system unit shall be installed with the following additional sensors and monitors as a minimum:

- Air flow monitoring (flow switch after fan) – interlocked to shut down the heater and connected to IICATS (Networks) or WWTP/WRP SCADA system (Wastewater Treatment Plants).
- Differential pressure transmitter over the pre-filter – connected to IICATS (Networks) or WWTP/WRP SCADA system (Wastewater Treatment Plants).
- Differential pressure indicator over the activated carbon filter – connected to IICATS (Networks) or WWTP/WRP SCADA system (Wastewater Treatment Plants).
- Temperature transmitters before and after the heater – connected to IICATS (Networks) or WWTP/WRP SCADA system (Wastewater Treatment Plants).
- Where required, Lower Explosive Limit (LEL*) – interlocked to shut down the unit at >5%** and connected to IICATS (Networks) or WWTP/WRP SCADA system (Wastewater Treatment Plants).

*NOTE: * LEL is defined as the concentration of flammable gas, vapour or mist in air below which an explosive gas atmosphere will not be formed. For methane, the LEL is 5% (by volume) in air.*

*** Where the LEL has the potential to be >5% there will need to be an assessment on whether the installation is in a Zone 2 classified area. The definition of a Zone 2 classified area is a place in which an explosive gas atmosphere consisting of a mixture with air of flammable substances in the form of gas, vapour or mist is not likely to occur in normal operation but, if it does occur, will persist for a short period only. If so, appropriate requirements are to be included (refer TG0502 – Classification and Management of Flammable Gas Hazardous Areas).*

NOTE: Standard P&IDs for the control systems of different types of OCUs are currently being developed to align with the latest TOG_TS08.

3.7 Adsorptive Media

The Contractor shall include information including details and price of the activated carbon intended to be supplied in the concept design for review. Sydney Water may agree to proceed with this intended carbon, however reserves the right to specify the carbon to be used for detailed design purposes. In this case, Sydney Water will provide performance information of the carbon to the Contractor, to facilitate the detailed design of the OCU.

The Principal reserves the right to free supply the activated carbon for the OCU and not use the media offered by the Contractor. Should the Principal agree to use the Contractors carbon, it shall comply with the following requirements:

- The adsorptive media shall be either impregnated activated carbon or other similar proprietary media that is predominantly an activated carbon material, chemically treated to adsorb the constituent gases from the collected airstream.
- The carbon shall be extruded, steam activated and impregnated with sodium hydroxide or potassium hydroxide, potassium iodide or copper oxide. Details of the selected adsorptive media, and its performance characteristics, particularly moisture ingress shall be provided. Peat, coconut shell or high-grade coal shall be used as the base material for manufacture of the carbon.
- The depth of media shall be such that the minimum contact time for the airstream in the OCU is at least 3.0 seconds at maximum design airflow without exceeding the manufacturer recommended gas velocity through the activated carbon (typically maximum 25-30 cm/s). The adsorptive media shall be evenly distributed in the bed so that no bypassing or short circuiting of foul air occurs within the OCU.
- The activated carbon shall also be required to absorb levels of hydrocarbons that may be present at times.
- The design life of the adsorptive media shall be a minimum of 24 months. The activated carbon shall have an odour removal efficiency of not less than 99% for all sewer based odours and meet discharge odorous gas limit concentration.

The carbon media shall meet the following minimum specifications.

Sodium Hydroxide/Potassium Hydroxide (Caustic) Impregnated Activated Carbon (NaOH/KOH)

PARAMETER	REQUIREMENT	TEST METHOD
Potassium Hydroxide or Sodium Hydroxide content	up to 10%	
Apparent Density	0.45 to 0.62 g/mL	ASTM D2854
Ball-Pan Hardness	95 minimum	ASTM D3802
Particle Diameter	4 mm	ASTM D2862
Particle Length	6 mm	ASTM D2862
Mean Particle Diameter	3.6 to 4.7 mm	ASTM D2862
Surface Area	1000 m ² /g minimum	N ₂ BET Method
Hydrogen Sulphide Breakthrough Capacity	0.06 H ₂ S g/cm ³ Carbon minimum	ASTM D6646

Potassium Iodide Impregnated Activated Carbon

PARAMETER	REQUIREMENT	TEST METHOD
Potassium Iodide content	1.8% minimum	
Apparent Density	0.40 to 0.60 g/mL	ASTM D2854
Ball-Pan Hardness	90 minimum	ASTM D3802
Particle Diameter	3 to 4 mm	ASTM D2862
Particle Length	6 to 8 mm	ASTM D2862
Mean Particle Diameter	3.6 to 4.8 mm	ASTM D2862
Surface Area	1000 m ² /g minimum	N ₂ BET Method
Hydrogen Sulphide Breakthrough Capacity	0.09 H ₂ S g/cm ³ Carbon minimum	ASTM D6646

Copper Oxide Impregnated Activated Carbon

PARAMETER	REQUIREMENT	TEST METHOD
Copper Oxide content	5% minimum	
Apparent Density	0.40 to 0.55 g/mL	ASTM D2854
Ball-Pan Hardness	90 minimum	ASTM D3802
Particle Diameter	2 to 3.5 mm	ASTM D2862
Particle Length	3 to 5 mm	ASTM D2862
Mean Particle Diameter	2.25 to 3.89 mm	ASTM D2862
Surface Area	1000 m ² /g minimum	N ₂ BET Method
Hydrogen Sulphide Breakthrough Capacity	0.07 H ₂ S g/cm ³ Carbon minimum	ASTM D6646

An analysis sheet shall accompany each batch of carbon media. Random sampling may be carried out by the Principal for product quality testing. The testing may be made by any laboratory approved by the Principal. All costs associated with the test work shall be borne by the Contractor.

4 TECHNICAL SPECIFICATIONS – BIOTRICKLING FILTER WITH CARBON POLISHING TYPE OCU

Generic P&ID of stand-alone biotrickling filter and activated carbon are provided in Appendices B and A.

4.1 Pre-filter

A pre-filter will not normally be required. However, if a flame arrestor is required upstream of the biotrickling filter, then a pre-filter will be required. For details, see Section 3.2 of this Specification.

4.2 Biotrickling Filter Unit

The biotrickling filter units shall be capable of continuously treating odorous air at the specified flow rates and be designed to meet the minimum required removal efficiency of 99% H₂S following commissioning.

The biotrickling filter shall be supplied complete with all auxiliary equipment required for system operation. The biotrickling filter unit shall generally consist of an inlet isolation valve, one or more contactors containing a suitable bio growth media and support frame, a liquor recirculation system, if part of the suppliers' design, to maintain the media in a moist state, a liquor decant and makeup (water and nutrients where required) system, extraction fan(s), discharge stack, control equipment panel, and monitoring equipment.

One or multiple layers of media will be of a design such that it provides sufficient surface and contact time (EBRT of 10 seconds is required under normal operation and an EBRT of 8 seconds when one tower is offline, or as specified) to treat agreed contaminant loads to the agreed discharge quality whilst being open enough to not suffer from blockage or short circuiting over its operational life span. The number of media layers and treatment stages are as specified by the Supplier. The Contractor shall submit calculations to the Principal, substantiating the choice of media to meet the required performance and life span. The media should be guaranteed for at least 10 years without the requirement of media change-out, without pressure drop increase (no increase after start-up period) nor shrink or compact (maximum 5% compaction of the original bed depth). Examples or specific tests illustrating that the media can be guaranteed shall be provided as part of the proposal.

The biotrickling filter shall be designed structurally to withstand both the operating gas pressures (whether operating under a vacuum as preferred) as well as any other stresses that might be expected during loading and unloading of the media (for example, need to provide support for at least two people standing on top typically 200 kg plus the media).

