Air Quality Assessment

Application to vary the Bespoke Installation Permit

Purolite Ltd.

Purolite Ltd. Unit C, Llantrisant Business Park, Llantrisant, Rhondda Cynon Taff, CF72 8LF

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ETL663/2022

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13 May 2022

QUALITY CONTROL

Document Title:	**Air Quality Assessment, Application to vary the Bespoke Installation Permit, Purolite Ltd. Unit C, Llantrisant Business Park, Llantrisant, Rhondda Cynon Taff, CF72 8LF**
Revision:	V1.0
Date:	13 May 2022
Document Reference:	ETL663/AQA/V1.0/Purolite/May 2022
Prepared For:	Purolite Ltd.
Project Reference:	ETL663/2022
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Quality control sign off

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Abbreviations

AAD	Ambient Air Quality Directive (2008/50/EC)
AGE	Allyl glycidyl ether
AOD	Above Ordnance Datum
AQA	Air Quality Assessment
AQMA	Air Quality Management Area
AQS	Air Quality Standards
AQSR	Air Quality Standards Regulations 2010
ASNW	Ancient Semi Natural Woodland
AW	Ancient woodland
AWSUC	Ancient Woodland Site of Unknown Category
BAT	Best Available Techniques
BLD	Boundary layer depth
[redacted]	[redacted]
CLe	Critical level (concentration)
CLo	Critical load (deposition)
CO	Carbon monoxide
CO_2	Carbon dioxide
Defra	Department for the Environment, Food and Rural Affairs
EA	Environment Agency
EAL	Environmental Assessment Level
EC	European Commission
ELV	Emission limit value
EMS	Environmental Management System
EPCH	Epichlorohydrin
EPR	Environmental Permitting Regulations
EPUK	Environmental Protection UK
EU	European Union
GFS	Global Forecast System
GMAC	Glycidyl-trimethyl-ammonium chloride
H1	Environment Agency Horizontal Guidance Note H1
IAQM	Institute of Air Quality Management
IBC	Intermediate Bulk Container
IED	Industrial Emissions Directive
IMS	Industrial Methylated Spirit
LAQM	Local Air Quality Management
MCP	Medium Combustion Plant
n/a	Not applicable

N	Nitrogen
NGR	National Grid Reference
NRW	Natural Resources Wales
NTS	Non-Technical Summary
O_2	Oxygen
O_3	Ozone
PAWS	Plantation on Ancient Woodland Site
PC	Process Contribution
PEC	Predicted environmental concentration
RAWS	Restored Ancient Woodland Site
RCTC	Rhondda Cynon Taf Council
SAC	Special Area of Conservation
SEWBReC	South East Wales Biodiversity Records Centre Limited
SO_2	Sulphur dioxide
SPA	Special Protection Area
SSSI	Site of Special Scientific Interest
TG	Technical Guidance
TVOC	Total gaseous and vaporous organic substances, expressed as total organic carbon
VOC	Volatile organic compounds
WTR	Wildlife Trust Reserve

Executive Summary

The assessment presented herein has been undertaken to provide supporting evidence for an application to vary the bespoke installation environmental permit (permit reference EPR/AB3894ZF), for an organic chemical manufacturing plant operated by Purolite Limited.

The existing permit was issued by Natural Resources Wales (NRW) in 2018. The operator seeks to implement operational changes, including the addition of two new emission points to air including a stack from a bromine abatement plant associated with a new bromination process, and the addition of a second natural gas-fired back-up steam generator.

The Site is not situated within or near to an Air Quality Management Area (AQMA). The site is situated in a mixed land-use setting located within Llantrisant Business Park, Llantrisant, Rhondda Cynon Taff. The northern and western perimeter of the site is bounded by industrial units, with the eastern perimeter being adjacent to Llantrisant Common and Pastures Site of Special Scientific Interest (SSSI). The nearest residential premises is situated 0.4km to the southwest.

Quantification of the risk associated with emissions to air using the Environment Agency H1 screening tool identified the requirement for detailed modelling for the potential short-term impacts of nitrogen dioxide (NO_2) at human receptor locations in addition to the potential for long and short-term oxides of nitrogen (NOx) impact at conservation sites (ecological receptors).

Detailed assessment was undertaken using ADMS 5 dispersion model to calculate concentrations of the pollutants, from which dry deposition to sensitive conservation sites has also been calculated.

The predicted short-term impacts of NO_2 at human receptor locations were considered to be not significant.

The potential for long and short-term impacts of NOx at Cardiff Beech Woods Special Area of Conservation (SAC) and locally designated conservation sites were determined to be not significant. The potential for nutrient nitrogen and acid deposition to impact these sites was also considered unlikely.

At the Llantrisant Common and Pastures SSSI the predicted concentrations (PCs) and predicted environmental concentrations (PECs) of NOx were within the long-term (annual) limit. Predicted short-term (daily) NOx concentrations were within the lower (screening) limit and upper limit (used in conjunction with ozone for detailed NOx assessment).

The highest levels of nutrient nitrogen and acid deposition were predicted at areas of the SSSI adjacent to and/or within close proximity of the operation. On this basis, it is considered that the operation is unlikely to unduly impact the SSSI.

1. Introduction

1.1 Background

This document comprising an Air Quality Assessment (AQA), has been prepared by Earthcare Technical Ltd (ETL) on behalf of Purolite Limited. It supports an application to vary the bespoke installation environmental permit (permit reference EPR/AB3894ZF), which regulates the organic chemical manufacturing plant, namely the manufacture of agarose-based resin for pharmaceutical use, at Unit C, Llantrisant Business Park, Llantrisant, Rhondda Cynon Taff, CF72 8LF herein termed 'the Site' operated by Purolite Limited, herein termed 'the Operator'.

The permit was issued by Natural Resources Wales (NRW) on 31st May 2018 and is regulated under the Environmental Permitting (England and Wales) Regulations 2016 under Schedule 1, Part 2, Section 4.1 Organic Chemicals, Part A(1).

The operator seeks to implement operational changes, a summary of which can be found in the Non-Technical Summary (NTS) which accompanies this application.[1] The AQA has been prepared by ETL on behalf of the Operator and in conjunction with Shann Pitts Consulting Ltd, and further reference should be made to the permit variation application supporting documents for full process descriptions.[2,3]

The AQA presented herein has been carried out to provide supporting evidence for the addition of two new emission points to air including;

- a stack from a [redacted] abatement plant associated with a new bromination process; and
- the addition of a second natural gas-fired back-up steam generator.

A description of the processes at the plant and the sources of emissions to air is given in Section 2. Appendix A contains the Site drawings: the Site layout and Site elevations.

1.2 Site description

The Site is located 17km northwest of Cardiff. It is approximately 1.2km north northwest of Llantrisant and 1.9km west of Beddau. The centre of the Site is at approximate National Grid Reference (NGR) ST 04131 84511, as shown in Figure 1.

The Site is situated in a mixed land-use setting located within Llantrisant Business Park. The Site includes an industrial building (Unit C), within which the production process takes place, situated adjacent to Purolite's offices (Unit D). The northern and western perimeter of the site is bounded by industrial units on the Business Park, with the eastern perimeter being adjacent to Llantrisant Common and Pastures Site of Special Scientific Interest (SSSI).

Two further areas designated as 'Rhos Tonyrefail' SSSI are situated within 2km of the Site (the closest extent of which is approximately 0.88km to the northwest of the Site). Cardiff Beech Woods is

[1] Non-Technical Summary (SPC0055/Variation/NTS/V1/May 2022)

[2] Environmental Risk Assessment (SPC0055/Variation/ERA/V2/May 22)

[3] Best Available Techniques Assessment (SPC0055/Variation/BAT Assessment/V2/May 22)

nationally designated as a Special Area of Conservation (SACs) and is situated approximately 7km to the southeast. There are no designated Special Protection Areas (SPAs) within 10km.[4]

Within 2km of the site there is a Wildlife Trust Reserve located approximately 1km to the northeast, in addition to several sites of Ancient Woodland (AW) that include: Ancient Semi Natural Woodland (ASNW); Restored Ancient Woodland Site (RAWS); Plantation on Ancient Woodland Site (PAWS); Ancient Woodland Site of Unknown Category (AWSUC); and NRW Priority Area (Woodland – PAWS).[5,6]

The Site is not situated within or near to an Air Quality Management Area (AQMA).[7] The nearest AQMAs, all declared due to exceedances of the objective for nitrogen dioxide (NO_2) (annual mean), include:

- Mwyndy AQMA (approximately 3.2km, south-southeast).
- Llanharan AQMA (approximately 4.1km, southwest).
- Church Village AQMA (approximately 4.7km, northeast).
- Tonyrefail AQMA (approximately 4.8km, northwest), and
- Broadway AQMA (approximately 6.0km, northeast).

The nearest residential receptors include a farmhouse situated 0.4km to the southwest, a hospital (Royal Glamorgan Hospital) 0.5km to the southwest. The nearest commercial premises on the Llantrisant Business Park are situated 0.73km to the west of the centre of the Site.

At an elevation of approximately 70m Above Ordnance Datum (AOD) the Site occupies a lower position within marked valley topography where land rises to 100m AOD 0.2km to the southeast, and to 164m AOD 0.9km south southeast, and 251m AOD 1.6km to the southwest.

1.3 Scope of report

This AQA assesses the impact on human and ecological receptors of emissions to air from manufacturing and combustion processes undertaken at the Site.

The ADMS 5 dispersion model has been used to calculate concentrations of the pollutants, from which dry deposition to sensitive conservation sites has been calculated.

While Emission limit values (ELVs) and the air quality standards (AQS) for ecological receptors are specified for NOx, standards for human health are for nitrogen dioxide (NO_2) which is emitted as a by-product of combustion and is formed (and consumed) in chemical reactions including NOx and other species.

[4] https://magic.defra.gov.uk/MagicMap.aspx (accessed March 2022)

[5] Ecological data provided by South East Wales Biodiversity Records Centre Limited (SEWBReC)

[6] Rhondda Cynon Taf Council Local development Plan Constraints Map, February 2009 https://www.rctcbc.gov.uk/EN/Resident/PlanningandBuildingControl/LocalDevelopmentPlans/LDPEvidenceBaseLibraryandAnnualMonitoringRe/RelateddocumentsEvidenceBase/EB7d.pdf

[7] AQMAs interactive map (defra.gov.uk) Data based on 2022 AQMA Dataset (This is based on information reported by local authorities for 2022. This data set is correct as of March 2022.)

Predicted concentrations have been compared with relevant AQS (limits, targets, objectives, and environmental assessment levels) to assess their significance, considering background concentration data where relevant.

The pollutants considered in this AQA are:

- Oxides of nitrogen (NOx);
- Nitrogen dioxide (NO_2);
- Bromine (Br); and
- Odour.

Predicted depositions have been compared with critical loads for nutrient nitrogen deposition and acid deposition at sensitive conservation sites.

This report describes: processes on Site (section 2); relevant legislation and guidance for industrial emissions; ambient air quality and modelling of emissions to air (Section 3); the assessment methodology used to model concentrations of pollutants and odour (Section 4); assessment criteria (Section 5); background concentrations and deposition fluxes (Section 6); and results of the dispersion modelling (Sections 7, 8 and 9) before Section 10 concludes.

2. Process description

A full process description is provided in the supporting documents that accompany this permit application. The locations of point source emissions to air from the manufacturing facility are shown in the Permitted Site Layout Plan (Appendix A).

2.1 Existing process description

Agarose Manufacturing

The regulated facility is an agarose bead production process, for use in the pharmaceutical and organic chemical sector. Agarose, a polysaccharide, is a highly pure form of agar that is derived from seaweed. Agarose is the key raw input into the production process. The final products are in the form of spherical beads stored in 20% ethanol. The final cationic or anionic charged beads are either sold directly to customers or shipped to a packaging plant.

The plant is batch-operated, the complete production of a batch takes [redacted] days. [redacted] batches are completed, during the 48 weeks per year that the plant is operational. The [redacted]-day process involves a series of reaction, dilution, screening and mixing vessels. Steps range from mixing of the initial ingredients through to [redacted].

It is a batch process, which cannot be operated continuously. Heating and cooling are used to help control the reaction processes. Condensers are used as part of the process control, cooling the air coming off the vessels and allowing volatile organic compounds (VOCs) to re-enter solution and maintain a constant composition in the process vessel.

The production process is conducted entirely within a building under highly controlled conditions. Under normal operating conditions there are only controlled emissions to air from the main stack, emission Point Source (A1). The emissions to air comprise a variety of VOCs. Due to the batch nature of the process, emissions to air occur in peaks over time and not continuously.

Emissions to air from the main stack are controlled by ensuring:

- A minimum release velocity of 15m/s is maintained at all times to ensure effective dispersion from A1 and to prevent odour issues; and
- A flowmeter is fitted to the vent stack to monitor exit velocity. An alarm sounds if the velocity falls below 15m/s.

The stack has two standby fans to ensure emissions can still be released at the required velocity even if one fan fails. If a fan does fail, the SCADA system puts the plant into a controlled hold, alerting the operator to the issue so it can be rectified, during which time the velocity speed will still be maintained by the standby fan.

Combustion

There is an existing 510kWth Certuss Universal TC Steam generator, Point Source (A4), with a proposal to add another generator of the same specification as part of the permit variation. Steam generated

on-site is piped to various points of use. The additional back-up generator, Point Source (A5), is required to ensure sufficient steam supply for the most heat-intensive processes on site and to allow there to be contingency steam generation capacity. As a conservative assumption, the back-up generator will be required to operate for 4 hours only within a given 24-hour period and not every day. The Certuss steam generators are sized appropriately to accommodate the usage and ranges of operation. The steam generator specification is in Appendix D.

The steam generators (A4 and A5) will combust natural gas and will emit pollutants including NOx and carbon monoxide (CO), from individual stacks 8.2m in height, the impacts of which have been considered in this assessment.

2.2 Proposed process description

Additional [redacted] Process

The variation is required to reflect the addition of a [redacted] and cross-linking process to allow the production of additional end products for the pharmaceutical industry. The [redacted] process is carried out at ambient temperature and the cross-linking process at [redacted] degrees Celsius. There are a new set of process controls for the [redacted] and cross-linking processes. These have been linked to the existing Supervisory Control and Data Acquisition (SCADA) control system.

The [redacted] process is a batch process, on a [redacted]-hour cycle time. As a maximum there would be one batch per day, but not every day. As a worst-case assumption the process may be run up to five times per week. The period during which [redacted] is used is less than [redacted] hours from start to finish and therefore, as a maximum, the process may occur for up to [redacted] hours per week.

The [redacted] water is made up by transferring [redacted] litres (l) of water to the [redacted] water tank then transferring [redacted] in through a dip pipe below the water level to minimise vapour generation. This is then recirculated for [redacted] minutes by the pump before being pumped to the process vessel. The transfer line is then purged with air to clear the line. After [redacted] minutes of mixing, [redacted] is added to the [redacted] water tank from the local IBC [redacted] solution). The [redacted] is recirculated and then transferred to the [redacted] process (Reactor RE09) to neutralise the [redacted].

Air containing any excess unreacted [redacted] is treated via an abatement plant which is a media bed through which sodium formate liquid in droplet form is trickled down as gas is drawn through using a fan. The treated air comprising carbon dioxide (CO_2), produced as a result of the sodium formate and [redacted] reaction, and any residual [redacted] gas is released via a 10m stack, Point Source (A6), to atmosphere.

Air is also used to purge the process pipework. The air used in purging is routed through the [redacted] abatement plant for treatment prior to discharge through the abatement plant stack (A6). The potential impact to air of [redacted] has been assessed as part of the AQA.

Odour

[redacted] is an odorous gas and an assessment of the potential for odour impact from the [redacted] abatement plant stack has been included in the AQA as part of the current permit variation application.

A quantitative assessment of potential odour impact from the existing plant was undertaken for the original permit application.[8] The assessment, which combined estimated peak pollutant emissions data provided by Purolite Ltd and published data on odour thresholds, concluded that odour concentrations were not predicted to exceed the adopted threshold (3 OU_E/m^3) for odour nuisance at the modelled receptor locations.

Monitoring of point source emissions to air has subsequently been carried out to comply with Improvement Condition 1 of the permit with respect to monitoring of [redacted] at the main stack (A1) to test assumptions made within the original permit application.

Monitoring has also been undertaken on the additional Point Source A6. Monitoring data for both A1 and A6 has been used to inform an updated odour assessment presented herein to ensure that the conclusions of the previous AQA with regard to odour, submitted for the original permit application, remain valid.

2.3 Odour sources

For the existing process, the majority of the reactor vessels are connected to the main stack (A1) via condensers which use a heat exchanger to cool the air coming off the vessels and allow VOCs to re-enter solution. The exceptions to this are:

- The reactor vessels from which only hydrogen is released; and
- The [redacted] abatement plant which has its own dedicated stack.

In addition, four of the bulk chemical and waste storage tanks containing the most potentially odorous compounds have their tank breather valves (TBVs) connected to the main stack namely:

- [redacted] storage tank;
- [redacted] which is stored with nitrogen (for quality);
- Waste Stream D [redacted] waste; and
- Waste Stream F [redacted] waste.

TBVs not connected to the main stack are for tanks containing chemicals with a lower odour potential. The loss of vapour from all tanks is controlled through tank design; such as use of tall tanks with low surface area and appropriate pressure rating to reduce vapour loss. TBVs will not open under normal operating conditions. Losses are minimal with venting only occurring when the weather is warm enough for liquid to evaporate and build up headspace pressure high enough to overcome the breather valve. The losses of VOCs from TBVs not connected to the Main Stack are not considered to be significant and have therefore not been assessed further.

There is no odour potential from the hydrogen and nitrogen vents as these are odourless gases.

When liquid raw material tanks are being filled and waste tanks are being emptied for off-site disposal, there is a closed loop system for road tanker filling and emptying to ensure vapour return (except for

[8] Ricardo (2016) Air Quality and Odour Assessment. Ref: ED62380131- Issue Number 1.

GMAC). This system was introduced into site design to reduce vapour loss and to minimise odour emissions.

2.4 Summary of emissions to air

Table 1 lists the sources of emissions to air and summarises the rationale for inclusion within the impact assessment.

Table 1 Summary of point source emissions to air

Ref.	Source	Emissions	Rationale for further assessment	Requirement for further assessment
A1	Main stack	Odour	Release of odorous emissions of VOCs [redacted]	Quantitative odour assessment
A2	Hydrogen vent routing	Hydrogen and nitrogen	Venting of odourless gases	Not included
A3	[redacted] tank venting	Principally nitrogen	The storage tank vents low levels of nitrogen; the carbon filter is installed as a contingency to prevent [redacted] emissions	Not included
A4	Steam generator (Stack A)	NOx, CO	Emissions to air from combustion of natural gas	H1 and quantitative assessment
A5	Back-up steam generator (Stack B)	NOx, CO	Emissions to air from combustion of natural gas	H1 and quantitative assessment
A6	[redacted] abatement plant stack	[redacted], odour	Air containing any excess unreacted [redacted] is treated via an abatement plant and released via a 10m stack to atmosphere	H1 and quantitative odour assessment
TBVs	TBV01: [redacted] tank vent TBV02: Waste tank (stream A) vent TBV03: [redacted] tank vent TBV04: Waste tank (stream B) vent	Intermittent, low level VOC release	Contain chemicals with a low odour potential. The losses of VOCs from TBVs not connected to the Main Stack are not considered to be significant and have therefore not been assessed further.	Not included

The control measures in relation to point source emissions to air are further detailed within Table 6 of the Emissions Management Plan, a up to date version of which supports this permit variation application.[9]

[9] Emissions Management Plan, V2.0, Shann Pitts Consulting, May 2022

3. Legislation and guidance

3.1. Overview

This section describes the relevant legislation, policy, and guidance relevant to this assessment which is summarised in Table 2 and described further in Sections 3.2 to 3.3. Section 5 summarises the air quality limit values, objectives and Environmental Assessment Levels (EALs).

Table 2 Summary of legislation, policy and guidance

Short name	Name	Body	Scope
Legislation			
1995 Act	Environment Act 1995[10]	UK Parliament	Establishes the framework for managing air quality to achieve compliance with air quality objectives
4th Daughter Directive	Directive 2004/107/EC[11]	European Commission, now EU	Sets limit values for arsenic, cadmium, mercury, nickel and polycyclic aromatic hydrocarbons in ambient air
AAD	Ambient Air Quality Directive 2008/50/EC[12]	EU	Ambient air quality, sets limit and target values
IED	Industrial Emissions Directive, 2010/75/EU[13]	EU	Industrial emissions
MCPD	Medium Combustion Plant Directive, EU/2015/2193[14]	EU	Emission limit values for pollutants from combustion plant greater than 1MWth and less than 50MWth
AQSR	Air Quality (Standards) Regulations 2010[15] as amended in 2016[16]	UK Parliament	Ambient air quality, standards for pollutant concentrations. Transposed EU limit values defined in AAD into law in England and Wales
EPR	Environmental Permitting Regulations 2018[17]	UK Parliament	Industrial emissions. Transposed IED into law in England and Wales

[10] Environment Act 1995, 1995 Chapter 25, Part IV Air Quality
[11] DIRECTIVE 2004/107/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL, of 15 December 2004, relating to arsenic, cadmium, mercury, nickel and polycyclic aromatic hydrocarbons in ambient air
[12] DIRECTIVE 2008/50/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 21 May 2008 on ambient air quality and cleaner air for Europe comment on amendment
[13] DIRECTIVE 2010/75/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 24 November 2010 on industrial emissions (integrated pollution prevention and control)
[14] DIRECTIVE (EU) 2015/2193 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 25 November 2015 on the limitation of emissions of certain pollutants into the air from medium combustion plants
[15] Statutory Instrument: 2010 No. 1001, ENVIRONMENTAL PROTECTION, The Air Quality (Standards) Regulations 2010 comment on amendment
[16] The Air Quality Standards (Amendment) Regulations 2016, Statutory Instrument 2016 No, 1184, Made 6th December 2016
[17] The Environmental Permitting (England and Wales) (Amendment) Regulations 2018, Statutory Instrument 2018 No, 110, 29th January 2018

Short name	Name	Body	Scope
Guidance			
Defra permit guidance	Air emissions risk assessment for your environmental permit[18]	Department for Environment, Food & Rural Affairs and Environment Agency	How to undertake an air quality assessment for a permit
Organic Chemicals Sector BAT	How to comply with your environmental permit. Additional guidance for: Speciality Organic Chemicals Sector (EPR 4.02)[19]	Natural Resources Wales	Sets out indicative Best Available Technique (BAT) or appropriate measures
EA H4	Technical Guidance Note H4 – Odour Management[20]	Environment Agency	Guidance on assessing odour impact, includes benchmark values
Defra SWIP	Specified generators: dispersion modelling assessment[21]	Environment Agency and Natural Resources Wales	Includes reference for conversion of NOx to NO_2
AQTAG06	AQTAG06 Technical guidance on detailed modelling approach for an appropriate assessment for emissions to air[22]	Air Quality Advisory Group	Guidance on calculating deposition
LAQM.TG16	Local Air Quality Management, Technical Guidance (TG16)[23]	Department for Environment, Food & Rural Affairs and the Devolved Authorities	Includes general guidance on dispersion modelling

3.2. Legislation

Environment Act

The Environment Act, which established the Environment Agency for England and Wales with functions including the control of pollution. Part IV of the Environment Act 1995 establishes the framework for managing air quality to achieve compliance with air quality objectives and for local air quality management (LAQM). Under LAQM local authorities (district councils) are required to monitor, review, assess and improve air quality in their areas; if exceedances are monitored or predicted, they

[18] Department for Environment, Food & Rural Affairs and Environment Agency, Air emissions risk assessment for your environmental permit https://www.gov.uk/guidance/air-emissions-risk-assessment-for-your-environmental-permit (accessed 11/5/2022)

[19] How to comply with your environmental permit. Additional guidance for: Speciality Organic Chemicals Sector (EPR 4.02), Natural Resources Wales, September 2014. https://naturalresources.wales/media/2105/how-to-comply-with-your-environmental-permit-additional-guidance-for-speciality-organic-chemicals.pdf

[20] Environment Agency (March 2011) Technical Guidance Note H4 - Odour Management. How to comply with your environmental permit

[21] Environment Agency and Natural Resources Wales, Specified generators: dispersion modelling assessment https://www.gov.uk/guidance/specified-generators-dispersion-modelling-assessment#nosubxsub-to-nosub2sub-conversion-ratios-to-use (accessed 9/9/2020)

[22] Air Quality Advisory Group, 2014, AQTAG06 Technical guidance on detailed modelling approach for an appropriate assessment for emissions to air

[23] Department for Environment, Food & Rural Affairs and the Devolved Authorities, Local Air Quality Management Technical Guidance (TG16), February 2018

must consider establishing an AQMA. Part IV requires the Secretary of State to prepare a National Air Quality Strategy.

Ambient Air Quality Directive and 4th Daughter Directive

The Ambient Air Quality Directive and 4th Daughter Directive contain **Limit Values** and **Target Values** with which the UK must comply. The Ambient Air Quality Directive also addresses the following: common methods and criteria; information on ambient air quality to help combat air pollution and nuisance, to monitor long-term trends; and making information and pollution alerts available to the public.

Industrial Emissions Directive

The Industrial Emissions Directive (IED) is the main EU instrument by which pollutant emissions from industrial installations are regulated. It consolidated seven earlier directives including, in particular, the Integrated Pollution Prevention and Control Directive and the Waste Incineration Directive. It defines ELVs for some process-fuel combinations but there are no ELVs relevant to the Biogas upgrading stack.

Medium Combustion Plant Directive

The MCPD regulates emissions of SO_2, NOx and dust to air and requires monitoring of CO emissions in order to reduce emissions and risks to human and ecological receptors. MCPD ELVs apply from 2025 or 2030 for existing plants, depending on their size.

The existing and proposed steam generators are of the same specification and both have a net rated thermal input of 510kWth and are therefore not Medium Combustion Plants (MCPs).

Air Quality Standards Regulations

The Air Quality (Standards) Regulations 2010 is the instrument by which the Ambient Air Quality Direction and the 4th Daughter Directive were transposed into English law.

Environmental Permitting Regulations

The Environmental Permitting (England and Wales) (Amendment) Regulations 2018 is the latest consolidated version of instrument by which the IED was transposed into national legislation.

3.3. Guidance

Air emissions risk assessment for your environmental permit

The webpage provides Department for Environment, Food & Rural Affairs (Defra) and Environment Agency (EA) guidance on how to carry an air emissions risk assessment. It replaced the Environment Agency, H1 Annex F – Air Emissions.[24] It includes guidance on the ecological receptors to be assessed, tests on significance on results, relevant air quality Limit Values (from the Ambient Air Directory), objectives from the National Air Quality Strategy and it lists short-term (hourly) and long-term (annual mean) **EALs** for human health.

Organic Chemicals Sector BAT

This document is a reference document on indicative Best Available Techniques (BAT) for the organic chemicals sector. The standards within the Organic Chemicals Sector BAT document are derived primarily from the current IPPC BREF document (Integrated Pollution Prevention and Control Reference Document on the Best Available Techniques for the manufacture of Organic Fine Chemicals, European Commission, August 2006). This includes BAT for managing activities and environmental performance, the associated emission levels (and other environmental performance levels) and the associated monitoring for this sector.

Technical Guidance Note H4 – Odour Management

The guidance from EA is intended for permit holders and applicants, to advise them on how to comply with odour conditions set by the permit. It covers, assessing odour pollution, measures to reduce pollution, control measures and monitoring. It contains advice on odour thresholds or benchmarks for assessment.

Specified generators: dispersion modelling assessment

The webpage provides Defra and EA guidance on how to do detailed air quality modelling for specified generators. This includes the use environmental standards for air, the use of NOx to NO_2 conversion ratios, and guidance on impact assessment.

Technical guidance on detailed modelling approach for an appropriate assessment for emissions to air

This document (AQTAG06) provides guidance on how to carry out a quantitative assessment (Stage 3 appropriate assessment) including guidance on calculating deposition for emissions to air in order to fulfil the requirements of the Habitats Regulations.

[24] Environment Agency, H1 Annex F – Air Emissions – now withdrawn. Version 2.2, December 2011

Local Air Quality Management, Technical Guidance

This technical guidance (LAQM.TG16) is published to support local authorities in carrying out their duties under the Environment Act 1995, which established the LAQM process. It provides guidance on monitoring and assessing air quality, action planning and reporting. While aimed at local authorities the advice is used more widely by those working in the field, and not just for LAQM.

4. Assessment Methodology

4.1 Introduction

The methodology comprised three parts which are described in more detail in Sections 4 to 6:

1. Assessment of baseline conditions at the Site and the surrounding area:
    - AQMAs and designated conservation areas; background concentration and deposition (section 6).
2. A preliminary H1 assessment was undertaken to screen out substances from further detailed assessment (section 4.2 and Appendix F);
3. Modelling of impacts:
    - assessment of the likely changes in concentration and deposition due to emissions from the sources listed in and operation of the plant under normal operating conditions. The assessment was undertaken using the ADMS 5 dispersion model (section 4.3).
    - The modelling assessment included an assessment of the sensitivity of model results and hence, the impacts, to changes in model input (section 4.3 and Appendix H).
    - Modelling of odour impacts due to odour emissions from the sources listed in Table 3.
4. Assessment of significance which is described in sections 5.2, 5.3 and 5.4.

If the impacts are significant then further investigation would be required.

4.2 H1 Screening assessment

The potential environmental impact of the proposed emissions to air from emission points A4 and A5 (steam generators), and A6 (bromination process abatement stack) has been evaluated using the EA's H1 risk assessment software tool (Version 2.78, January 2017). [25]

The H1 tool has been used to assess predicted emissions against EALs and to determine the requirement for detailed dispersion modelling or whether the environmental impact could be screened out as not significant. The published long and short-term EALs for NO_2, NOx (as NO_2) daily mean for ecological sites, short-term CO and short-term bromine EALs are pre-populated into the H1 risk assessment tool.[26]

The input data for H1 are those given in Table 6 and are further detailed in Appendix G. As detailed in Appendix F, the outcome of the H1 assessment was that the releases to air were not screened out as insignificant in respect of:

- NO_2 for short-term impacts on human receptors; and
- NOx for long and short-term impacts on ecological receptors.

[25] Environment Agency, H1 Software Tool User Guide, Version 2.78, January 2017

[26] GOV.UK Guidance Air emissions risk assessment for your environmental permit (Air emissions risk assessment for your environmental permit - GOV.UK (www.gov.uk) (accessed May 2022)

A detailed modelling assessment has been carried out in addition to a detailed assessment of odour. The H1 results are summarised in Appendix F H1 Screening Assessment for long-term and short-term AQS respectively.