The biotrickling filter shell, internal components, and structural components shall be made of fibreglass or equivalent corrosion resistant as specified in section 2.3.4. Where fibreglass is used, the suitability of this material with resins selected for resistance to biological attack, the products of reaction and the general sewage environment shall be demonstrated.

The design shall include access hatches for loading and removal of support media, and for inspection of any other ancillary equipment. The hatches shall be of sufficient size to allow both removal of bio growth media through the side, and inspection and maintenance of the distribution sprays at the top. The inspection hatch(es) shall be designed to allow visual inspection by operators of the sprays and the top of the media during normal operation. The

hatches shall allow the easy removal of any internal components such as screens for maintenance purposes. Guardrails shall comply with the requirements of AS 1657: Fixed Platforms, Walkways, Stairways and Ladders – Design, Construction and Installation.

For activated carbon type filters, it is required that the fans be installed after the treatment component and draw air through the unit under vacuum, in order to remove the risk of gas leaks under pressure. For biotrickling filters combined with activated carbon polishing, it is required that the fans be installed after the biotrickling filter and before the activated carbon filter. Operation under vacuum will have implications on the structural design of the various elements and on the operation of the various monitors, and these shall be considered in the concept design.

The biotrickling filter and associated ductwork shall be designed to minimise pressure drop, prevent any short circuiting of gas flow, and provide easy access for maintenance. The colour of the odour adsorber shall be in accordance with WSA 201 and Sydney Water's Supplement to WSA 201.

4.3 Adsorber Unit

The adsorber shell, internal components, and structural components shall be made of fibreglass or equivalent corrosion resistant material as specified in section 2.3.4. Where fibreglass is used, the suitability of this material with resins selected for resistance to activated carbon, the products of reaction and the general sewage environment shall be required. The colour of the odour adsorber unit shall be in accordance with WSA 201 and Sydney Water's Supplement to WSA 201.

The design shall include access hatches for loading and removal of spent carbon, and for inspection of any other ancillary equipment. The hatches shall be of sufficient size to allow both removal of carbon by suction hose through the top, and by manual shovelling through the side. The hatches shall allow the easy removal of any internal components such as screens for maintenance purposes.

The adsorber and associated ductwork shall be designed to minimise pressure drop, prevent any short circuiting of gas flow, and provide easy access for maintenance.

The minimum activated carbon design bed life shall be 24 months based on the agreed maximum gas contaminant loading rate. The bed life is defined as the length of time between replacements of the activated carbon media based on breakthrough of gas contaminants above the target design levels. The Contractor shall submit calculations to the Principal, substantiating the amount of carbon to meet the carbon bed life specified.

The activated carbon adsorption units shall have a minimum empty bed gas contact time (EBRT) of two (2) seconds with the activated carbon media at the maximum design airflow.

The effective volume of the activated carbon vessel will be such that 20% extra bed depth can be added if necessary in the future when additional activated carbon is required or when a different type (e.g. lower density) of activated carbon will be used.

The Contractor shall include information including details and price of the activated carbon intended to be supplied in the concept design for review. Sydney Water may agree to proceed with this intended carbon, however reserves the right to specify the carbon to be

used for detailed design purposes. In this case, Sydney Water will provide performance information of the carbon to the Contractor, to facilitate the detailed design of the OCU (see also section 3.6).

Sydney Water also reserves the right to free supply the carbon to be used from its own store.

4.4 Monitoring

Monitoring systems shall be provided, as detailed in Section 7 of this Specification. The Contractor shall provide any additional sampling points at the inlet and outlet ductwork necessary to adequately monitor the performance of the OCU or its key components.

4.5 Control system

The biotrickling filter with activated carbon system shall be designed for unmanned remote operation fully automated with allowance for manual operation.

The biotrickling filter with activated carbon system unit shall be installed with the following additional sensors and monitors as a minimum:

- Water flow rate to nozzles – connected to IICATS (Networks) or WWTP/WRP SCADA system (Wastewater Treatment Plants).
- Water usage – connected to IICATS (Networks) or WWTP/WRP SCADA system (Wastewater Treatment Plants).
- Nutrient flow (flow switch) – connected to IICATS (Networks) or WWTP/WRP SCADA system (Wastewater Treatment Plants).
- Level and/or low-level switch of the liquid in the nutrient storage tank – connected to IICATS (Networks) or WWTP/WRP SCADA system (Wastewater Treatment Plants).
- Air flow monitoring (flow switch after fan) – connected to IICATS (Networks) or WWTP/WRP SCADA system (Wastewater Treatment Plants).
- Differential pressure indicator over the BTF and activated carbon unit with local readout and connected to IICATS (Networks) or WWTP/WRP SCADA system (Wastewater Treatment Plants).
- Where required, Lower Explosive Limit (LEL) – interlocked to shut down the unit at >5% and connected to IICATS (Networks) or WWTP/WRP SCADA system (Wastewater Treatment Plants).
- Where required, pH and or electrical conductivity level for the sump liquor – connected to IICATS (Networks) or WWTP/WRP SCADA system (Wastewater Treatment Plants). In addition, provision for taking a sample of the drain or sump liquid should be provided.
- Where required, level of liquor in contactor sump – connected to IICATS (Networks) or WWTP/WRP SCADA system (Wastewater Treatment Plants). In addition, a manual sight glass shall be provided to allow visual checking.

Both the biotrickling filter and activated carbon unit shall have a local differential pressure indicator. Three additional permanent sampling ports shall be provided on the adsorber, each at increasing depths across the activated carbon media bed (for example, at 25%, 50% and 75% of the bed depth). These shall be terminated in 12mm full bore stainless steel ball valves and be designed to withdraw a representative gas sample at that depth without blockage or escape of the carbon media.

NOTE: Standard P&IDs for the control systems of different types of OCUs are currently being developed to align with the latest TOG_TS08.

4.6 Liquor Recirculation System

A minimum of two pumps with automatic change-over shall be provided to recirculate the sump liquor. They shall be in duty/standby arrangement. The pumps shall be centrifugal pumps and mechanically sealed. The pump head and seals shall be suitable for the corrosive nature of the sump liquor.

A sump purge valve shall be provided to flush out contaminant build up within the reticulation system. This shall be automatically controlled and allow for operator adjustment.

Flow indication shall be provided for each component flow on the recirculation system including flows to the humidifier (if present), to the spray in each contactor, and to monitoring instruments.

A no flow alarm shall be provided should the recirculation of sump liquor fail. Similarly, a low liquor sump level alarm should stop the recirculation pumps. Failure of the reticulation system shall be connected to IICATS (Networks) or WWTP/WRP SCADA system (Treatment Plants).

Any automated valves shall be provided with a manual by-pass.

A once-through type system shall provide all flow indications and alarms to ensure that proper water flows is provided for each component flow on the system including flows to the humidifier (if present), to the spray in each contactor, to monitoring instruments.

NOTE: Standard P&IDs for the liquor recirculation systems of different types of OCUs are currently being developed to align with the latest TOG_TS08.

4.7 Nutrient Dosing System (if required)

A nutrient dosing system shall be provided to dose the sump liquor during purge makeup sequence. The dosing system shall consist of storage tank, duty dosing pump, low level indicator, calibration tube, backpressure valve, pressure gauge and dosing lines. It shall comply with the relevant sections of Sydney Water's Technical Specification, Part 2 Mechanical Works, Section M37: Chemical Systems.

5 TECHNICAL SPECIFICATIONS – BIOTRICKLING FILTER TYPE OCU

A generic P&ID of a stand-alone biotrickling filter is provided in Appendix B. Stand-alone biotrickling filters are not preferred by Sydney Water and will not normally be accepted in built up areas or where they would be close to neighbouring residents unless the supplier can prove reliable long-term operations with sufficient performance. A combination of biotrickling filter with an activated carbon polishing filter will be accepted and the technical specifications of a biotrickling filter combined with a carbon polishing unit are provided in Section 4.