Table 3 Sources of emissions to air to be assessed

Ref.	Source	Emissions	Actual Operating Profile	Modelled Operating Profile[1]
Existing Point sources				
A1	Main stack	Odour [redacted])	Batch process (21-day cycle). Plant operational 48 weeks per year (92% of the year or 8,086 hours)	Continuous (8,760 hours)
A1	Main stack	Odour [redacted])	Batch process (3.5 hrs per batch when there are emissions of AGE; 167 batches per year equates to 585 hours per year, or 6.67% of the year). Other odorous compounds may be emitted whenever the stack is emitting.	Continuous (8,760 hours)
A1	Main stack	Odour [redacted])	Batch process (15 hrs per batch, 167 batches per year, 2,505 hrs per year, 28.6% of the year)	Continuous (8,760 hours)
A4	Steam generator (Stack A)	NOx, CO	Batch process [redacted]-day cycle). Plant operational 48 weeks per year (80% of the time the plant is operational, or 74% of the year – [redacted] hours per year)	74% of the year (6,964 hours) [2]
New Point Sources				
A5	Back-up steam generator (Stack B)	NOx, CO	Back-up steam generator. Will operate ~5% of the time the plant is operational, or 4.6% of the year (404 hours per year) and no more than 4 hours per day [3]	4.6% of the year (404 hours)
A6	A6: [redacted] abatement plant stack	[redacted] Odour	10 hours/ week (480 hours/ year, or 5.48% of the year)	Continuous (8,760 hours)

Notes:

[1] Operational profile entered into the H1 screening tool

[2] Used to factor modelled long-term PCs for comparison with long-term (annual) AQS

[3] The back-up steam generator will not operate for more than 4 hours in any given 24-hour period. The corresponding factor was applied to modelled short-term (maximum daily) PCs for comparison with short-term (daily) NOx AQS.

4.3 Modelling of air quality impacts

Model

The dispersion model used to predict ambient concentrations due to the stack emissions was ADMS 5 (version 5.2.2.0). The model is termed a 'new generation' model and is commonly used in the UK for industrial permit applications to the EA and NRW.

It requires as input: data on the source of emissions and the mass emission rates of each pollutant (Table 4, Table 5), meteorological data and associated parameters, buildings data, terrain data, and receptor locations. Full details of the meteorological, buildings and receptor data are described in Appendix G.

The outputs calculated by the model are the air concentrations of pollutants from the sources modelled for the relevant averaging times and statistics. The contribution from the modelled sources on the Site, to air concentration and to deposition rates, are referred to the Process Contribution (PC), which is then compared with the relevant AQS. When background concentrations or deposition rates are added to the PC, the totals are referred to as Predicted Environmental Concentration (PEC) and Predicted Environmental Deposition Rate (PEDR) respectively, which are also compared with the relevant AQS.

From air concentrations of NO_2 the deposition rate of nitrogen can be calculated and the acid deposition due to nitrogen; from the air concentration of SO_2 the contribution of sulphur to acid deposition.

Model options and scenarios

One main emission scenario has been modelled, namely the continuous operation all year of all sources. In practice the main manufacturing process would operate for approximately 8,080 hours per year and the bromination process for 480 hours per year but they have been modelled assuming operation for 8,760 hours. To calculate representative annual means the long-term PC has been factored to reflect the operating hours for each stack-pollutant combination. However, for short-term PCs all emissions were assumed to be at the maximum and to operate for 8,760 hours per year (*,784 in a leap year). This is a pessimistic approach as it means the sources which do not operate continuously have been modelled coinciding with worst case meteorological data.

The model was run for each of the five years of meteorological data (2016-2020) for the following combinations of model option scenarios:

- Flat terrain: no buildings;
- Flat terrain: with buildings; and
- Terrain (hills): with buildings.

Results at the receptors were calculated as the maximum value at each receptor from these model runs and are therefore worst-case values across all five years and the three model options scenarios.

Model options and sensitivity

The impact of buildings, terrain, meteorological data year and choice of surface roughness value (z0d (m)) at the dispersion site (the Site) were assessed and the results are given in Appendix H.

The sensitivity tests showed that modelling buildings and terrain led to higher model predictions for human receptor locations than flat terrain without buildings. The variation due to the addition of buildings had the most pronounced effect particularly at nearby ecological receptor locations. Flat terrain with the inclusion of buildings resulted in the maximum predicted long and short-term concentrations at ecological receptor locations. The result of tests varying z0d led to a value of either 0.3m or 0.5m being used in the final model runs (the 15 model runs referred to in the previous section).

Sources and emissions

The source geometry, parameters, design emission limits and calculated emissions are given in Table 5 for point sources: A1 (Main Stack); A4 (Steam Generator Stack A), A5 (back-up Steam Generator Stack B); and A6 ([redacted] Scrubber stack). The source locations are shown in Figure 2.

Testing of the Main Stack (A1) has been carried out by Element Materials Technology Environmental Ltd, formerly Exova Environmental (UK) Ltd. Four monitoring events have been carried out fulfilment of Improvement Condition (IC) 1 required under the existing Permit. Appendix C includes the results of each monitoring event.

The monitoring data has been used to derive odour concentrations for measured pollutants, namely [redacted] and to verify the stack emission parameters. Odour concentrations were calculated by dividing pollutants by their applicable published odour threshold values and summing the total to provide a total odour concentration (odour unit per cubic meter or OU/m^3), from which an odour emission rate from the stack is calculated.

Where monitoring has not been required for certain pollutants under IC1, including [redacted] estimated peak emissions data has been relied upon, as provided by Purolite Ltd and Briggs of Burton. Appendix C - Main Stack (A1) includes the data provided; a summary of the data used as input is in Table 4.

Stack emissions testing has in addition been undertaken on the [redacted] abatement plant stack and the results are included as Appendix E. Two sample runs were undertaken during the [redacted] batch process, for a duration of 90 minutes on each occasion, as evidenced in a copies of the Batch Protocol (01/04/22) and Handover Log (01/04/22) provided in Appendix E - [redacted] Abatement Plant Stack (A6). [redacted] concentrations were recorded at the limit of detection for the method used on both occasions. As a robust assessment, this concentration has been used as input to H1 and for derivation of an odour concentration for release from the abatement plant.

The existing generator does not have an emission limit value ELV for releases to air set in the existing permit. Stack emissions test data for a comparable Certuss generator, have been provided by Purolite Ltd. Slightly higher NOx emissions (60ppm) were observed at 50% operating load when compared with full (100%) load (57ppm). As a conservative approach, emissions concentrations have been based on both generators operating continuously at 50% load. Assuming the continuous operation of these

sources provides a pessimistic prediction of impacts as the plant is operational for a total of 8,086 hours, and no account has been taken of plant downtime for maintenance. The manufacturer technical specifications and monitoring data used are given in Appendix D - Natural Gas Steam Generators (A4, A5)

Ongoing stack emission testing will be carried out as required subject to the assessment of the AQA by NRW during the permit variation application determination process.

The permit variation reflecting the addition of two new emissions points to air, namely the bromine abatement plant stack (A6) and the second back-up steam generator (A5) may trigger a requirement for periodic emissions to air monitoring.

Table 4 Odour concentrations and emission parameters: A1 (Main stack), A6 (Bromination scrubber stack)

Pollutant	Odour Concentration (mg/m^3)	Odour Threshold (mg/m^3)	Odour Concentration (ou/m^3)	Odour emission rate (ou/s)
Main stack (A1) Estimated (Briggs Peak Emissions 10/11/16)				
[redacted]	165	0.043 [27]	3,838	452
[redacted]	9,078	0.28 [27]	32,420	3819
[redacted]	-	0.28 [27]	-	-
[redacted]	448	4 [28] – 13.12 [29] *	112	13
Flow rate m3/s (ACTUAL)				0.118
Main stack (A1) Monitored Peak Emissions				
[redacted]	5,518	0.644 [27]	8,569	778
[redacted]	1,198	0.28 [27]	4,277	388
[redacted]	5.19	44.0 [30]	0.12	0.01
[redacted]	73.7	3.52 [31]	20.9	1.90
Flow rate m^3/s (REF)				0.091
Total (point source A1)			**49,237**	**5,454**
[redacted] **abatement plant stack (A6)**				
[redacted]	0.03	0.352	0.085	0.006
Total (point source A6)			**0.085**	**0.006**
Notes: * As a conservative approach, the lower odour threshold value cited within the literature has been applied, consistent with the previous AQA assessment approach.[8]				

[27] SEPA Odour guidance 2010 (https://www.sepa.org.uk/media/154129/odour_guidance.pdf) Accessed May 2022.

[28] Woodfield, M. and Hall, D. (1994) Odour measurement and control – An update. AEA Technology National Environmental Technology Centre.

[29] Pubchem National Library of Medicine National Center for Biotechnology Information. Methanol. (https://pubchem.ncbi.nlm.nih.gov/compound/887#section=Surface-Tension)

[30] Pubchem Compound Summary Allyl glycidyl ether https://pubchem.ncbi.nlm.nih.gov/compound/Allyl-glycidyl-ether#section=LogP (after Ruth, J.H.; Am Ind. Hyg. Assoc. J 47: A-142-51 (1986) Odor thresholds and irritation levels of several chemical substances: a review.) Accessed May 2022.

[31] Epichlorohydrin (1-Chloro-2,3-Epoxypropane) (https://www.epa.gov/sites/default/files/2016-09/documents/epichlorohydrin.pdf) Accessed May 2022.

Table 5 Stack and emission parameters: A1 (Main stack), A4 and A5 (Steam generators), A6 (Bromination scrubber stack)

Parameter	Units	(A1) Main stack[1]	(A6) [redacted] stack[2]	(A4, A5) Natural Gas generators[3]
Location	NGR (X,Y) m	304170, 184500	304161, 184509	(A4) 304152, 184505 (A5) 304151, 184504
Stack height	m	12.7	10.0	8.2
Internal diameter at stack exit	m	0.09	0.10 [5]	0.30
Load	%	Batch process	Batch process	50%
Volume flow rate (dry)	Nm^3/s	0.091	0.067	0.15
Volume flow rate (wet)	Am^3/s	0.095	0.071	0.25
Velocity	m/s	15.0	9.05	3.56
Temperature	°C	15.1 [4]	19.5	187 [6] (226) [7]
Exit concentration [redacted] (REF)	mg/m^3	-	0.03	-
Exit concentration NOx	mg/m^3	-	-	73.1 [8]
Exit concentration NOx (REF)	mg/Nm^3	-	-	126 (3% O2)
Exit concentration CO	mg/Nm^3	-	-	331 [9]
Exit concentration CO (REF)	mg/Nm^3	-	-	570 (3% O_2)
Exit concentration Odour	OU/m^3	49,237	0.085	-
Emission rate [redacted]	g/s	-	0.000002	-
Emission rate NOx	g/s	-	-	0.018
Emission rate CO	g/s	-	-	0.083
Emission rate Odour	OU/s	5,454	0.006	-

Notes:

[1] Odour concentrations calculated based on stack emissions test data provided in Appendix C - Main Stack (A1)

- Briggs of Burton Estimated Data

Monitoring Results and estimated emissions concentrations provided by Purolite Ltd and Briggs of Burton. Odour concentrations and emission rates have been calculated based on measured stack diameter, and an average of volume flow rates across the sample periods. Emission rates shown are for the continuous operation of the plant.

[2] Based on stack emissions test data (Appendix E - Bromination Abatement Plant Stack (A6)

- Drawings

Monitoring results). Data on equipment, height, diameter of stack, and volume flow rate were supplied Purolite Ltd (Appendix E - [redacted] Abatement Plant Stack (A6)) and verified through monitoring. Emission rates shown are for continuous operation of the bromination process.

[3] 510kWth Certuss Universal TC Steam generator fuelled by natural gas (Appendix D - Natural Gas Steam Generators (A4, A5). NOx and CO concentrations have been calculated based on measured data, as supplied by the technology provider. Flue gas diameter, volume flow rate wet and dry taken/ calculated from the manufacturer's datasheet.

[4] Average exhaust temperature based on four sets of monitoring data (Appendix C - Main Stack (A1).

[5] The stack diameter at the point of release is narrowed to 0.1m (Appendix E - Bromination Abatement Plant Stack (A6)).

[6] Temperature at 50% load. 3.4% average measured oxygen content. (Appendix D - Natural Gas Steam Generators (A4, A5)).

[7] Temperature at 100% load. 3.4% average measured oxygen content (Appendix D - Natural Gas Steam Generators (A4, A5)).

[8] Based on measured concentration of 60ppm (73 mg/m^3 at 187°C) (Appendix D - Natural Gas Steam Generators (A4, A5)).

[9] Based on measured concentration of 29ppm (331 mg/m^3 at 226°C) (Appendix D - Natural Gas Steam Generators (A4, A5).

Table 6 H1 Input parameters

Parameter	Unit	A4	A5	A6
		Steam Generator Stack A	Steam Generator Stack B	[redacted] Abatement Stack
Effective height	(m	0	0	0.498
Efflux velocity	(m/s)	3.56	3.56	9.05
Total flow	(m^3/hr)	906.4	906.4	240
Measurement method	-	Estimated [1]	Estimated [1]	Periodic [2]
Load	(%)	74 [3]	4.6 [4]	5.5 [5]
Concentration				
NO_2	mg/m^3	73.1	73.1	-
NO_2 (Ecological – Daily Mean)	mg/m^3	73.1	73.1	-
CO	mg/m^3	331	331	-
Bromine	mg/m^3	-	-	0.03
Release rates				
NO_2	g/s	0.018	0.018	-
NO_2 (Ecological – Daily Mean)	g/s	0.018	0.018	-
CO	g/s	0.083	0.083	-
Bromine	g/s	-	-	0.000002

Notes:

[1] Based on monitoring data for comparable model, supplied by Purolite Ltd and Certuss (Appendix D - **Natural Gas Steam Generators (A4, A5).**

[2] Based on periodic monitoring data. Stack emissions testing undertaken on the bromination abatement plant stack on 01/04/22 for a total duration of 180 minutes during the bromination batch process.

[3] The Operator has estimated the operating mode for the existing Steam Generator (Stack A) is 80% of the time that the plant is operational. The plant operates for 8,086 hrs per year. Generator Stack A is therefore operational for ~6,469 hrs per year (or 74% of the year).

[4] The Operator has also estimated the operating mode for the proposed back-up Steam Generator (Stack B) will be 5% of the time that the plant is operational. The plant operates for 8,086 hrs per year. Back-up Steam Generator Stack B will therefore be operational for ~ 404hrs per year (or 4.6% of the year).

[5] The operating mode for the bromination process has been calculated based on a conservative assumption of 10 hrs operation per week (for 48 weeks) = 480 hrs per year (or 5.48 % of the time).

5. Assessment criteria

5.1 Air Quality Standards

European and national legislation, policy and guidance, as described in Section 3.2 to Section 3.3, set various limit values, target values, objectives and EALs that may apply to human or ecological receptors. These will be collectively referred to throughout this report as AQS.

The AQS are defined with respect to an averaging time and a statistic. Annual mean AQS are an example of a long-term AQS, which is defined over a long period of time as the effects of the pollutant on human health or the environment are chronic, that is, due to long-term exposure. Pollutants may also have acute impacts, that is, the effects become apparent after short period of exposure to high values. For these pollutants short-term AQS are defined, for instance the 1-hour limit for bromine is a maximum hourly average that must not be exceeded.

5.2 AQS for human health

Table 7 sets out the AQS for human health for the pollutants relevant to this assessment. The standards which apply at human receptor locations apply where people will be exposed to a pollutant for a period relevant to the standard such as at residential locations, hospitals and schools for annual mean values.

Table 7 Air Quality Standards for human health

Substance	Emission period	Limit (average)	Standard	Exceedances[1]
[redacted]	1-hour	70µg/m³	EAL (EPAQS Halogen and Hydrogen Halides (2006))	None
Carbon monoxide	8 hour running average across a 24-hour period	10,000µg/m³	AAD Limit Value	None
Nitrogen dioxide	1-hour	200µg/m³	AAD Limit Value	Up to 18 1-hour periods
Nitrogen dioxide	Annual	40µg/m³	AAD Limit Value	None

Notes: AQS taken from https://www.gov.uk/guidance/air-emissions-risk-assessment-for-your-environmental-permit
[1]number of times a year that you can exceed the limit

Significance of results

The Defra permit guidance addresses when impacts can be considered insignificant. The guidance considers initial screening and then detailed modelling.

At the initial screening stage, a PC can be screened out from further assessment if:

- the short-term PC is less than 10% of the short-term environmental standard, and
- the long-term PC is less than 1% of the long-term environmental standard

The second stage of screening considers the background concentration as well as the PC. The Predicted Environmental Concentration (PEC) is the sum of the PC and background concentration. A further assessment is not needed if:

- the short-term PC is less than 20% of the short-term environmental standards minus twice the long-term background concentration, and
- the long-term PEC is less than 70% of the long-term environmental standards

If the PC cannot be screened out on that basis, following detailed modelling, two tests are applied:

- the proposed emissions must comply with BAT associated emission levels (AELs) or the equivalent requirements where there is no BAT AEL
- the resulting PECs will not exceed environmental standards

If those tests are not satisfied it is necessary to consider whether: the PCs could cause the PEC to exceed an AQS; the PEC already exceeds an AQS; or the activity on site is not covered by a BAT reference document. Ultimately a cost-benefit analysis may be required.

5.3 AQS for sensitive conservation sites

Table 8 sets out the AQS for the pollutants relevant to this assessment for designated ecological site receptors. The AQS for which there are numerical values in Table 8 are critical levels (CLes) as they are values for concentrations of pollutants in air.

The critical loads (CLos) for deposition of nutrient nitrogen and acid deposition vary spatially and with habitat. Values of the maximum and minimum critical loads (CLomax, CLomin) for the most sensitive species/habitat are given in Table 9 .

Table 8 Environmental standards for protected conservation areas

Substance	Target	Emission period
Nitrogen oxide (expressed as nitrogen dioxide)[2]	30µg/m³	Annual
Nitrogen oxide (expressed as nitrogen dioxide)	75µg/m³, 200 µg/m³ but only for detailed assessments where the ozone is below the AOT40 critical level and sulphur dioxide is below the lower critical level of 10 micrograms per cubic metre	Daily
Ozone (used for detailed daily oxides of nitrogen assessment)	AOT40 of 6,000 microgram per cubic metre calculated from accumulated hourly ozone concentrations – AOT40 means the sum of the difference between each hourly daytime (08:00 to 20:00) ozone concentration greater than 80 micrograms per cubic metre (40 parts per billion) and 80 micrograms per cubic metre, for the period between 01 May and 31 July	Period between May and July
Nutrient nitrogen deposition	Depends on location, use www.apis.ac.uk[32] to check it, see Table 9	Annual
Acidity deposition	Depends on location, use www.apis.ac.uk to check it, see Table 9	Annual
Notes: Environmental standards taken from https://www.gov.uk/guidance/air-emissions-risk-assessment-for-your-environmental-permit [2]30µg/m³ is an AAD Limit Value		

[32] UK Air Pollution Information System (APIS) http://www.apis.ac.uk/)

Table 9 Nutrient nitrogen and acidity deposition critical loads and background values

Designation/ Receptor	Most sensitive habitat[1]	Relevant Nitrogen Critical Load Class	Nutrient Nitrogen (kg N/ha/yr)	Acidity Class	Acidity Critical Loads (keq)	Total Acid Deposition (Nitrogen|Sulphur) keq/ha/yr
Llantrisant Common and Pastures (SSSI) (E1 – E18)	Acid grassland	Inland dune pioneer grasslands	8-15	Acid grassland	MinCLminN: 0.366, MaxCLminN: 0.581 MinCLMaxS: 0.22, MaxCLMaxS: 1.65 MinCLMaxN: 0.586, MaxCLMaxN: 2.88	1.3|0.3 (max); 1.2|0.2 (min); 1.2|0.3 (avg)
Rhos Tonyrefail (SSSI) (E19 – E24)	Acid grassland	Inland dune pioneer grasslands	8-15	Acid grassland	MinCLminN: 0.366, MaxCLminN: 0.581 MinCLMaxN: 0.66, MaxCLMaxN: 2.78 MinCLMaxS: 0.24, MaxCLMaxS: 1.64	1.4|0.3 (max); 1.2|0.3 (min); 1.2|0.3 (avg)
	Coniferous woodland (for nutrient nitrogen)	Coniferous woodland	5-15	Unmanaged Broadleafed/ Coniferous Woodland	MinCLminN: 0.285, MaxCLminN: 0.5 MinCLMaxS: 1.37, MaxCLMaxS: 2.969 MinCLMaxN: 1.316, MaxCLMaxN: 3.326	2.1|0.4 (max); 1.8|0.3 (min); 1.9|0.3 (avg)
	Broadleaved deciduous woodland (for acidity)	Broadleaved deciduous woodland	10-20	Unmanaged Broadleafed/ Coniferous Woodland	MinCLminN: 0.285, MaxCLminN: 0.5 MinCLMaxS: 1.37, MaxCLMaxS: 2.969 MinCLMaxN: 1.316, MaxCLMaxN: 3.326	2.1|0.4 (max); 1.8|0.3 (min); 1.9|0.3 (avg)
Cardiff Beech Woods (SAC) (E25 – E27)	Asperulo-Fagetum beech forests (H9130)	Fagus woodland	10 - 20	Unmanaged Broadleafed/ Coniferous Woodland	MinCLminN: 0.142 | MaxCLminN: 0.5 MinCLMaxS: 1.286 | MaxCLMaxS: 11.299 MinCLMaxN: 1.428 | MaxCLMaxN: 11.441	1.8 | 0.3 (max); 1.8 | 0.3 (min); 1.8 | 0.3 (avg)
ASNW (E28 – E30)	Broadleaved, Mixed and Yew Woodland	Acidophilous Quercus-dominated woodland:	10 - 20	Broadleafed/ Coniferous unmanaged woodland	CLminN: 0.357, CLmaxS: 2.94, CLmaxN: 3.297	1.88 | 0.33
ASNW (E31)	Broadleaved, Mixed and Yew Woodland	Acidophilous Quercus-dominated woodland:	10 - 15	Broadleafed/Coniferous unmanaged woodland	CLmaxS: 3 CLminN: 0.357 CLmaxN: 3.357	1.88 | 0.33
ASNW (E32)	Broadleaved, Mixed and Yew Woodland	Acidophilous Quercus-dominated woodland:	10 - 15	Broadleafed/Coniferous unmanaged woodland	CLmaxS: 2.984 CLminN: 0.357 CLmaxN: 3.341	2.01 | 0.33
ASNW (E33)	Broadleaved, Mixed and Yew Woodland	Acidophilous Quercus-dominated woodland:	10 - 15	Broadleafed/Coniferous unmanaged woodland	CLmaxS: 2.956 CLminN: 0.357 CLmaxN: 3.313	1.88 | 0.33

Designation/ Receptor	Most sensitive habitat[1]	Relevant Nitrogen Critical Load Class	Nutrient Nitrogen (kg N/ha/yr)	Acidity Class	Acidity Critical Loads (keq)	Total Acid Deposition (Nitrogen|Sulphur) keq/ha/yr
ASNW (E34)	Mixed and Yew Woodland	Acidophilous Quercus-dominated woodland:	10 - 15	Broadleafed/Coniferous unmanaged woodland	CLmaxS: 1.024 CLminN: 0.285 CLmaxN: 1.309	1.88 | 0.33
ASNW_PAWS (E35)	Mixed and Yew Woodland	Acidophilous Quercus-dominated woodland:	10 - 15	Broadleafed/Coniferous unmanaged woodland	CLmaxS: 0.915 CLminN: 0.285 CLmaxN: 1.2	1.84 | 0.31
ASNW_PAWS (E36)	Mixed and Yew Woodland	Acidophilous Quercus-dominated woodland:	10 - 15	Broadleafed/Coniferous unmanaged woodland	CLmaxS: 2.838 CLminN: 0.357 CLmaxN: 3.195	1.84 | 0.31
ASNW (E37)	Mixed and Yew Woodland	Acidophilous Quercus-dominated woodland:	10 - 15	Broadleafed/Coniferous unmanaged woodland	CLmaxS: 0.896 CLminN: 0.285 CLmaxN: 1.181	1.84 | 0.31
RAWS (E38 – E39)	Mixed and Yew Woodland	Acidophilous Quercus-dominated woodland:	10 - 15	Broadleafed/Coniferous unmanaged woodland	CLmaxS: 1.024 CLminN: 0.285 CLmaxN: 1.309	1.88 | 0.33
RAWS_PAWS (E40 – E43)	Mixed and Yew Woodland	Acidophilous Quercus-dominated woodland:	10 - 15	Broadleafed/Coniferous unmanaged woodland	CLmaxS: 0.896 CLminN: 0.285 CLmaxN: 1.181	1.84 | 0.31
RAWS (E44 – E46)	Mixed and Yew Woodland	Acidophilous Quercus-dominated woodland:	10 - 15	Broadleafed/Coniferous unmanaged woodland	CLmaxS: 0.927 CLminN: 0.285 CLmaxN: 1.212	1.89 | 0.29
PAWS (E47)	Mixed and Yew Woodland	Acidophilous Quercus-dominated woodland:	10 - 15	Broadleafed/Coniferous unmanaged woodland	CLmaxS: 0.901 CLminN: 0.285 CLmaxN: 1.186	1.84 | 0.31
PAWS_AWUC (E48 – E50)	Mixed and Yew Woodland	Acidophilous Quercus-dominated woodland:	10 - 15	Broadleafed/Coniferous unmanaged woodland	CLmaxS: 0.896 CLminN: 0.285 CLmaxN: 1.181	1.84 | 0.31
WTR (E51)	Acid grassland	Alpine and subalpine grasslands	5 - 10	Acid grassland	CLmaxS: 0.48 CLminN: 0.581 CLmaxN: 1.061	1.20 | 0.25
Notes: Information sourced from: UK Air Pollution Information System (APIS) http://www.apis.ac.uk/)						

Significance of results

For nationally designated sites the significance tests are the same as for human receptors (as given in section 5.2). For locally designated sites (AW, LWS), effects can be screened out as insignificant if the short-term and long-term PCs are less than 100% of the relevant AQS.

5.4 Odour benchmarks

Most odours arise from mixtures of pollutants and the odour threshold is judged subjectively.

EA H4 Odour Management guidance[20] sets out benchmark odour criteria based on the 98th percentile of hourly mean concentrations of odour modelled over a year at a site boundary, that is, the benchmarks are odour concentrations that may be exceeded during 2% of hours.

The benchmarks, to which predicted odour impacts have been compared are:

- 1.5 OU_E/m^3 for "most offensive" odours e.g. processes involving septic effluent or sludge, processes involving decaying animal or fish remains, biological landfill odours.
- 3.0 OU_E/m^3 for "moderately offensive" odours e.g. intensive livestock rearing, well-aerated green composting, sugar beet processing. Odours from poultry rearing and Wastewater Treatment Works operating normally i.e. non-septic conditions, are usually placed in the "moderately offensive" category.
- 6.0 OU_E/m^3 for "less offensive" odours e.g. brewery, bakery, coffee roasting.

Odours from the normal operation of the manufacturing plant are considered to fall within the "moderately offensive" category.

Odour concentrations have been calculated by dividing individual pollutants by their applicable published odour threshold values and summing the total to provide the total concentration in odour unit per cubic meter (OU/m^3). The predicted odour concentrations at receptor locations are then compared against an odour benchmark of 3 OU_E/m^3 as a 98th percentile.

6. Background concentrations and deposition fluxes

6.1 Air quality monitoring

The Site is situated within Rhondda Cynon Taf Council (RCTC). In response to breaches of the Air Quality Objectives for nitrogen dioxide, there are currently 16 AQMAs within Rhondda Cynon Taf. The nearest AQMA, Mwyndy AQMA, situated 3.2km to the southeast of the site, was declared on 01/11/2007, due to raised levels of NO_2 (above 40ug/m^3) and includes an area surrounding Lakeside Court, Penstowe. [33]

RCTC undertakes automatic monitoring of NO_2 at three roadside sites and, until 2020, PM_{10} at an additional site (4No. total) across its district.

The monitors are not located within the nearest AQMAs to the Site. RCTC also monitored NO_2 at 50 sites during 2020 using passive monitors, diffusion tubes, including a roadside location within the Mwyndy AQMA.[34]

There are 11 passive monitoring locations within 6km of the Site; nine of which are representative of roadside exposure. Table 10 shows the 11 site locations and annual mean concentrations for the years 2016 to 2020.

The nearest urban background monitoring locations (diffusion tube location No.103 located in Ty Mawr Farm, Efail Isaf) is located approximately 4.7km from the Site. Between 2016 – 2020, the maximum recorded annual mean NO_2 concentration was 8.9μg/m^3 (an average of 7.7 μg/m^3).

The nearest suburban background monitoring locations (diffusion tube location No.4 located in Lanelay Terrace, Maesycoed) is located approximately 5.9km from the Site. Between 2016 – 2020, the maximum recorded annual mean NO_2 concentration was 19.0μg/m^3 (an average of 15.5μg/m^3).

[33] AQMAs Declared by Rhondda-Cynon-Taff Council (Local Authority Details - Defra, UK)

[34] Rhondda Cynon Taf County Borough Council, 2021 Air Quality Annual Progress Report (ASR), June 2021

Table 10 Monitored annual mean background concentrations (µg/m³)

Ref.	X	Y	km from Site	Site Type	NO_2 Mean Concentrations (µg/m³)						
					2016	2017	2018	2019	2020	Average	Max
82	307281	184886	3.2	Roadside	36.7	30.8	28.4	24.9	19.4	29.5	36.7
37	305442	181579	3.2	Roadside	49.6	41	37.1	32.3	22.7	38.7	49.6
110	303533	181287	3.3	Roadside	36.2	30	29	30.5	18.6	30.1	36.2
111	300259	183082	4.1	Roadside	-	34.2	36.5	33.1	26.9	33.4	36.5
132	302880	180517	4.2	Roadside	43.4	35.8	29.5	31	19.6‡	36.6	43.4
85	308579	185863	4.6	Roadside	48.4	41.1	34.5	30.3	22.7	37.6	48.4
103	308817	183891	4.7	Urban Background	11.7‡	7.3	8.9	7.9	5.6	7.72	8.90
129	308687	185905	4.8	Roadside	36.9	28.2	23.9	23.1	18.1‡	29.8	36.9
122	300966	188131	4.8	Roadside	38.4	33.8	29.2	28.7	22.5	31.8	38.4
113	300976	188165	4.8	Roadside	43.5	40.4‡	33.9‡	31.4	25.1‡	39.5	43.5
4	306587	189833	5.9	Suburban	19	15.5	15.2	14.1	10.3	15.5	19.0

Notes: Data from Air Quality Annual Progress Report 2021.[34]
Means for diffusion tubes have been corrected for bias with means labelled with a ‡ having been "annualised" as per Boxes 7.9 and 7.10 in LAQM.TG16, as their valid data capture for the full calendar year is less than 75%.

6.2 Defra modelled background

Defra provides maps of background concentration that include concentrations of carbon monoxide (CO) (based on a reference year of 2001). Factors are provided to project the concentrations to future years.[35] The maps and factors have been used to determine 2019 background concentrations at each of the receptors which are shown in Table 11. Background concentrations of NOx and SO_2, for assessment of impact at ecological receptors, have been obtained from APIS.[36]

Background NO_2 concentrations are broadly comparable with the maximum 8.90 µg/m³ values monitored at the urban background site located 4.7km from the Site, and just below the average NOx concentrations (15.5 µg/m³) monitored at the suburban monitoring location 5.9km from the Site. The Defra spatially varying background concentrations have been used in this assessment for the human receptors.