5.1 Pre-filter

A pre-filter will not normally be required. However, if a flame arrestor is required upstream of the biotrickling filter, then a pre-filter will be required. For details, see Section 3.2 of this Specification.

5.2 Biotrickling Filter Unit

The biotrickling filter units shall be capable of continuously treating odorous air at the specified flow rates and be designed to meet the minimum required removal efficiency of 99% H₂S and 95% of the odour concentration as measured according to AS/NZS 4323.3. Outlet conditions for the clean air discharge shall meet discharge odorous gas limit concentration as specified in section 2.2.2.

The biotrickling filter shall be supplied complete with all auxiliary equipment required for system operation. The biotrickling filter unit shall generally consist of an inlet isolation valve, one or more contactors containing a suitable bio growth media and support frame, a liquor recirculation system, if part of the suppliers' design, to maintain the media in a moist state, a liquor decant and makeup (water and nutrients) system, extraction fan(s), discharge stack, control equipment panel, and monitoring equipment.

Different layers of media will be of a design such that it provides sufficient surface and contact time to treat agreed contaminant loads to the agreed discharge quality whilst being open enough to not suffer from blockage or short circuiting over its operational life span. The number of media layers and treatment stages are as specified by the Supplier, with a minimum of two individual stages providing at least one stage with an acidic pH to provide optimal conditions for the autotrophic micro-organisms and at least one stage with a neutral pH (pH 6-8) to provide optimal conditions for the heterotrophic micro-organisms. The Contractor shall submit calculations to the Principal, substantiating the choice of media and the number of stages to meet the required performance and life span. The media should be guaranteed for at least 10 years without the requirement of media change-out, without pressure drop increase (no increase after start-up period) nor shrink or compact (maximum 5% compaction of the original bed depth). Examples or specific tests illustrating that the media can be guaranteed shall be provided as part of the proposal.

The diameter and height of the biotrickling filter shall be properly sized to meet the specified performance requirements. The biotrickling filter must have a minimum contact time (EBRT of 10 seconds is required under normal operation and an EBRT of 8 seconds when one tower is offline, or as specified) sufficient to provide 99% removal efficiency of H₂S and 95% removal efficiency of all odours during normal operation and meet discharge odorous gas limit concentration as specified in section 2.2.2.

The biotrickling filter shall be designed structurally to withstand both the operating gas pressures (whether operating under a vacuum as preferred or under positive pressure) as well as any other stresses that might be expected during loading and unloading of the media (for example, need to provide support for at least two people standing on top).

The biotrickling filter shell, internal components, and structural components shall be made of fibreglass or equivalent corrosion resistant as specified in section 2.3.4. Where fibreglass is used, the suitability of this material with resins selected for resistance to biological attack, the products of reaction and the general sewage environment shall be demonstrated.

A demister may be required to prevent any carryover of liquid droplets with the outlet gas stream.

The design shall include access hatches for loading and removal of support media, and for inspection of any other ancillary equipment. The hatches shall be of sufficient size to allow both removal of bio growth media through the side, and inspection and maintenance of the distribution sprays at the top. The inspection hatch(es) shall be designed to allow visual inspection by operators of the sprays and the top of the media during normal operation. The hatches shall allow the easy removal of any internal components such as screens for maintenance purposes and access to the hatches shall be provided. Guardrails shall comply with the requirements of AS 1657: Fixed Platforms, Walkways, Stairways and Ladders – Design, Construction and Installation.

The biotrickling filter and associated ductwork shall be designed to minimise pressure drop, prevent any short circuiting of gas flow, and provide easy access for maintenance. The colour of the odour adsorber shall be in accordance with the WSA 201 and Sydney Water's Supplement to WSA 201.

5.3 Monitoring

Monitoring systems shall be provided, as detailed in Section 7 of this Specification. The Contractor shall provide any additional sampling points at the inlet and outlet ductwork necessary to adequately monitor the performance of the OCU or its key components.

5.4 Control system

The biotrickling filter shall be designed for unmanned remote operation fully automated with allowance for manual operation.

The biotrickling filter unit shall be installed with the following additional sensors and monitors as a minimum:

- Water flow rate to nozzles – connected to IICATS (Networks) or WWTP/WRP SCADA system (Wastewater Treatment Plants).
- Water usage – connected to IICATS (Networks) or WWTP/WRP SCADA system (Wastewater Treatment Plants).
- Nutrient flow (flow switch after dosing pump) – connected to IICATS (Networks) or WWTP/WRP SCADA system (Wastewater Treatment Plants).
- Level and/or low-level switch of the liquid in the nutrient storage tank – connected to IICATS (Networks) or WWTP/WRP SCADA system (Wastewater Treatment Plants).

- Air flow monitoring (flow switch after fan) – connected to IICATS (Networks) or WWTP/WRP SCADA system (Wastewater Treatment Plants).
- Differential pressure indicator over the BTF – connected to IICATS (Networks) or WWTP/WRP SCADA system (Wastewater Treatment Plants).
- Where required, Lower Explosive Limit (LEL) – interlocked to shut down the unit at >5% and connected to IICATS (Networks) or WWTP/WRP SCADA system (Wastewater Treatment Plants).
- Where required, pH and or electrical conductivity level for the sump liquor – connected to IICATS (Networks) or WWTP/WRP SCADA system (Wastewater Treatment Plants). In addition, provision for taking a sample of the drain or sump liquid should be provided.
- Where required, level of liquor in contactor sump – connected to IICATS (Networks) or WWTP/WRP SCADA system (Wastewater Treatment Plants). In addition, a manual sight glass shall be provided to allow visual checking.

NOTE: Standard P&IDs for the control systems of different types of OCUs are currently being developed to align with the latest TOG_TS08.

5.5 Liquor Recirculation System

A minimum of two pumps per stage with automatic change-over shall be provided to recirculate the sump liquor. They shall be in duty/standby arrangement. The pumps shall be centrifugal pumps and mechanically sealed. The pump head and seals shall be suitable for the corrosive nature of the sump liquor.

A sump purge valve shall be provided to flush out contaminants build up within the reticulation system. This shall be automatically controlled and allow for operator adjustment.

Flow indication shall be provided for each component flow on the recirculation system including flows to the humidifier (if present), to the spray in each contactor, to monitoring instruments.

A no flow alarm shall be provided should the recirculation of sump liquor fail. Similarly, a low liquor sump level alarm should stop the recirculation pumps. Failure of the reticulation system shall be connected to IICATS (Networks) or WWTP/WRP SCADA system (Wastewater Treatment Plants).

Any automated valves shall be provided with a manual by-pass.

A once-through type system shall provide all flow indications and alarms to ensure that proper water flows is provided for each component flow on the system including flows to the humidifier (if present), to the spray in each media layer and monitoring instruments.

NOTE: Standard P&IDs for the liquor recirculation systems of different types of OCUs are currently being developed to align with the latest TOG_TS08.

5.6 Nutrient Dosing System (if required)

A nutrient dosing system shall be provided to dose the sump liquor during purge makeup sequence. The dosing system shall consist of storage tank, duty dosing pump, low level indicator, calibration tube, backpressure valve, pressure gauge and dosing lines. It shall comply with the relevant sections of Sydney Water's Technical Specification, Part 2 Mechanical Works, Section M37: Chemical Systems.

6 TECHNICAL SPECIFICATIONS – CHEMICAL SCRUBBER TYPE

A generic P&ID of this system is provided in Appendix C. Chemical Scrubbers shall only be used in treatment plants, and not the networks. This is due to the hazardous nature of the chemicals used.

6.1 Chemical Scrubber Unit

The chemical scrubber units shall be capable of continuously treating odorous air at the specified flow rates and be designed to meet the minimum required removal efficiency of 99% H₂S and 95% of the odour concentration as measured according to AS/NZS 4323.3. Outlet conditions for the clean air discharge shall meet discharge odorous gas limit concentration as specified in section 2.2.2.

The chemical scrubber unit shall be supplied complete with all auxiliary equipment required for system operation.

Each scrubber shall be a counter-current, packed-bed tower design with bottom gas inlet, top recirculation flow inlet. A mist eliminator shall be installed at the scrubber outlet to prevent venting of entrained droplets. The mist eliminator shall be sized to remove entrained droplets from the scrubbed gas stream and prevent fogging at the outlet of the vent stack.

The scrubber packing shall either be a randomly packed or structurally packed type. The diameter and height of the packed bed shall be properly sized to meet the specified performance requirements whilst being open enough to not suffer from blockage or short circuiting over its operational life span. The Contractor shall submit calculations to the Principal, substantiating the choice of media to meet the required performance and life span. The media should be guaranteed for at least 10 years without the requirement of media change-out, without pressure drop increase (no increase after start-up period) nor shrink or compact (maximum 5% compaction of the original bed depth). Examples or specific tests illustrating that the media can be guaranteed shall be provided as part of the proposal.

The chemical scrubber shall be designed structurally to withstand both the operating gas pressures (whether operating under a vacuum as preferred or under positive pressure) as well as any other stresses that might be expected during loading and unloading of the media (for example, need to provide support for at least two people standing on top).

The tower, internal components, structural components and where applicable the sump tanks shall be fabricated of fibreglass reinforced plastic or approved equal which is resistant to the chemicals used in and removed by the scrubbing process and shall be fabricated in accordance with the requirements specified in EN 13121 and as detailed in section 2.3.4 of this Specification.

The design shall include access hatches for loading and removal of support media, and for inspection of any other ancillary equipment including the inspection and maintenance of the distribution sprays at the top. The inspection hatch(es) shall be designed to allow visual inspection by operators of the sprays and the top of the media during normal operation. The hatches shall allow the easy removal of any internal components for maintenance purposes and access to the hatches shall be provided. Guardrails shall comply with the requirements of AS 1657: Fixed Platforms, Walkways, Stairways and Ladders – Design, Construction and Installation.

The chemical scrubber and associated ductwork shall be designed to minimise pressure drop, prevent any short circuiting of gas flow, and provide easy access for maintenance. The colour of the odour adsorber shall be in accordance with the WSA 201 and Sydney Water's Supplement to WSA 201.

Each scrubber shall be mounted on a sump tank integral with the scrubber shell. The sump tank shall be sized to match with the design and operation of its associated scrubber. The tank shall be a vertical, flat bottom storage tank, and shall be fabricated with flanged nozzles, including the following:

- Scrubber (top);
- Access hatch/es, as far as practicable (top);
- Recirculation pump suction (side);
- Chemical make-up inlet(s) into recirculation line;
- Make-up water inlet (side);
- Overflow (side);
- Drain (bottom).

The tank nozzles shall be located as recommended by the Contractor to provide easy access and to minimise piping. All nozzle locations shall be clearly labelled and located on the Shop Drawings. Required structural supports, hold down and lifting lugs shall be installed. The size and configuration of access points shall be designed to minimise the severity of the confined space within the scrubber.

6.2 Monitoring

Monitoring systems shall be provided, as detailed in Section 7 of this Specification. The Contractor shall provide any additional sampling points at the inlet and outlet ductwork necessary to adequately monitor the performance of the OCU or its key components.

6.3 Control system

The chemical scrubber shall be designed for unmanned remote operation fully automated with allowance for manual operation.

The chemical scrubber unit shall be installed with the following additional sensors and monitors as a minimum:

- Water flow rate to nozzles – connected to WWTP/WRP SCADA system.
- Water usage – connected WWTP/WRP SCADA system.
- Chemical flow (flow switch after dosing pump) – connected to WWTP/WRP SCADA system.
- Level and/or low-level switch of the liquid in the chemical storage tanks – connected to WWTP/WRP SCADA system.
- Air flow monitoring (flow switch after fan) –connected to WWTP/WRP SCADA system.

- Differential pressure indicator over the chemical scrubber – connected to WWTP/WRP SCADA system.
- Where required, Lower Explosive Limit (LEL) – interlocked to shut down the unit at >5% and connected to WWTP/WRP SCADA system.
- Where required, pH, ORP and or electrical conductivity level for the sump liquor – connected to WWTP/WRP SCADA system. In addition, provision for taking a sample of the drain or sump liquid should be provided.
- Where required, level of liquor in contactor sump – connected to WWTP/WRP SCADA system. In addition, a manual sight glass shall be provided to allow visual checking.

NOTE: Standard P&IDs for the control systems of different types of OCUs are currently being developed to align with the latest TOG_TS08.

6.4 Liquor Recirculation System

A minimum of two duty/standby pumps with automatic change-over shall be provided to recirculate the sump liquor. They shall be in duty/standby arrangement. The pumps shall be centrifugal pumps and mechanically sealed. The pump head and seals shall be suitable for the corrosive nature of the sump liquor.

A sump purge valve shall be provided to flush out contaminants build up within the reticulation system. This shall be automatically controlled and allow for operator adjustment.

Flow indication shall be provided for each component flow on the recirculation system including flows to the spray in each contactor.

A no flow alarm shall be provided should the recirculation of sump liquor fail. Similarly, a low liquor sump level alarm should stop the recirculation pumps. Failure of the reticulation system shall be connected to IICATS.

Any automated valves shall be provided with a manual by-pass.

NOTE: Standard P&IDs for the liquor recirculation systems of different types of OCUs are currently being developed to align with the latest TOG_TS08.

6.5 Chemical Dosing System

A chemical dosing system shall be provided to dose the recirculation line. The dosing system shall consist of storage tank (at least 14 days of storage capacity), duty/standby dosing pumps, calibration tube, low level indicator, backpressure valve, pressure gauge and dosing lines. It shall comply with the relevant sections of Sydney Water's Technical Specification, Part 2 Mechanical Works, Section M37: Chemical Systems.

7 TECHNICAL SPECIFICATION – MONITORING SYSTEM

These specifications relate to the monitoring of H₂S gas, as this gas is usually the predominant gas in sewer systems. Hence H₂S will be used as the online indicator gas for sewage odours that are present in the airstream at the inlet and outlet of the OCU. In some cases, Sydney Water will specify that there are more than one odorants of interest, or different target odorants. Where these odorants can be monitored online, the above also holds for these gases.

7.1 Standards & Recognised Practices

The standards that will be referred to and that are to be followed in the procurement, installation and maintenance of both high and low-level monitoring systems are as follows:

- “Air Pollution Measurement Manual” – A Practical Guide to Sampling & Analysis, Volumes 1 & 2, Clean Air Society of Australia & New Zealand (CASANZ).
- ISO 6141, ISO 6142, ISO 6143 – Gas Analysis
- AS 3580.2.1 “Preparation of Reference Test Atmospheres – Permeation Tube Method”
- AS/NZS 3580.2.2 – Preparation of Reference Test Atmospheres – Compressed Gas Method”
- “Handbook of Air Pollution Analysis”, edit. Roy M. Harrison & Roger Perry. Chapman & Hall, printer/publisher: University Press, Cambridge 1986 ISBN 0412 244101

7.2 On-Line Monitoring System

A generic P&ID of this system is provided in Appendix D.

The complete monitoring system will consist of the following:

- H₂S analysers
- Sample port arrangement (draws sample away from duct wall)
- Sampling Pumps
- Condensate traps
- Flow Control Valves
- Flow Meters
- Differential Pressure sensors
- Pipework, Tubing & Ancillary Fittings
- Monitoring cubicle
- Data logging and display equipment
- Any other monitoring equipment as required by the specific site application to ensure reliable operation of the OCU (e.g. pH probes, chlorine analysers, LEL monitors, etc.)