[35] Defra, Background Maps, https://laqm.defra.gov.uk/review-and-assessment/tools/background-maps.html (accessed 6/3/2022)
[36] www.apis.ac.uk[Accessed 6 March 2022]

Table 11 2019 annual mean background concentrations (µg/m^3)

ID	Annual mean concentration (µg/m^3)	
	NO_2	CO
R1	13.1	220
R2	13.1	220
R3	13.1	220
R4	11.2	241
R5	11.2	241
R6	9.96	248
R7	9.24	232
R8	9.24	232
R9	10.9	225
R10	13.1	220
R11	13.1	220
R12	10.9	225
R13	10.9	225
R14	10.9	225
R15	13.1	220
R16	13.1	220
R17	13.1	220
R18	8.15	217
R19	8.15	217
R20	8.15	217
R21	8.36	225
R22	11.2	241
Notes: Data from Defra Background Maps.[35] The maximum background value of CO at any receptor location has been applied for H1 assessment purposes.		

6.3 NOx concentration at sensitive conservation sites

Background concentrations of NO_X and sulphur SO_2 at the ecological receptors have been obtained from APIS designated site-specific values for the designations, and the APIS location-specific values for the AWs and LWSs; they are an average for the years 2017-2019 and are shown in Table 12. NOx concentrations are given on a 1km grid cell basis.

Background deposition fluxes for nutrient nitrogen deposition (NDep) are provided by APIS on a 5km grid cell basis with values for deposition to woodland and grassland on a grid-averaged value. The values are given in Table 12.

Acid deposition due to nitrogen (NAcidDep) and sulphur (SAcidDep) are also supplied by APIS on a 5km grid cell basis. Values for the nationally designated sites are specific to the designated site and those for locally designated sites have been selected as the local value for acid deposition to the sensitive habitat. The values used are given in Table 9.

Table 12 Background concentrations at ecological receptors

ID	Receptors	NOx (µg/m³)	SO_2 (µg/m³)	NDep (kgN/ha/yr)
E1	Llantrisant Common & Pastures SSSI (1)	15.69	1.82	16.52
E2	Llantrisant Common & Pastures SSSI (2)	15.69	1.82	16.52
E3	Llantrisant Common & Pastures SSSI (3)	15.69	1.82	16.52
E4	Llantrisant Common & Pastures SSSI (4)	15.69	1.82	16.52
E5	Llantrisant Common & Pastures SSSI (5)	15.69	1.82	16.52
E6	Llantrisant Common & Pastures SSSI (6)	15.69	1.82	16.52
E7	Llantrisant Common & Pastures SSSI (7)	15.69	1.82	16.52
E8	Llantrisant Common & Pastures SSSI (8)	15.69	1.82	16.52
E9	Llantrisant Common & Pastures SSSI (9)	15.69	1.82	16.52
E10	Llantrisant Common & Pastures SSSI (10)	15.69	1.82	16.52
E11	Llantrisant Common & Pastures SSSI (11)	15.69	1.82	16.52
E12	Llantrisant Common & Pastures SSSI (12)	15.69	1.82	16.52
E13	Llantrisant Common & Pastures SSSI (13)	15.69	1.82	16.52
E14	Llantrisant Common & Pastures SSSI (14)	15.69	1.82	16.52
E15	Llantrisant Common & Pastures SSSI (15)	15.69	1.82	16.52
E16	Llantrisant Common & Pastures SSSI (16)	15.69	1.82	16.52
E17	Llantrisant Common & Pastures SSSI (17)	15.69	1.82	16.52
E18	Llantrisant Common & Pastures SSSI (18)	15.69	2.22	16.52
E19	Rhos Tonyrefail SSSI (1)	10.83	1.51	17.08
E20	Rhos Tonyrefail SSSI (2)	10.83	1.76	17.08
E21	Rhos Tonyrefail_SSSI_AW (3)	10.83	1.51	17.08
E22	Rhos Tonyrefail SSSI_AW (4)	9.410	1.44	17.08
E23	Rhos Tonyrefail SSSI (5)	9.410	1.44	17.08
E24	Rhos Tonyrefail SSSI (6)	9.410	1.44	17.08
E25	Cardiff Beech Woods SAC (1)	13.08	1.35	25.76
E26	Cardiff Beech Woods SAC (2)	19.48	1.82	25.76
E27	Cardiff Beech Woods SAC (3)	13.69	1.36	25.76
E28	Ancient Semi-Natural Woodland (1)	11.41	1.52	26.32
E29	Ancient Semi-Natural Woodland (2)	11.41	1.52	26.32
E30	Ancient Semi-Natural Woodland (3)	11.41	1.52	26.32
E31	Ancient Semi-Natural Woodland (4)	10.19	1.51	28.14
E32	Ancient Semi-Natural Woodland (5)	11.69	1.51	28.14
E33	Ancient Semi-Natural Woodland (6)	9.740	1.52	26.32
E34	Ancient Semi-Natural Woodland (7)	10.89	1.52	26.32
E35	ASNW Plantation on Ancient Woodland Site (8)	10.89	1.81	25.76
E36	ASNW Plantation on Ancient Woodland Site (9)	18.85	1.81	25.76
E37	Ancient Semi-Natural Woodland (10)	14.23	1.81	25.76
E38	Restored Ancient Woodland Site (1)	10.89	1.52	26.32
E39	Restored Ancient Woodland Site (2)	10.89	1.52	26.32
E40	Restored Ancient Woodland Site_PAWS (3)	14.23	1.81	25.76
E41	Restored Ancient Woodland Site (4)	14.23	1.81	25.76
E42	Restored Ancient Woodland Site (5)	14.23	1.81	25.76
E43	Restored Ancient Woodland Site (6)	14.23	1.81	25.76
E44	Restored Ancient Woodland Site (7)	13.93	1.54	26.46
E45	Restored Ancient Woodland Site (8)	13.93	1.54	26.46
E46	Restored Ancient Woodland Site (9)	13.93	1.54	26.46
E47	Plantation on Ancient Woodland Site (1)	11.33	1.81	25.76
E48	Plantation on Ancient Woodland Site (2)	14.23	1.81	25.76
E49	Plantation on Ancient Woodland Site (3)	14.23	1.81	25.76
E50	Ancient Woodland Site of Unknown Category (1)	14.23	1.81	25.76
E51	Y Gweria Pasture Wildlife Trust Reserve	12.97	1.54	16.80

Notes: Data from UK Air Pollution Information System (APIS).[32]

6.4 Odour

The manufacturing plant has been operational since 2018. The [redacted] process has been under trial since 2020. There have been no odour complaints received since operations began.

[redacted] is an odorous compound the release of which and is controlled through the [redacted] abatement plant, the function of which is described in Section 2 and further detailed in the updated supporting Emissions Management Plan.[9] If odour is found to be an amenity issue, then an Odour Management Plan will be developed in consultation with NRW.

Where there is no history of odour problems then modelling may not be required by NRW although it is noted that there can still be an underlying level of annoyance without complaints being made. Monitoring data for both A1 and A6 has been used to inform an updated quantitative odour assessment to ensure that the conclusions of the previous AQA remain valid.

7. Impact assessment of air quality on human health

Predicted impacts of each pollutant at each human receptor are given in Appendix I. In this section the highest results are presented, that is, the impacts at the worst-case receptor. Table 13 shows the predicted short-term impacts. The predicted concentrations, with and without background concentrations, have been compared with the AQS.

The maximum short-term concentration across all receptors and all meteorological years, and the worst of with and without buildings, is given in Table 13. The maximum short-term impacts are predicted at receptor R9, a location selected as representative of a commercial premises 'RPC Containers' to the northwest of the Site.

The predicted NO_2 PC does not exceed the screening threshold of 10%, and the PC does not exceed 20% of the headroom.

Therefore, the modelled short-term impacts of NO_2 on modelled human receptor locations can be screened out as not significant.

Table 13 Results, short-term AQS

Pollutant	Statistic	AQS ($\mu g/m^3$)	PC ($\mu g/m^3$)	PC/AQS (%)	Headroom ($\mu g/m^3$)	PC/ Headroom (%)	PEC/ AQS (%)	Receptor
NO_2	99.79^{th} 1h	200	4.7	2%	178	3%	13%	R9
Notes: Based on the continuous operation of plant. Data on each row is for one receptor, the receptor at which the percentage of PC/AQS is greatest.								

8. Impact assessment of air quality on ecological receptors

Predicted impacts of each pollutant at each ecological receptor are given in Appendix J. In this section the highest results are presented, that is, the impacts at the worst-case receptor across all meteorological years, the worst of with and without buildings and the worst of surface roughness length (z0d (m)).

Considering the nationally designated sites, Table 14 shows the maximum concentrations, with and without background concentrations, compared to the AQS.

Llantrisant Common and Pastures SSSI

The maximum predicted LT NOx PC exceeds the threshold screening value (of 1% of the AQS) at receptor E4 (42% of the AQS), a location selected as representative of the SSSI located directly adjacent to the Site. The predicted PEC at E4 is 94% of the AQS; for screening purposes this would indicate the requirement for detailed modelling. In this instance detailed modelling predicts that the PEC is below 100% of the AQS (NOx CLe of 30 μg/m^3). Further detailed assessment has been undertaken over a 1km x 1km area that includes the SSSI, the results of which are presented as a contour plot in Figure 9. As shown, the long-term NOx PEC is not predicted to exceed the AQS at the SSSI designation.

In terms of screening threshold criteria, the maximum PCs of the AQS for the short-term (daily) NOx are above the 10% screening threshold at receptor E5 (76%), when compared with the lower short-term (screening) limit (75 μg/m^3). The short-term PC is also more than 20% of the short-term environmental standards minus twice the long-term background concentration (or 'headroom') of the lower short-term CLe at this location (130%).

For detailed assessments where the ozone is below the AOT40 (daily) critical level (80 μg/m^3) and SO_2 is below the lower critical level of 10 μg/m^3 an upper short-term NOx CLe of 200 μg/m^3 applies. The nearest ozone monitoring station is 'Cardiff Centre', 16.4km from the Site, and representative of urban exposure.[37] The peak annual average maximum daily 8-hour mean O_3 concentration between 2016 - 2020 is 65 μg/m^3 (the average concentration for this period is 61 μg/m^3). [38] It would be expected that the AOT40 (24-hour) critical level (of 80 μg/m^3) will be met where the measured peak annual average maximum daily 8-hour mean O_3 concentration is less than (80 μg/m^3). There is no contribution of SO_2 from the process and, as shown in Table 12, the average SO_2 background value for the majority of the SSSI including the areas closest to the site is 1.82 μg/m^3 and therefore significantly less than 10ug/m^3.

When compared with screening criteria and with the upper short-term CLe (200 μg/m^3), the maximum PC of the AQS for the short-term (daily) NOx are above the 10% screening threshold at receptor E5 (28%); the PC is also >20% of the available headroom (34%).

[37] UK AIR Air Information Resource Site Information for Cardiff Centre (UKA00217) https://uk-air.defra.gov.uk/networks/site-info?uka_id=UKA00217 (accessed May 2022)

[38] Air Quality Statistics in the UK National Statistics Ozone (O3) Tables (ENV02 - Air quality statistics - GOV.UK (www.gov.uk)) (accessed May 2022)

The results of detailed modelling which are presented as a contour plot in Figure 10 show that the long-term NOx PEC is not predicted to exceed the AQS at the SSSI designation. The maximum short-term NOx PC is 28% of the upper NOx CLe (200 μg/m^3). The predicted long and short-term PCs are therefore below the relevant AQS.

The special features of the SSSI include marshy grassland, acid flush, acid grassland, species rich neutral grassland.[39] The modelled results have been assessed against the relevant CLe and CLos for acid grassland cited as the most sensitive habitat type to nitrogen or acidity.[32]

The maximum predicted PC for NDep is given in Table 16 and is 16% of CLomin, and 8.4% of CLomax, at E4. As background levels are high and exceed the CLos, the PEDR is 222% of CLomin and 119% of CLomax.

The maximum predicted acid deposition is predicted at receptor E4 where the PC is 15.4% of the minimum set of Clos and 3.1% of the maximum set of CLos. Background levels are high and therefore the PEDR is 271% of the minimum set of Clos and 55% of CLomax.

Cardiff Beech Woods SAC

The maximum predicted long-term NOx PC does not exceed the threshold screening value (of 1% of the AQS) at receptor E25, a location selected as representative of the Cardiff Beech Woods SAC. The maximum PC of the AQS for the short-term (daily) NOx are below the 10% screening threshold at receptor E25, when compared with both the lower short-term CLe (75 μg/m^3) and upper short-term NOx CLe (200 μg/m^3). When assessed against screening criteria, the potential long and short-term NOx impact is considered not significant at these locations.

The maximum predicted PC for NDep is given in Table 16 and is less than 1% of CLomax and CLomin. It is therefore considered that the impact of nutrient nitrogen deposition at the SAC is unlikely to be of significance.

The maximum predicted acid deposition (Table 17) does not exceed 1% of CLomax and CLomin and therefore the impact of acid deposition at the SAC may be regarded as not significant in accordance with EA screening criteria, and no further detailed assessment has been undertaken.

Local Sites

Considering the locally designated sites within 2km of the Site, AWs and LWSs, Table 15 shows that the predicted PCs of the long-term AQS do not exceed the screening threshold (100%) for NOx (CLe of 30μg/m^3); they do not exceed 1% of the AQS. The maximum PCs of the short-term AQS for NOx is below the 100% screening threshold; they do not exceed 1% of the AQS. Therefore, the potential long and short-term impact is considered not significant at these locations.

The maximum predicted PC for NDep is given in Table 16 and is less than 100% of CLomax and CLomin at all receptors (it is less than 1%) and therefore the impact of nutrient nitrogen deposition at the

[39]Initiative for Nature Conservation Cymru (INCC)
Marsh Fritillary Habitat Condition Survey for Llantrisant Common & Pastures SSSI (2011 – 2020)
https://natureconservation.wales/wp-content/uploads/2020/12/Llantrisant-Common-SSSI-Habitat-Comparison-2011-2020.pdf)

locally designated sites may be regarded as unlikely to be of significance. The maximum predicted acid deposition does not exceed 100% (it does not exceed 1%) of the set of CLos and therefore the impact of acid deposition at the locally designated sites may be regarded as not significant (Table 17).

With particular reference to the quantifying ecological impacts, it should be noted that a number of conservative assumptions have been made throughout the AQA:

- Results at the receptors were calculated as the maximum value at each receptor from 30 model runs and are therefore worst-case values across all five years, all model option scenarios that includes the impact of meteorological data year, buildings, terrain, and choice of surface roughness value (z0d (m)).
- For the modelling of ecological impacts terrain data was not modelled as its inclusion led to lower results than model runs without terrain.
- Impacts have been compared with the minimum CLes and CLos for the most sensitive habitat at each sensitive conservation site.
- Concentration and deposition due to combustion process at the plant (from 2018) are included in the background values from APIS (2017 – 2019) and therefore there is an element of double-counting.
- Modelling has not taken account of plume depletion, a function of land-use and pollutant concentration, between the sources and receptors. With plume depletion the predicted concentration and, therefore, the predicted values of nitrogen deposition and acid deposition will be lower.

The adopted approach is therefore likely to have overestimated predicted concentrations and hence deposition at receptors.

Ongoing stack emission testing will be carried out as required subject to the assessment of the AQA by NRW during the permit variation application determination process.