The *Supplier* who shall provide all the services, equipment, fixtures and fittings required to achieve a complete, fully integrated and operational monitoring system meeting all of the design conditions, testing requirements and warranty conditions as specified herein.

The monitoring system should comply with Sydney Water’s Instrumentation and Control Standards TOG_TS01 and Sydney Water’s IICATS Sewer Odour and Corrosion Standards

TOG_TS08 (for Networks) or WWTP/WRP SCADA system (for Wastewater Treatment Plants).

The equipment supplied shall be suitable for the specified operating conditions and shall be designed and constructed for a minimum of 10 years. Electrochemical cell life shall be of a minimum of 12 months at the specific operating condition.

7.2.1 H₂S monitors

H₂S monitors shall be provided on the inlet and outlet of each unit process of the OCU. For example, a biotrickling filter unit followed by an activated carbon unit, then additional H₂S monitors will be required to assess the performance of each unit process. As a minimum, H₂S monitors shall be provided on the inlet and outlet of every individual OCU.

The H₂S monitors shall provide accurate (see below at [section 7.2.9.1 *Electrochemical Cells*](#)) and reliable on-line monitoring of H₂S in the monitored gas stream at the required accuracy. The required accuracy will be determined by the designed output concentration.

It is recommended that the H₂S analyser be installed near (a maximum of 6 m) to the sampling port. This is to prevent the decomposition of sampled gases before presentation to the analyser.

7.2.2 Sampling lines and ports

Gas sampling arrangements shall consist of sampling ports into the ductwork to allow the gas flow to be sampled away from the duct wall. Each of these sample ports shall terminate in 12 mm full bore stainless steel ball valve. The outlet from the sampling port isolation valve is then piped to the condensate trap located in the monitoring cubicle. This line must either rise steadily to the condensate trap or have one high point only. There shall be no low points that would act as water traps. Lines shall meet the requirements set out in Section 7.2.10 of this Specification. Hatches suitable for installing manual Odaloggers on both inlet and outlet shall be provided and shall be lockable.

7.2.3 Condensate Trap

A high volume (in the order of 150mL) condensate trap shall be used. The trap shall have a clear bowl to visually check its performance and shall contain a suitable media to promote condensation. The trap will be connected to the suction side of the sample pump .

7.2.4 Sampling Pump

A sample pump (about 5 l/min) shall be provided to withdraw gas from the sampling port (and the condensate trap if applicable) and provide a sufficient gas sample volume to the analyser. The pump is to be of the positive displacement, diaphragm or high-speed graphite vane types or other suitably approved type, which provide a gas sample stream at constant flow and constant pressure to the analyser. The pump is to be capable of withstanding system back pressure and shall provide a minimum flow of 1 L/min to the sensor, at commissioning.

7.2.5 Flow Control Valves

From the outlet of the sampling pump the flow shall be split to two (2) flow control valves, one to control the flow to the H₂S analyser, and the other controlling a side waste stream that is

pipled back to the ductwork. One of these valves is typically incorporated into the flowmeter going to the H₂S analyser.

All flow control valves shall be of the high tolerance needle type valve, with stainless steel fittings and accessories. The valves shall be suitable to operate in the conditions of the online monitoring system, and shall be sized to suit the required flowrate at midrange of the valve performance characteristics.

7.2.6 Flow Meter

The flow meter shall be of the rotameter type, with a full-scale deflection of 1 L/min. The meter will be selected to ensure that all internal surfaces are suitable for the gases present in the sample airstream. The flow meter will be installed upstream of the analyser.

7.2.7 Manual Sampling Ports

Manual sampling ports shall be provided on the inlet sample line as well as on the discharge of the sample pump, to allow manual gas testing. The sampling port shall terminate in 12 mm full bore stainless steel ball valve pointing upwards.

7.2.8 Return of Foul Air

Additional tapping points, typically two (2), will be required upstream of the OCU for return of the foul air samples from the H₂S meters.

7.2.9 Analysers

Two principles of measurement shall be acceptable for monitoring H₂S gas levels, these being Electrochemical cell or photo optical methods.

7.2.9.1 Electrochemical Cells

Electrochemical cell type sensors shall be of proven design and capable of operating within the performance parameters and conditions described below.

ITEM	SPECIFICATION
Sampled Air Relative Humidity	15% to 90%
Temperature Range	-5°C to +40°C
Repeatability	2% of signal
Drift	Less than 5% per month
Operating Pressure	± 10% ambient
Output Signal	4 to 20 mA
Service Life	1 to 2 years
Response Time	Zero to +95% in 60 seconds
Recovery Time	1 to 5 minutes
Minimum Detection Limit	0.1 ppm _v
Maximum Range (inlet)	0 to 100 ppm _v

7.2.9.2 Photo Optical “Paper Tape” “Chemcassette” method

Sydney Water will only accept this method of monitoring for the outlet of OCUs at WWTP/WRPs. The paper tape type sensors are particularly sensitive to variation in ambient temperature. Where there may be the likelihood of ambient temperatures more than 25°C, an air-conditioned controlled temperature environment shall be provided in the monitoring cubicle, to ensure that the temperature of the paper tape cassette is maintained at 25°C.

Paper tape type sensors shall be of proven design and capable of operating within the performance parameters and conditions described below.

ITEM	SPECIFICATION
Sampled Air Relative Humidity	15% to 90%
Ambient temperatures	-5°C to +40°C
Repeatability	2% of signal
Drift	less than 5% per month
Operating Pressure	± 10% ambient
Output Signal	4 to 20 mA
Service Life (tapes)	1-month average for LP tapes
Sample Time	10 minutes maximum
Lower Detection Limit	0.005 ppm _v
Minimum Range (outlet)	0 to 1500 ppb _v

7.2.10 Pipework, Tubing and Ancillary Fittings

All pipework, tubing and ancillary fittings (nominal internal diameter at least 6mm) within the sampling and monitoring systems shall be as scheduled in the table below in order to be resistant to corrosion and chemical absorption.

ITEM	SPECIFICATION
Pipework (rigid pipe)	All rigid pipework will be in stainless steel grade 316.
Tubing (Flexible)	All flexible tubing to be used only within the cabinet and will be PTFE (Teflon [®]) or equivalent and be connected to barbed hose fittings.
Ancillary Fittings	All fittings that provide connection will be stainless steel grade 316 of the highest-grade compression type, providing proper seals to prevent low level gas escape.

All internal lines and surfaces are to be subjected to a passivation gas treatment in order to minimise chemical absorption.

All lines shall be graded to prevent capture of moisture and pressure drops due to moisture entrapment. Pipework shall provide a steady rise (preferred) or a maximum of one high point - no low points will be acceptable.

All rigid sample lines are to be fixed where applicable by proper clamps that are similar or equal to ‘Stauff’ type. Mechanical protection of sample lines will be provided in those areas

where potential damage to the line may occur. All sample lines are to be kept to a minimum length.

Materials of construction for the pipework that has not been specified will not be accepted.

7.2.11 Monitoring cubicle

All electronic components of the monitoring system shall be mounted in a full length free standing cubicle similar to those used for SPS control cubicles (IP65 rating to AS 1939). The cubicle shall be:

- Painted stainless steel grade 316 with double opening doors (no centre pillar & secured top and bottom),
- Fitted with recessed/internal hinges to present a clean external face when the cabinet doors are closed,
- Have a lift out weather shield with wind resistant clips,
- Have suitable vents for natural convection,
- Suitable for locking with a padlock.

The cubicle shall include a power distribution board of suitable IP rating with circuit breakers for each instrument, a RCD protected 240V GPO, and auxiliary cubicle items (for example, exhaust fans, light).

The cubicle shall be fitted with a suitable light that is activated by opening the doors, an exhaust fan, and thermostatically controlled heater to prevent condensation during cold periods.

All equipment shall be mounted on full size backboard made from a suitable non-metallic material.