Table 14 Results at SSSI, SAC long-term and short-term AQS, worst case impact

Pollutant	AQS (µg/m³)	Averaging time	Statistic	LT or ST AQS*	PC (µg/m³)	PC/AQS (%)	PEC (µg/m³)	PEC/AQS (%)	Receptor
NOx	30	Annual	mean	LT	12.5	42%	28.2	94%	E4 (SSSI)
NOx	30	Annual	mean	LT	0.002	<1%	13.1	44%	E25 (SAC)
Pollutant	**AQS (µg/m³)**	**Averaging time**	**Statistic**	**LT or ST AQS***	**PC (µg/m³)**	**PC/AQS (%)**	**PEC (µg/m³)**	**PC/ Headroom (%)**	**Receptor**
NOx	75	24-hour	100th percentile	ST	56.7	76%	88.1	130%	E5 (SSSI)
NOx	200	24-hour	100th percentile	ST	56.7	28%	88.1	34%	E5 (SSSI)
NOx	75	24-hour	100th percentile	ST	0.02	0%	26.2	0%	E25 (SAC)
NOx	200	24-hour	100th percentile	ST	0.02	0%	26.2	0%	E25 (SAC)

Notes: *LT= long-term, ST = short-term; Bold font indicates an exceedance of the screening threshold

Data on each row is for one receptor, the receptor at which the percentage of PC/AQS is greatest

Table 15 Results at AW, LWS long-term and short-term AQS, worst case impact

Pollutant	AQS (µg/m³)	Averaging time	Statistic	LT or ST AQS*	PC (µg/m³)	PC/AQS (%)	PEC (µg/m³)	PEC/AQS (%)	Receptor
NOx	30	Annual	mean	LT	0.03	<1%	11.4	38%	E28 (ASNW)
Pollutant	**AQS (µg/m³)**	**Averaging time**	**Statistic**	**LT or ST AQS***	**PC (µg/m³)**	**PC/AQS (%)**	**PEC (µg/m³)**	**PC/ Headroom (%)**	**Receptor**
NOx	75	24-hour	100th percentile	ST	0.40	1%	23.2	1%	E28 (ASNW)
NOx	200	24-hour	100th percentile	ST	0.40	<1%	23.2	<1%	E28 (ASNW)

Notes: *LT= long-term, ST = short-term; Bold font indicates an exceedance of the screening threshold (PC/AQS = 100%)

Data on each row is for one receptor, the receptor at which the percentage of PC/AQS is greatest

Table 16 Worst-case nutrient nitrogen deposition

Pollutant	PC (kg/ha/y)	CLomin (ka/ha/y)	CLomax (ka/ha/y)	PC/CLomin (%)	PC/CLomax (%)	PEDR/CLomin (%)	PEDR/CLomax (%)	Receptor
SSSI	1.26	8	15	16%	8%	222%	119%	E4
SAC	0.0003	10	20	<1%	<1%	258%	129%	E25
AW, LWS	0.0057	10	15	<1%	<1%	263%	176%	E28

Notes: Bold font indicates an exceedance of the screening threshold; data on each row is for one receptor, the receptor at which the percentage of PC/CLmin is greatest

Table 17 Worst-case acid deposition

Pollutant	PC/CLo (%)	Background/CLo (%)	PEDR/CLo (%)	Receptor
SSSI with respect to CLmin	15.4%	256%	271%	E4
SSSI with respect to CLmax	3.1%	52%	55%	E4
SAC with respect to CLmin	0.0017%	126%	126%	E25
SAC with respect to CLmax	0.0002%	15.7%	15.7%	E25
AW, LWS with respect to CLmin	0.030%	182%	182%	E37
AW, LWS with respect to CLmax	0.030%	182%	182%	E37

Notes: Data on each row is for one receptor, the receptor at which the percentage of PC/CLo is greatest

9. Impact assessment of odour

Table 18 shows the predicted 98th percentile of 1-hour mean odour concentrations at the modelled discrete receptor locations. The values given are the worst case for each year (with the inclusion of both terrain and buildings, and with a surface roughness value of 0.3m), the maximum at each receptor and the year for which it was predicted are given in the final two columns.

The maximum predicted, 0.80 OU/m^3, is at R9, a location selected as representative of a commercial premises 'RPC Containers' to the northwest of the Site. The maximum odour impact predicted at Receptor R2, Royal Glamorgan Hospital, is 0.16 OU/m^3 Receptor R3, a farmhouse, 350m to the southwest of the Site, is the residential receptor at which the maximum odour impact is predicted (0.14 OU/m^3).

The maximum odour impact is below even the lowest threshold of 1.5 OU_E/m^3 for the "most offensive" odours and therefore the Site operation is not likely to be an odour nuisance at human receptors.

Table 18 98th percentile hour mean odour concentration (OU/m^3)

ID	2016	2017	2018	2019	2020	Maximum	Worst case year
R1	0.10	0.07	0.10	0.12	0.14	0.14	2020
R2	0.10	0.07	0.11	0.10	**0.16**	0.16	2020
R3	0.11	0.09	**0.14**	0.11	0.11	0.14	2018
R4	0.05	0.05	0.05	0.05	0.09	0.09	2020
R5	0.05	0.06	0.05	0.06	0.09	0.09	2020
R6	0.03	0.03	0.03	0.03	0.05	0.05	2020
R7	0.04	0.04	0.04	0.04	0.04	0.04	2019
R8	0.02	0.03	0.03	0.04	0.05	0.05	2020
R9	0.67	0.45	0.49	**0.80**	0.69	0.80	2019
R10	0.24	0.24	0.22	0.29	0.21	0.29	2019
R11	0.16	0.16	0.15	0.20	0.12	0.20	2019
R12	0.47	0.51	0.46	0.55	0.35	0.55	2019
R13	0.14	0.16	0.15	0.15	0.13	0.16	2017
R14	0.06	0.07	0.07	0.06	0.06	0.07	2017
R15	0.07	0.07	0.06	0.09	0.05	0.09	2019
R16	0.04	0.03	0.03	0.08	0.07	0.08	2019
R17	0.03	0.02	0.02	0.05	0.03	0.05	2019
R18	0.02	0.02	0.02	0.02	0.01	0.02	2019
R19	0.03	0.04	0.03	0.04	0.03	0.04	2017
R20	0.03	0.03	0.03	0.03	0.03	0.03	2017
R21	0.02	0.02	0.02	0.02	0.02	0.02	2019
R22	0.02	0.03	0.03	0.05	0.04	0.05	2019

10. Conclusion

This AQA has been prepared to support an application to vary the current bespoke installation permit Ref: EPR/AB3894ZF. The permit variation which this AQA Assessment supports is to add emission points A6, the bromine abatement plant stack and A5, the back-up Steam Generator (Stack B).

The Site is situated in mixed land-use setting located within Llantrisant Business Park. The northern and western perimeter of the site is bounded by industrial units on the Business Park, with the eastern perimeter being adjacent to Llantrisant Common and Pastures SSSI. The nearest commercial premises on the Llantrisant Business Park are situated 0.73km to the west. The nearest residential receptors include a farmhouse situated 0.4km to the southwest, and the Royal Glamorgan Hospital located 0.5km to the southwest.

The Site is not situated within or near to an Air Quality Management Area (AQMA). The nearest AQMA is Mwyndy AQMA, approximately 3.2km, to the south-southeast.

The primary control on bromine emissions is the use of sodium formate liquid to neutralise any residual bromine in the reaction vessel and a scrubber, prior to emission of air through the bromine abatement plant stack.

Baseline conditions of sensitive receptors, current background concentrations and deposition rates have been established. Inputs are based on estimated data provided by Purolite Ltd and Briggs of Burton in addition to stack emissions test data.

An H1 screening assessment identified the requirement for further detailed assessment of short-term impacts of NO_2 on human receptors and long and short-term impacts of NOx on ecological receptors. A quantitative assessment of odour has also been undertaken to verify the assumptions of the previous assessment together with the addition of the bromination process, that is the subject of the permit variation.

Detailed modelling has been carried out using the ADMS 5 dispersion model and numerical modelled meteorological data for the Site location.

Human receptors

A preliminary H1 screening assessment determined that the long-term impacts at all receptors can be screened out as not significant and there is no need for further assessment. The predicted short-term impacts of bromine were also screened out as insignificant. H1 screening determined that the short-term impacts of NO_2 required further detailed assessment.

Based on further detailed assessment of the predicted modelled concentrations of NO_2 at human receptor locations, short-term impacts were assessed as not significant and there is no need for further assessment.

Ecological receptors

Llantrisant Common and Pastures SSSI

Considering the nationally designated Llantrisant Common and Pastures SSSI site, the maximum PEC is 94% of the long-term NOx AQS at receptor E4. Further detailed assessment has been undertaken

over a 1km x 1km area that includes the SSSI. The long-term NOx PEC is not predicted to exceed the AQS at the SSSI designation.

The predicted short-term (daily maximum) concentrations of NOx were determined to be within the lower (screening) limit of 75ug/m^3 and within the upper limit of 200ug/m^3 (that is used in conjunction with the ozone critical level, for detailed daily NOx assessment). The predicted short-term PCs are therefore below the relevant AQS.

The modelled results have been assessed against the relevant CLe and CLos for acid grassland cited as the most sensitive habitat type to nitrogen or acidity. The maximum predicted PC for NDep is 16% of CLomin, and 8.4% of CLomax, at E4. As background levels are high and exceed the CLos, the PEDR is 222% of CLomin and 119% of CLomax.

The maximum predicted acid deposition is predicted at receptor E4 where the PC is 15.4% of the minimum set of Clos and 3.1% of the maximum set of CLos. Background levels are high and therefore the PEDR is 271% of the minimum set of Clos and 55% of CLomax.

As detailed within Tables 35 to 37, the highest levels of nutrient nitrogen and acid deposition were predicted at areas of the SSSI adjacent to and/or within close proximity of the Site. Further, a number of conservative assumptions have been made throughout the AQA. The adopted approach is therefore likely to have overestimated predicted concentrations and hence deposition at ecological receptors. On this basis, it is considered that the operation is unlikely to unduly impact the SSSI.

Cardiff Beech Woods SAC

For nationally designated Cardiff Beech Woods SAC, the maximum predicted long-term NOx PC does not exceed 1% of the AQS. The maximum PCs of the AQS for the short-term (daily) NOx are below the 10% screening threshold, when compared with both the lower and upper short-term NOx CLes. The potential long and short-term NOx impact is considered not significant at these locations.

The maximum predicted PC for NDep is less than 1% of CLomax and CLomin. The maximum predicted acid deposition does not exceed 1% of CLomax and CLomin. It is therefore considered that the impact of nutrient nitrogen and acid deposition at the SAC is unlikely to be of significance.

Ancient Woodland / Local Wildlife Sites

Considering the locally designated sites within 2km of the Site, the predicted NOx PCs of the long-term AQS do not exceed the screening threshold (100%) The maximum predicted PCs do not exceed 100% of the long or short-term AQS. Therefore, the potential for long and short-term impact is considered not significant at these locations.

The maximum predicted PCs for nutrient nitrogen and acid deposition similarly do not exceed 100% of the CLomin and CLomax at all receptor locations. Therefore, the impact of nutrient nitrogen and acid deposition at the locally designated sites may be regarded as unlikely to be of significance.

Odour

Due to the batch nature of the process, odour emissions will occur in peaks over time and not continuously. For assessment purposes, emissions of odour have been modelled as continuous so as

predict impacts during meteorological periods that may be less conductive to effective odour dispersal.

The maximum predicted odour impact is below even the lowest threshold of $1.5ou_E/m^3$ for the "most offensive" odours and therefore the Site operation is not likely to result in an odour impact at human receptors.

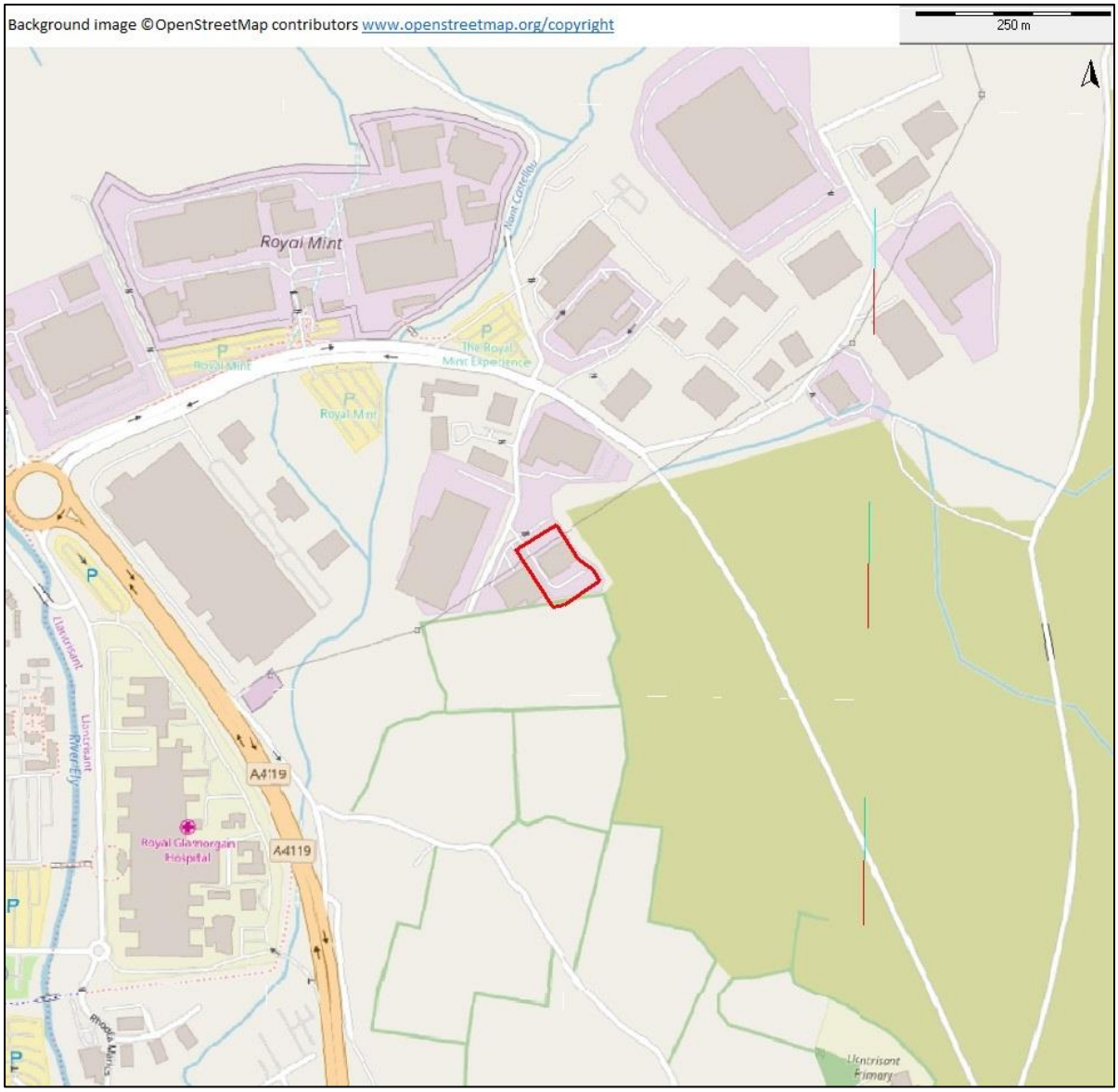
Based on the modelled results and the absence of odour complaints since the operation began, that includes the [redacted] process trial period, the impact of the proposed operation is not considered likely to impact local amenity in terms of odour.

Ongoing stack emission testing will be carried out as required subject to the assessment of the AQA by NRW during the permit variation application determination process.

The permit variation reflecting the addition of two new emissions points to air, namely the [redacted] abatement plant stack (A6) and the back-up Steam Generator (A5) may trigger a requirement for periodic emissions to air monitoring. Any required monitoring will be conducted in accordance with EA guidance 'Monitoring stack emissions: techniques and standards for periodic monitoring' and Technical Guidance Note M1 'Sampling requirements for stack emission monitoring.'