The cubicle shall nominally contain all required H₂S monitors and possibly others such as LEL and differential pressure transmitters. Careful layout of this cubicle is required with regard to levels to achieve steady grading of all sample tubing while also achieving a practical layout that allows both easy reading of displays and easy access for maintenance.

7.3 Calibration

Calibration will be provided on all equipment supplied within the sampling and monitoring system, and will be carried out in accordance with the guidelines stated in Section 7.1 of this Specification.

The calibration of all analysers, whether they be of the electrochemical or the photo optical type, will be carried out in accordance with either of the approved methods as detailed in the following;

- AS 3580 Method 2.1 – “Preparation of Reference Test Atmospheres – Permeation Tube Method”
- AS/NZ 3580 Method 2.2 – “Preparation of Reference Test Atmospheres – Compressed Gas Method”

Where proprietary calibration methods are used in checking the calibration of an analyser, the complete unit will be required to undergo calibration checks on a scheduled basis, to ensure that the total unit, and not simply the equipment electronics, is in full calibration.

8 INSTALLATION

8.1 Approval

Prior to installation, statutory approval from the local authorities shall be obtained.

8.2 Installation Practice

The installer shall be familiar with specification for the works and shall ensure that works are completed in accordance with good industrial practice. Written approval from the Principal and the designer shall be obtained for any deviations from the accepted design.

8.3 Materials and Equipment Inspection

Prior to transportation to site, materials and equipment shall be checked for compliance with the appropriate Specification or Standard by conducting a Factory Acceptance Test (See Section 9.1 of this Specification). The Contractor with the participation of the Principal's representative shall conduct these tests. On site, prior to installation, materials and equipment shall be checked to ensure that they are free from damage caused during transportation and are fit and suitable for use.

9 COMMISSIONING

Following installation, the OCU shall be tested and commissioned in accordance with Sydney Water's Maintenance Related Clauses for Capital and Operational Projects MEFA0001 (Section 7: Testing and Commissioning). The checklist in Appendix 1 and 2 of Sydney Water's Asset Commissioning Standard Administration Procedure (SAP) IMS0035, shall be used by the Commissioning Coordinator to ensure all the Principal's requirements for asset commissioning are met.

The Contractor shall develop a commissioning plan, which shall be submitted to the Principal's representative for review. Written approval from the Principal's representative shall be sought prior to commissioning.

The Contractor shall provide the necessary expertise and resources for successful commissioning of the unit.

9.1 Pre-Commissioning (Factory Acceptance Test)

Pre-Commissioning of the OCU shall be carried out at the factory in the presence of relevant personnel from the Principal, prior to transportation to the relevant sites. The pre-commissioning work shall include the following*:

- Running of the OCU and the testing of each fan's operation against its performance curve and design operating point.
- Testing of the control logic, sensors and programming.
- Testing of fail-safes and IICATS/SCADA alarms.
- Testing of dosing units, including pipe work, if pre-constructed.
- Structural integrity of OCU vessels.
- The whole structure of each OCU shall be examined for any fugitive emissions that may be the result of leaks.
- Air flow rates and designed retention times are to be confirmed.
- Noise testing using certified testing equipment.

The OCU shall not be transported to site until the Principal's representative has accepted the tests*.

*Note * For some large WWTP installations (e.g. Malabar, North Head, Bondi, etc.) it may not be possible to carry out all the pre-commissioning factory tests as listed above due to the size of the OCU system (i.e. only Site Commissioning can be carried out). If this is the case then Commissioning works will include all Pre-Commissioning and Site Commissioning works as described in sections 9.1 and 9.2 once site installation is complete.*

9.2 Site Commissioning

Following installation, the OCU shall be test run for a minimum period of one (1) month. The Contractor is responsible for conducting on site performance tests to the Principals satisfaction, to prove compliance with the guarantees. At a minimum, the following shall be checked or carried out:

- Odorous gas component(s) removal rate
- Pressure, relative humidity, and flow rate of inlet and outlet gases
- Equipment operation and adjustment checks.
- Casing and insulation joint testing, for example, using soap bubble test at operating pressure.
- Noise testing using certified testing equipment.
- Structural inspection by a certified Structural Engineer.
- Controls and Alarms

During the test run period, the Contractor shall maintain the OCU in a proper working manner. The unit shall be used to demonstrate system performance to the Principal's satisfaction. The Contractor shall carry out any work necessary to ensure the OCU is working correctly. At the end of this period, the Contractor shall issue a certificate to verify that the unit is working properly.

The Contractor shall supply all WAC Drawings, O&M Manuals along with trouble shooting guidelines and these shall be verified during the commissioning period. The O&M Manuals shall be in accordance with Sydney Water's Maintenance Related Clauses for Capital and Operational Projects MEFA0001 (Section 6: O&M Manuals) and Asset Creation Operational Readiness Standard D0000256 (Section 5.7: Operation and Maintenance Manuals).

9.3 Performance Testing

(i) General

Performance testing applies to all OCUs, unless specified by the purchaser.

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.

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

Before performing any tests, the Supplier shall arrange with the Purchaser to inspect the installation. When the following prerequisites are completed, the Purchaser will confirm a time for conducting the performance tests:

- The Purchaser has inspected the plant after commissioning and is satisfied with the installation and its function.
All documentation associated with commissioning have been received and approved by the Purchaser.
- All test equipment used during tests shall have a current calibration certificate (issued within the preceding 12 months) verifying its accuracy.

The Supplier shall operate and be responsible for test equipment used during performance testing. Before making any changes to the odour system that could affect equipment or processes external to the odour control system, the Supplier shall advise the plant operators of the intended change.

The Purchaser shall have the right to observe, sample, and carry out any tests in parallel during performance testing.

The Supplier shall include in their scope of work all sampling and laboratory analysis tasks. A Performance Testing Plan will be submitted to the Purchaser 4 weeks prior commencing the testing for approval. Laboratory analyses shall be done by an independent NATA accredited testing group. The testing group proposed by the Supplier shall be reviewed and accepted by the Purchaser.

The Performance Testing Plan shall include the verification of the guaranteed utilities (water, energy and nutrients consumption including pressure drop) and guaranteed removal of odour concentration and H₂S as outlined below to demonstrate the odour and H₂S removal efficiency of the equipment. Removal efficiency for both H₂S and odour is defined as:

$$\% \text{ removal} = (\text{inlet} - \text{outlet concentration}) / \text{inlet concentration} \times 100$$

The performance tests shall not be carried out until the Supplier is satisfied that the equipment has reached its optimum operational performance. The performance testing is to be carried out between the month of November to April and not within 1 week of a significant rain event resulting in STP flow rate greater than 4xADWF for longer than 2hrs. In the situation where commissioning is planned for the period May until October a practical completion preliminary testing can be carried out, but the official performance testing still will need to be completed during summer conditions.

The Supplier shall carry out the odour and H₂S performance assessment during dry weather, and when plant unit processes are operational under normal conditions. The Purchaser shall approve of proposed performance assessment time frame.

The collection and analysis of the odorous air samples shall be carried out in accordance with the requirements of the local environmental authority and AS/NZS 4323.3.

No manual adjustment of valves or instrumentation associated with the OCU will be allowed during the test period.

The odour control system shall be operated, to the satisfaction of the Purchaser, for seven (7) consecutive days without any major faults or alarms requiring attendance on site.

The gas flow rate and the OCU inlet gas pressure shall be maintained as close as practical (+/- 5%) to the design conditions. The Supplier must be satisfied that the air flow rate through the scrubbing system is in accordance with the design gas flow rates and conditions before commencing the performance tests.

Within 10 working days of the completion of the test period, the Supplier shall provide a written test report showing all laboratory and field test results. The report shall state the conclusions of the tests with reference to the performance criteria.