Figures

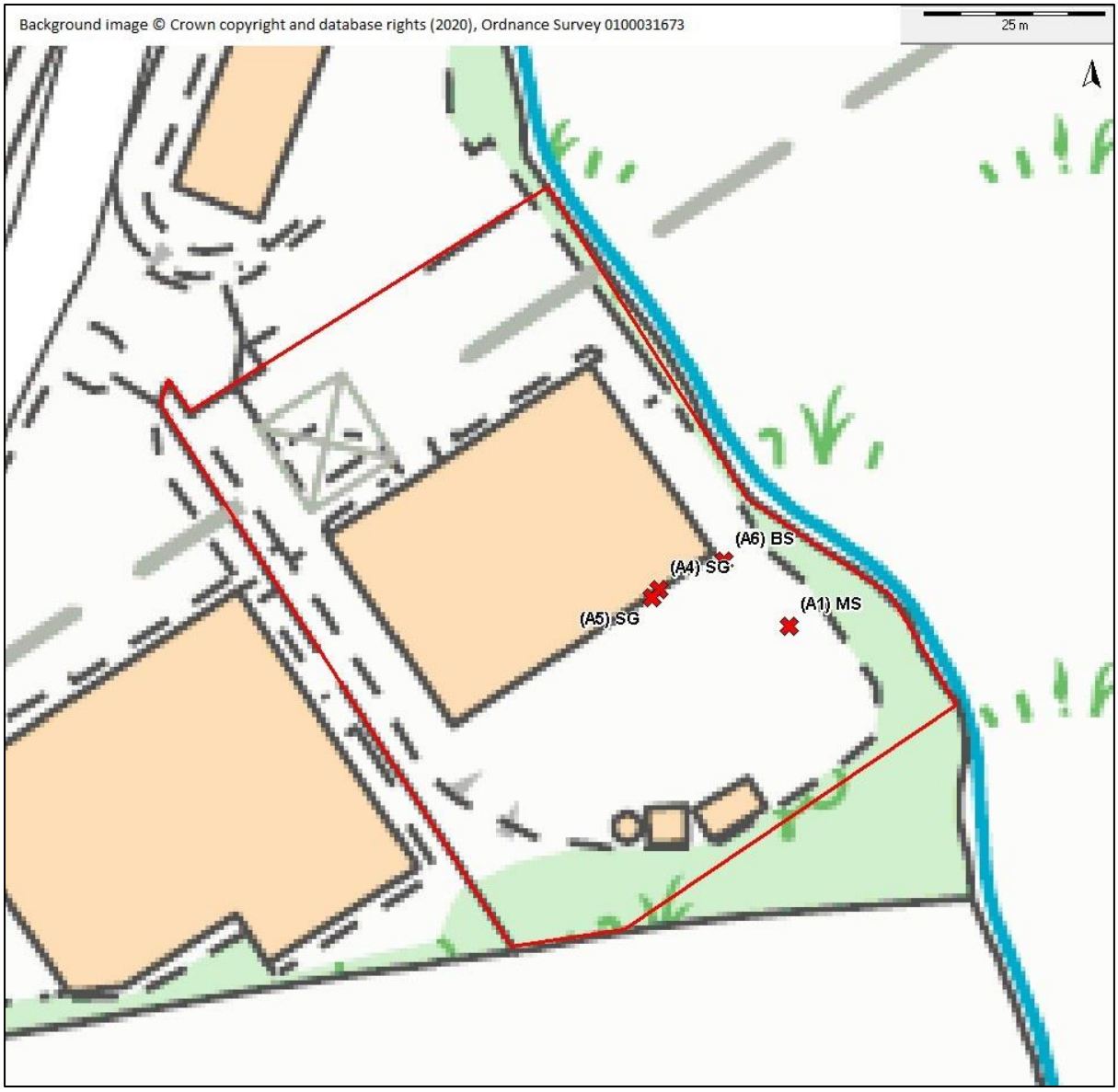
Figure 1 Site location



Legend

Site boundary

Figure 2 Modelled point sources



Legend

Site boundary

Point sources

Figure 3 GFS meteorological data, windroses 2016-2020

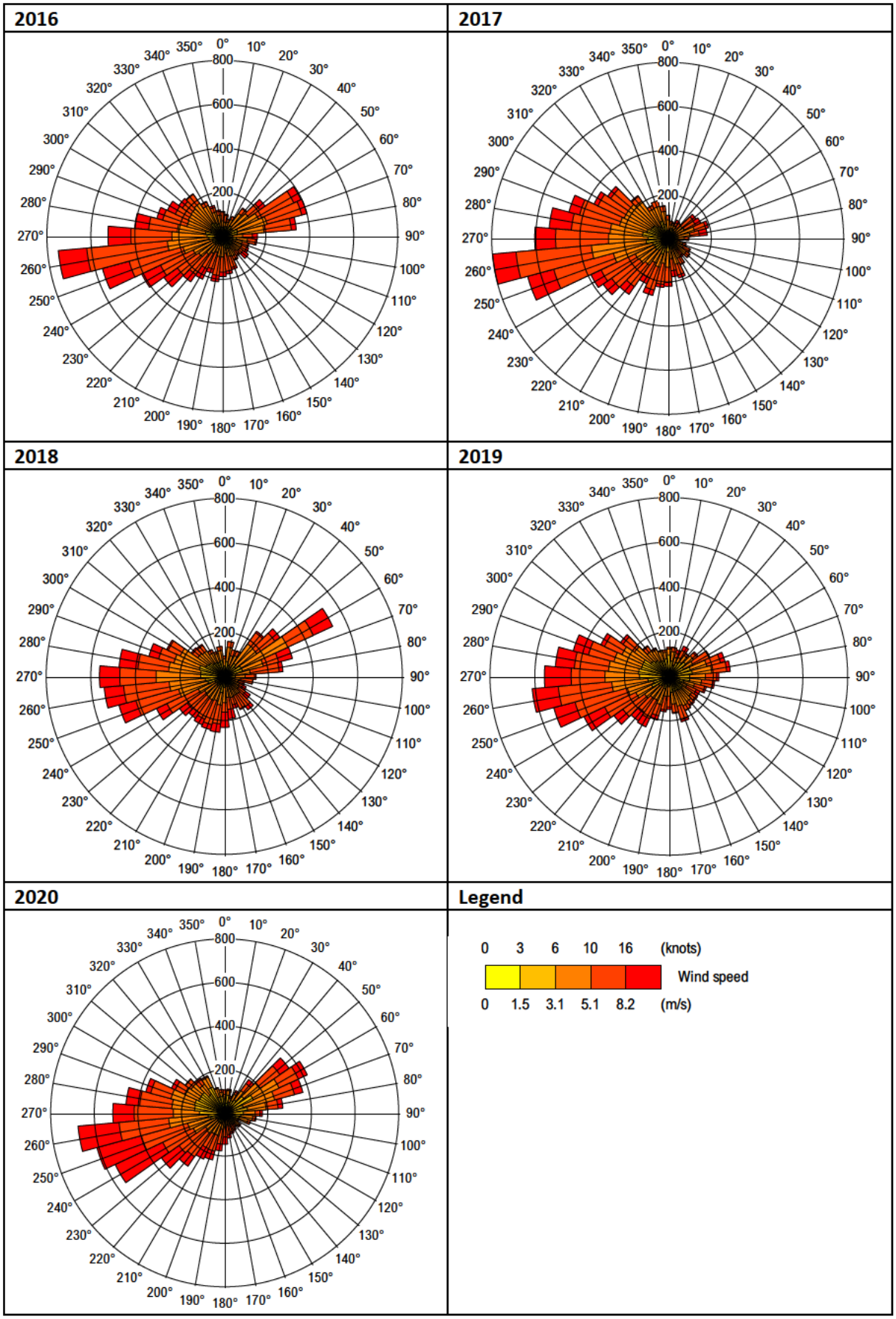
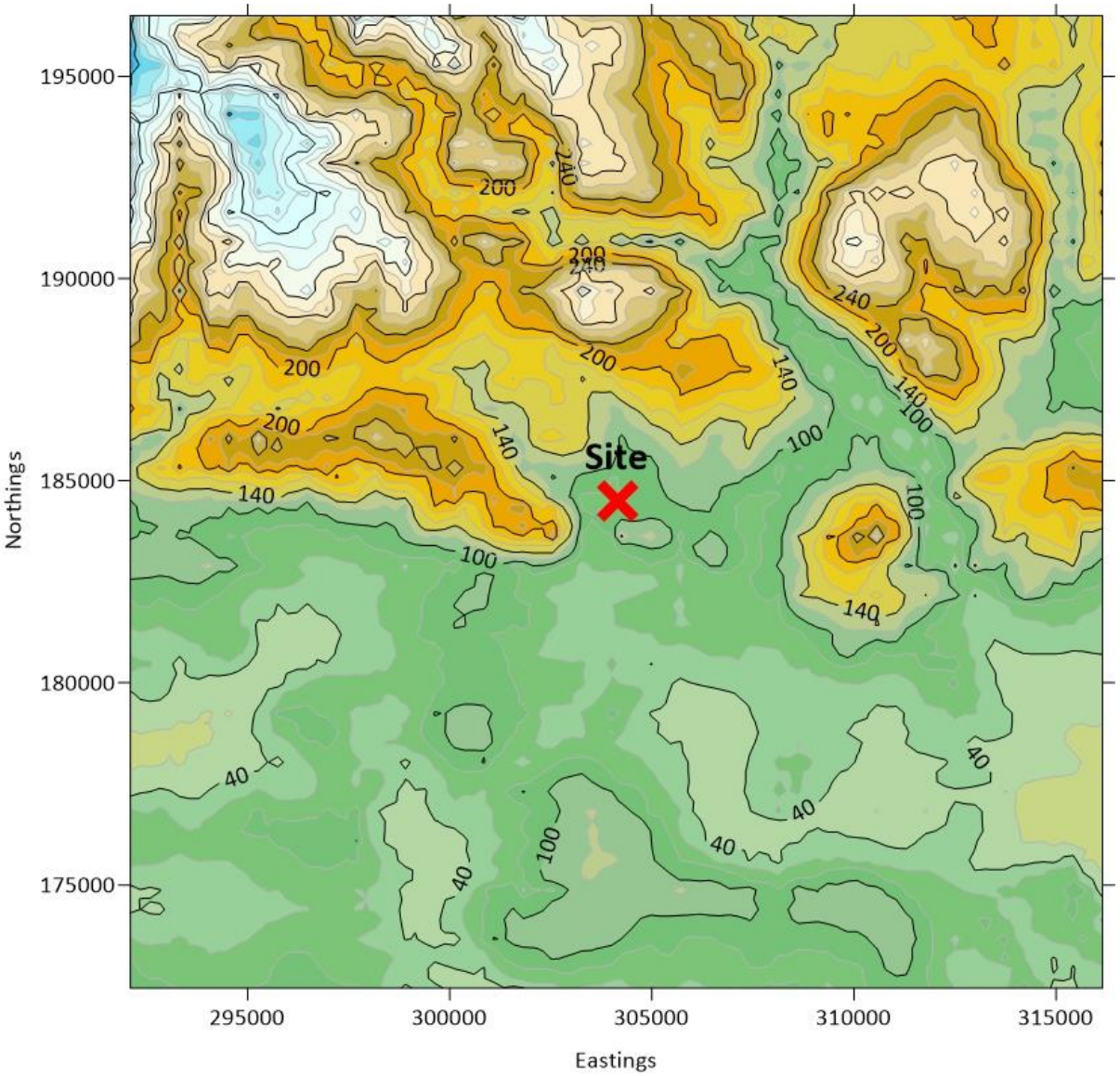


Figure 4 Modelled buildings

Legend

- Site boundary
- Buildings
- Point sources

Figure 5 Terrain elevation



Elevation (m)

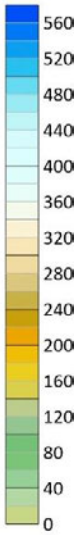
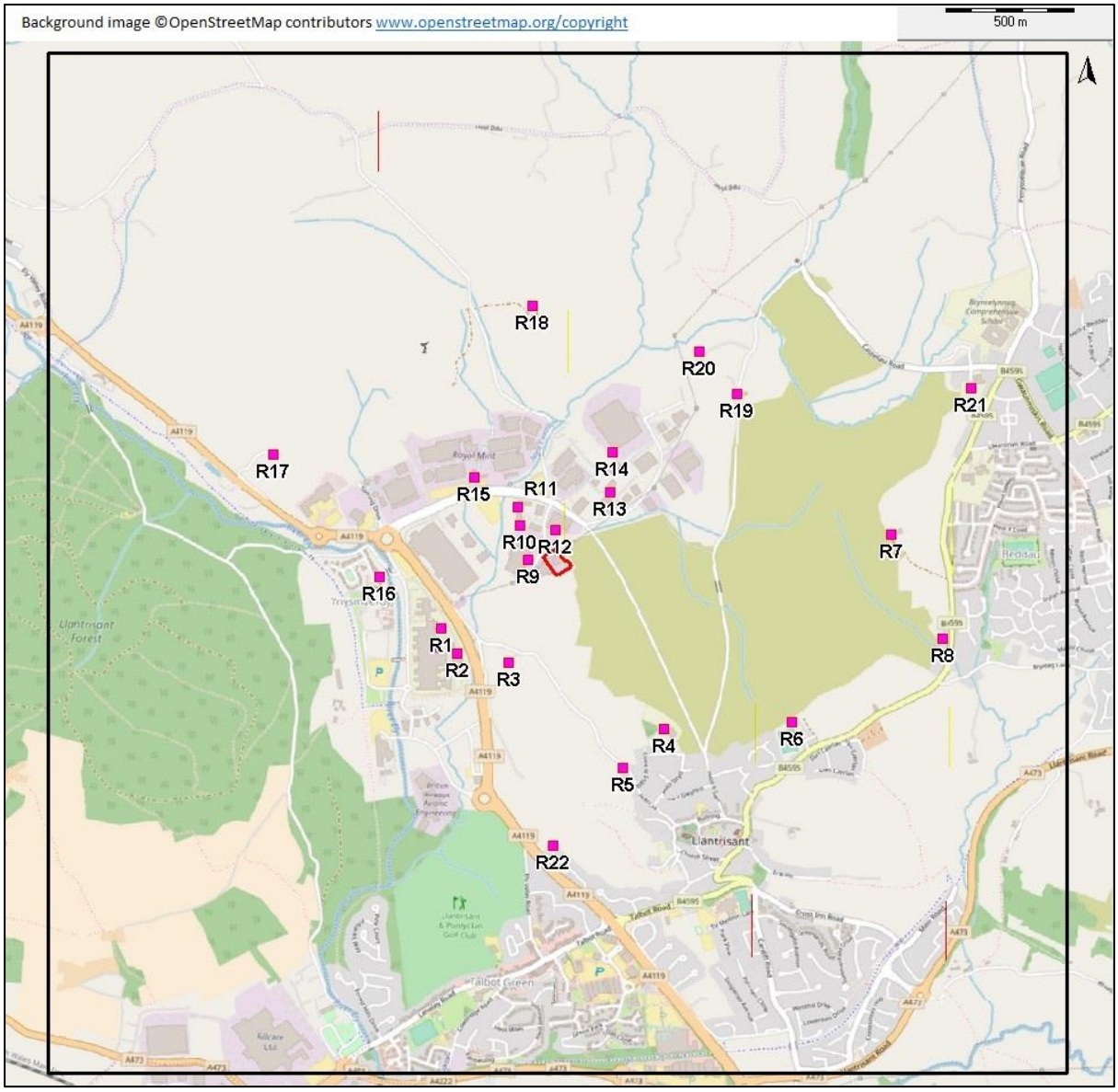