The methods to obtain all measurements and make calculations shall be included in the Performance Test Procedures and shall be carried out to the satisfaction of the Purchaser.

At the completion of the performance tests copies of the performance test data log sheets shall be provided by the Supplier to the Purchaser.

If OCU system fails to meet the performance requirements, the Supplier shall rectify the problems immediately. The Supplier shall, at no extra cost to the Purchaser, carry out all work necessary to ensure and prove that the equipment achieves the specified performance. When rectification work is complete, the equipment shall be retested to verify that the specified performance has been achieved.

If after two re-tests the performance requirements are still not met, then at the Purchaser's discretion only, the Purchaser may elect to accept the system as is, require the Supplier to make system modifications at the sole expense of the Supplier, or obtain a replacement at the expense of the Supplier. If system modifications are deemed necessary, additional tests shall be performed by the Supplier until performance requirements are proven to be met. All costs associated with re-testing shall be borne by the Supplier.

The maximum time between each re-test will be 30 days.

(ii) Odour Sampling and Testing for OCUs at WWTP/WRPs

- Two odour samples on the gas inlet and outlets of each OCU shall be taken per day. The inlet and outlet samples should be taken at approximately the same time to allow removal efficiency performance to be calculated and each set of inlet/outlet samples shall be taken at greater than 1-hour intervals to reflect the peak odour load notionally from about 9 am till 12 pm.
- The tests shall be repeated on two (2) consecutive days, such that a minimum of 4 inlet and 4 outlet odour samples are taken, i.e. a total of 8 samples.
- Care shall be taken to prevent the contamination of the sampling and analysis equipment of the low odour samples by the high odour samples.
- The odour samples shall be analysed within 24 hours of collection and shall not be exposed to direct sunlight before analysis.

(iii) H₂S Sampling and Testing

Continuous H₂S monitoring instruments for the OCU inlet and two outlet gas streams are required for the test period. The inlet and outlet readings are to be recorded for the seven (7) consecutive days corresponding with the test period described above in section (i). The H₂S monitoring instruments will be Odalog instruments or equal (provided with a recent calibration certificate showing proper calibration of the Odalog instrument). For the inlet airstream, a 0-50 ppmv range and for the outlets a 0-5 ppmv range will be used.

(iv) Analysis of Results

Odour removal efficiency for each of the inlet/outlet sample sets of each of the two consecutive test days shall be calculated using each individual odour concentration as determined by the NATA accredited lab.

- At least ten out of the twelve daily inlet/outlet readings meet the removal efficiency performance criteria as specified in the section 2.2.2.; and
- The average of all the daily inlet/outlet results meet the removal efficiency performance criteria as specified in the section 2.2.2.; and
- At least three out of the four OCU outlet odour concentration readings meet the maximum concentration criteria as specified in section 2.2.2.; and
- The average of all the daily OCU outlet odour concentration readings meet the maximum concentration criteria as specified in section 2.2.2.

H₂S removal efficiency shall be calculated from the H₂S monitoring instruments results. The performance tests shall be successful if, for each day of the seven (7) day test period:

- The calculated removal efficiency, based on averaging all results, meets the removal efficiency performance criteria as specified in section 2.2.2.
- The OCU outlet H₂S readings, based on averaging all results, meet the maximum level performance criteria as specified in section 2.2.2.
- The minimum instantaneous H₂S removal efficiency doesn't drop below the performance criteria as specified in section 2.2.2.
- The maximum H₂S concentration leaving the OCU does not exceed the maximum guaranteed concentration as specified (see section 2.2.2.).

9.4 Records

All tests and inspections shall be documented identifying the date of the test, inspector's name, equipment used, results, and any adjustment action taken.

Fully detailed written reports shall be provided to the Principal's representative following a successful commissioning.

9.5 Handover

The Asset Commissioning SAP shall be followed to ensure all issues are finalised before handover of the OCU to Sydney Water's Operations Division.

10 DOCUMENT CONTROL

Title: Odour Control Unit Standard	
Current review date: 18/05/2018	Review Period: 2 years
BMIS file name: ACP0004	
Document owner:	Ken Wiggins – Urban Design & Engineering Manager
Prepared by:	Jason Smith – Senior Mechanical Engineer
Stakeholders Consulted:	Gino Iori – Service Delivery Officer Level 6 Jeffrey Scott – Plant Manager Level 2 José González – Service Delivery Officer Level 5 Doanh Tang – Service Planning Lead Leighton Cramp – SCADA Project Engineer Anthony Sinton – SCADA Config & Test Engineer Level 6 Jeffrey Layanto – SCADA Config & Test Engineer Level 6 Paul Zhou – Senior Electrical Engineer Michael Kacprzak – Service Delivery Officer Level 4 Louisa Vorreiter – Asset Class Strategy Leader Christie Sebaratnam – Lead Structural Engineer Ian Blair – Project Management Officer Tony Petrevski – Technical Assurance Leader
Approved by:	Ken Wiggins – Urban Design & Engineering Manager

11 CHANGE HISTORY

Title: Odour Control Unit Standard		
Current review date: 18/01/2011	Review Period: 2 years	Registered file: 2010/01346F
BMIS file name: ACP0004		
Document owner:	Janssen Chan – Policy, Standards & Materials Manager	
Prepared by:	Sally Rewell – Chemical Engineer José González – Technical Specialist	
Stakeholders Consulted:	Alfred Soliman – Product Strategy Planner Fredrick Rodrigo – Maintenance Engineer Officer 5-6 Gilbert Baes – SCADA Project Engineer Gino Iori – System Operations Officer 5-6 Jeffrey Scott – Plant Manager Level 2 Louisa Vorreiter – Asset Class Strategy Leader Matthew Whalan – System Operations Officer 1- 4 Philip Duker – Water Technical Manager Rod Mackenzie – Senior Planner	
Approved by:	Janssen Chan – Policy, Standards & Materials Manager	

Version	Date revised	Approved by	Author/s	Brief description of change
1	13/12/10	Janssen Chan	Sally Rewell & José González	First issue
2	18/1/11	Janssen Chan	Sally Rewell & José González	Minor formatting amendments
3	22/6/12		Jeff Scott & José González	Updated together with CH2MHill several specifications among them documentation, BTF, BTF with activated carbon polishing, performance testing as well as I&C.
4	7/9/2016		Louisa Vorreiter	Minor change in residence times for BTF.
5	18/05/18	Ken Wiggins	Jason Smith	Updates (including current standards, Valves & Dampers, EBRT, formatting, monitoring, DTC drawings, Safety in Design, fibreglass design requirements) with key stakeholder inputs based on lessons learnt from installations such as North Head BTF, Cronulla and Warriewood.

APPENDIX A – ACTIVATED CARBON P&ID

P&ID drawing for activated carbon unit (refer to drawing [SEW1700-S1701](#)) and where applicable P&ID for treated air to stack ([SEW1700-S1706](#)).

APPENDIX B – BIOTRICKLING FILTER P&ID

P&ID drawing for biotrickling filter unit (refer to drawing [SEW1700-S1703](#)), and where applicable, P&ID for activated carbon unit ([SEW1700-S1701](#)) and where applicable P&ID for treated air to stack ([SEW1700-S1706](#)).

APPENDIX C – CHEMICAL SCRUBBER P&ID

P&ID drawing for chemical scrubber unit (refer to drawing [SEW1700-S1702](#)) and where applicable P&ID for treated air to stack ([SEW1700-S1706](#)).

APPENDIX D – MONITORING SYSTEM P&ID

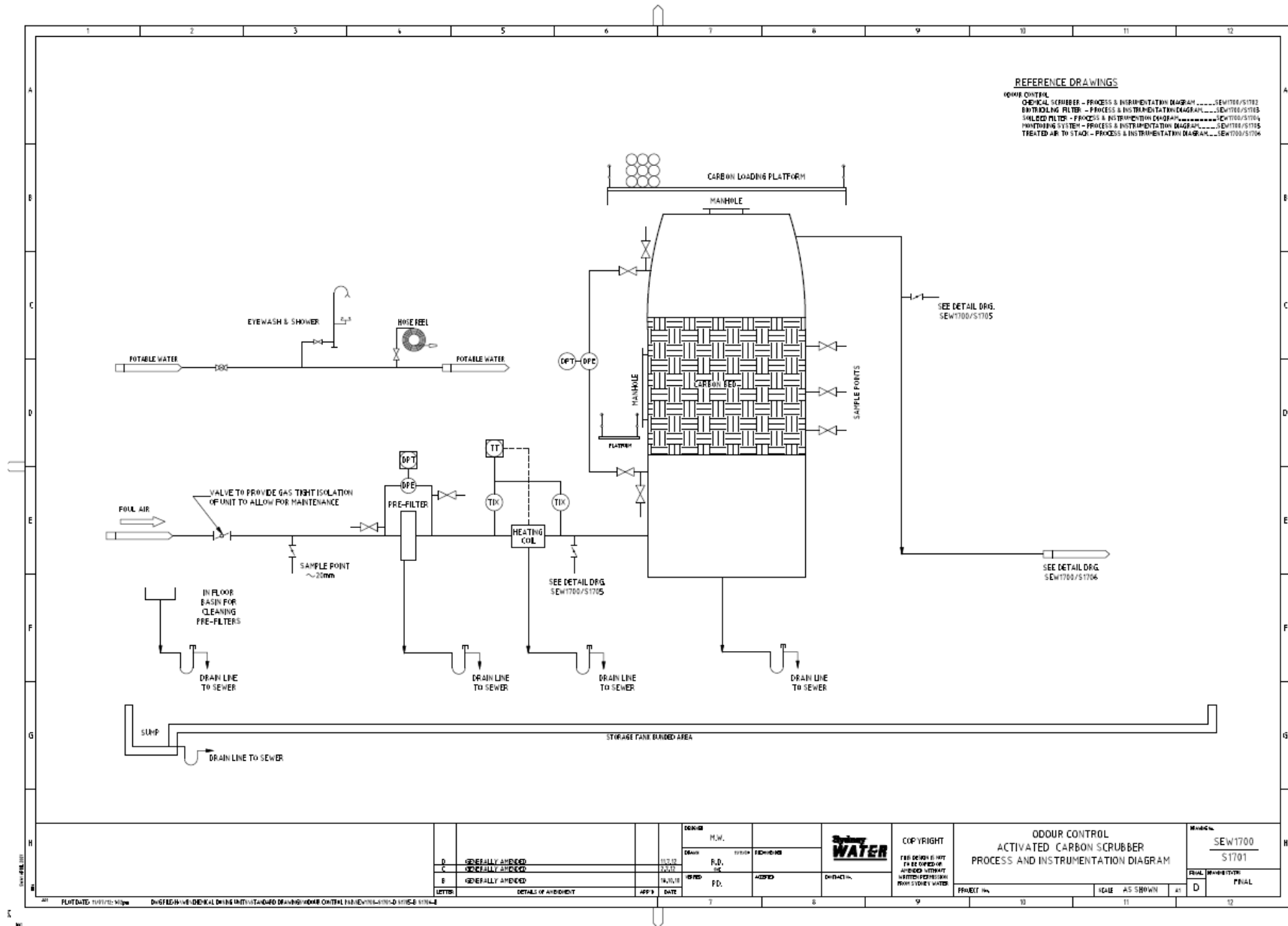
P&ID drawing for monitoring system (refer to drawing [SEW1700-S1705](#)).

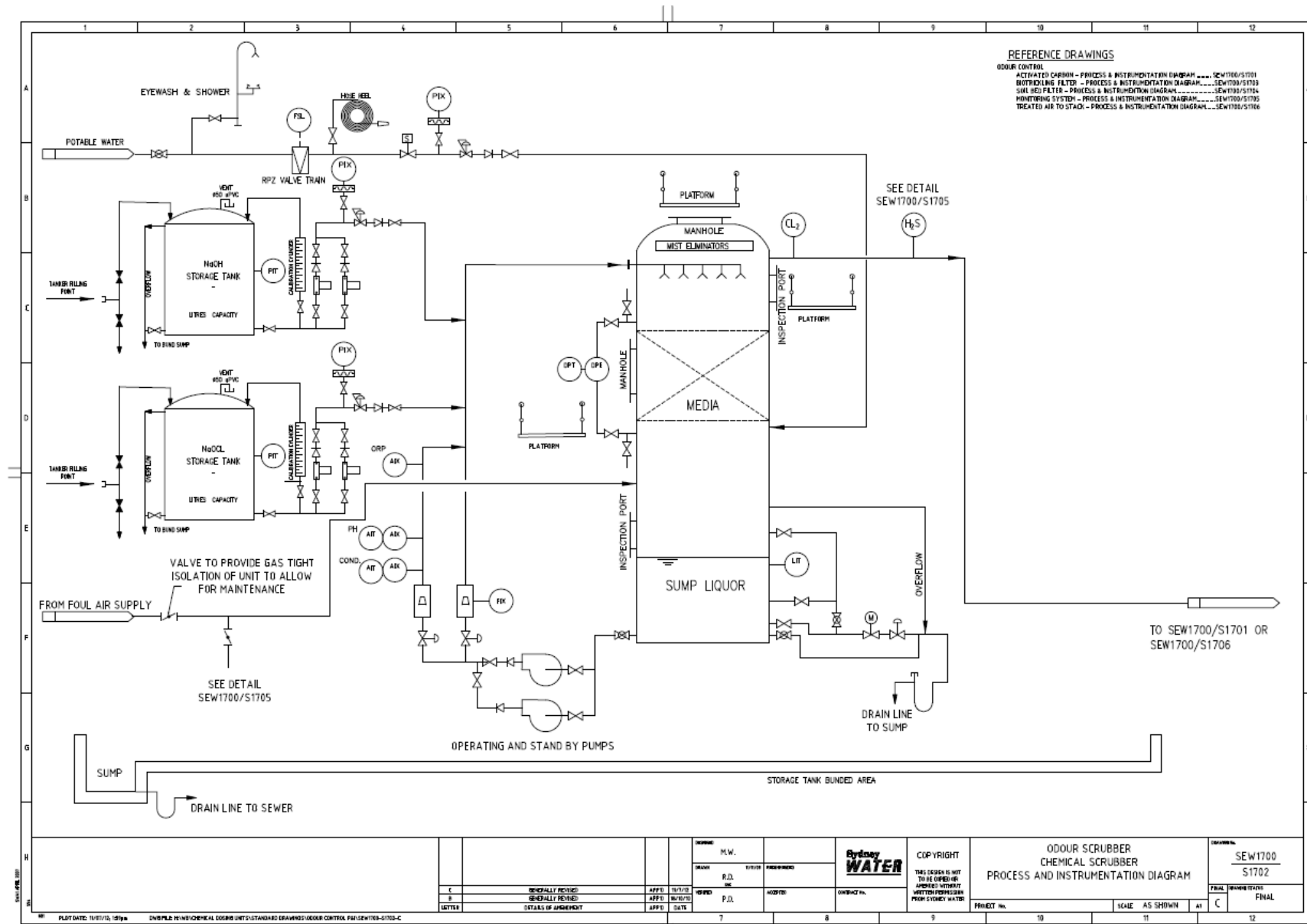
APPENDIX E – TREATED AIR TO STACK P&ID

P&ID drawing for treated air to stack arrangement (refer to drawing [SEW1700-S1706](#)).

APPENDIX F – BIOTRICKLING FILTER GENERAL ARRANGEMENT

P&ID drawing for treated air to stack arrangement (refer to drawing [SEW1700-S1708](#)).





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