Figure 6 Human receptors

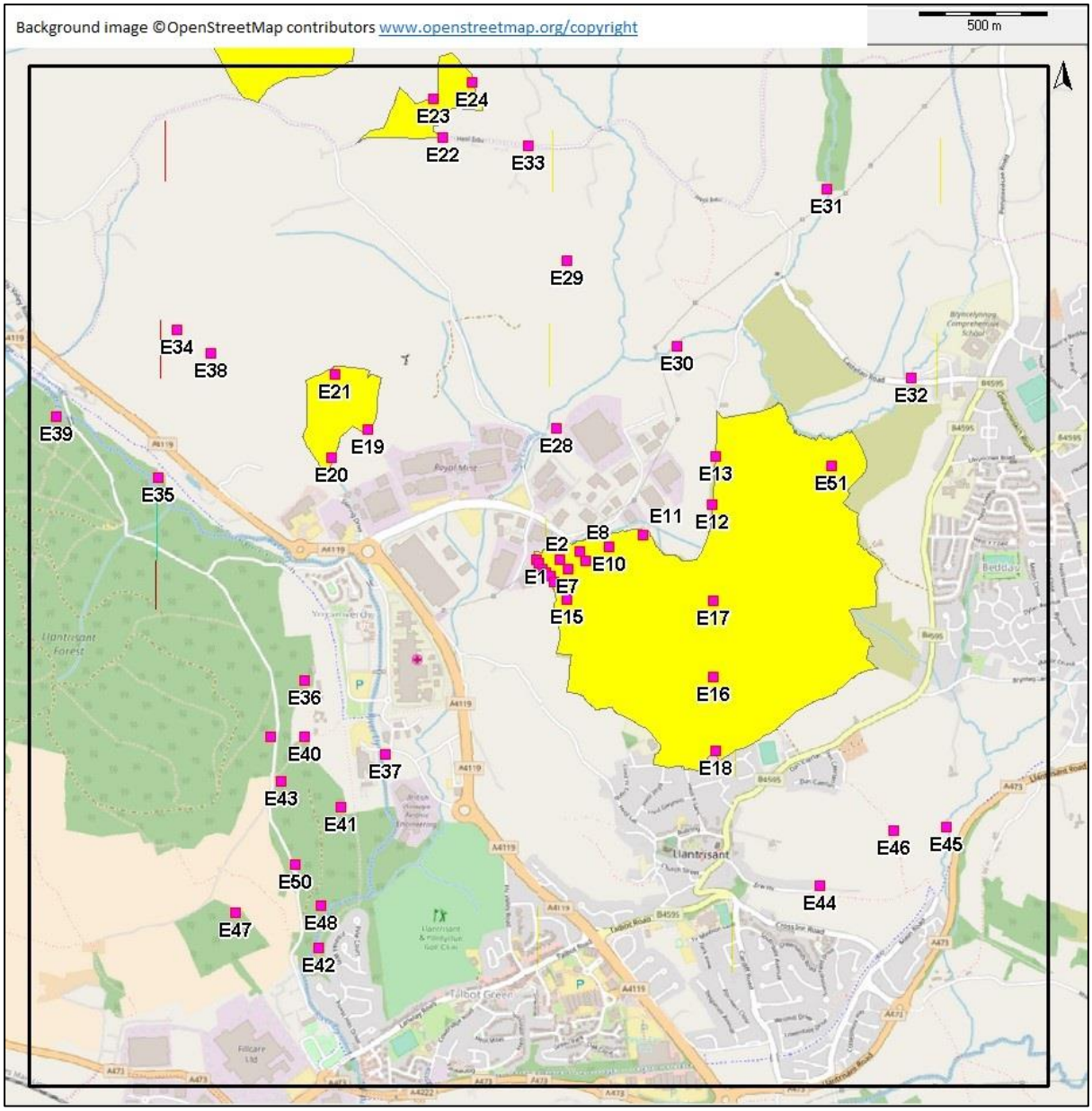


Legend

- Site boundary
- Human receptors
- +/-2km

- Site
- +/-2km
- Human receptors

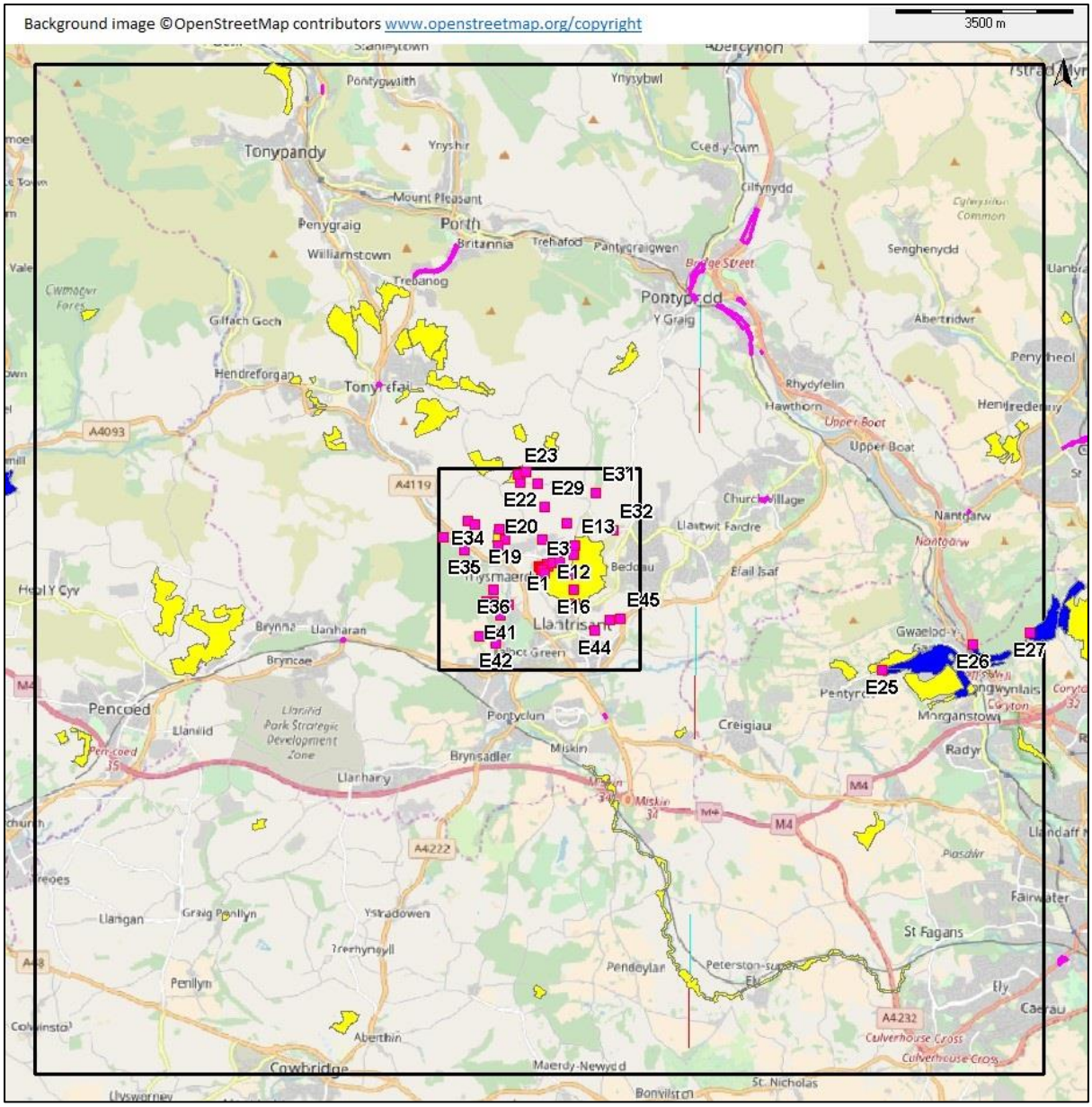
Figure 7 Ecological receptors within 2km



Legend

- Site boundary
- Ecological receptors
- +/-2km
- SSSIs

Figure 8 Ecological receptors within 10km



Legend

- Site boundary
- Ecological receptors
- +/-2km and +/-10km
- SAC

Figure 9 Concentrations contour plot, % NOx PEC of long-term (annual) AQS (30 µg/m^3)

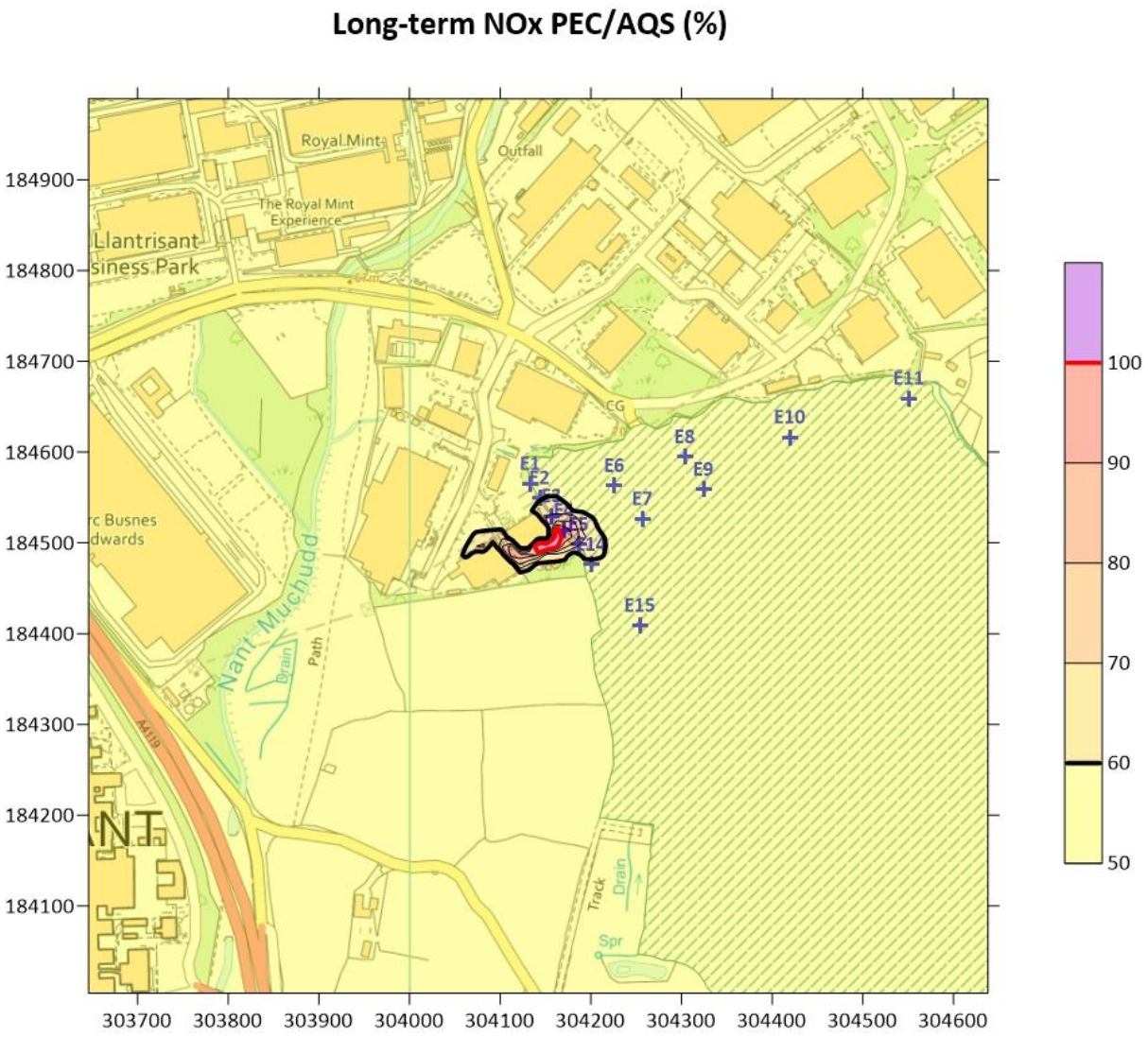


Figure 10 Concentration contour plot, % NOx of short-term (daily) AQS (EAL 75 μg/m³)

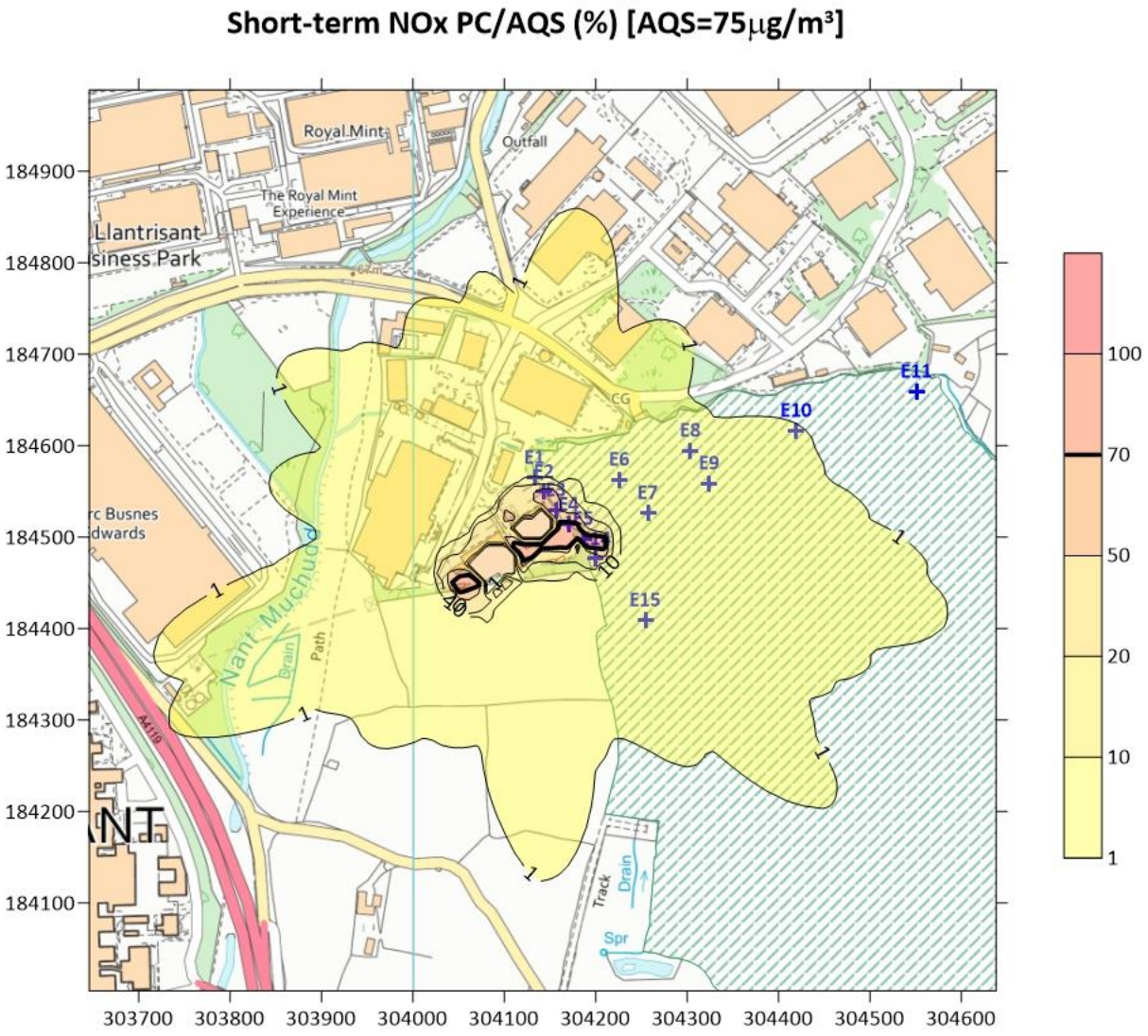
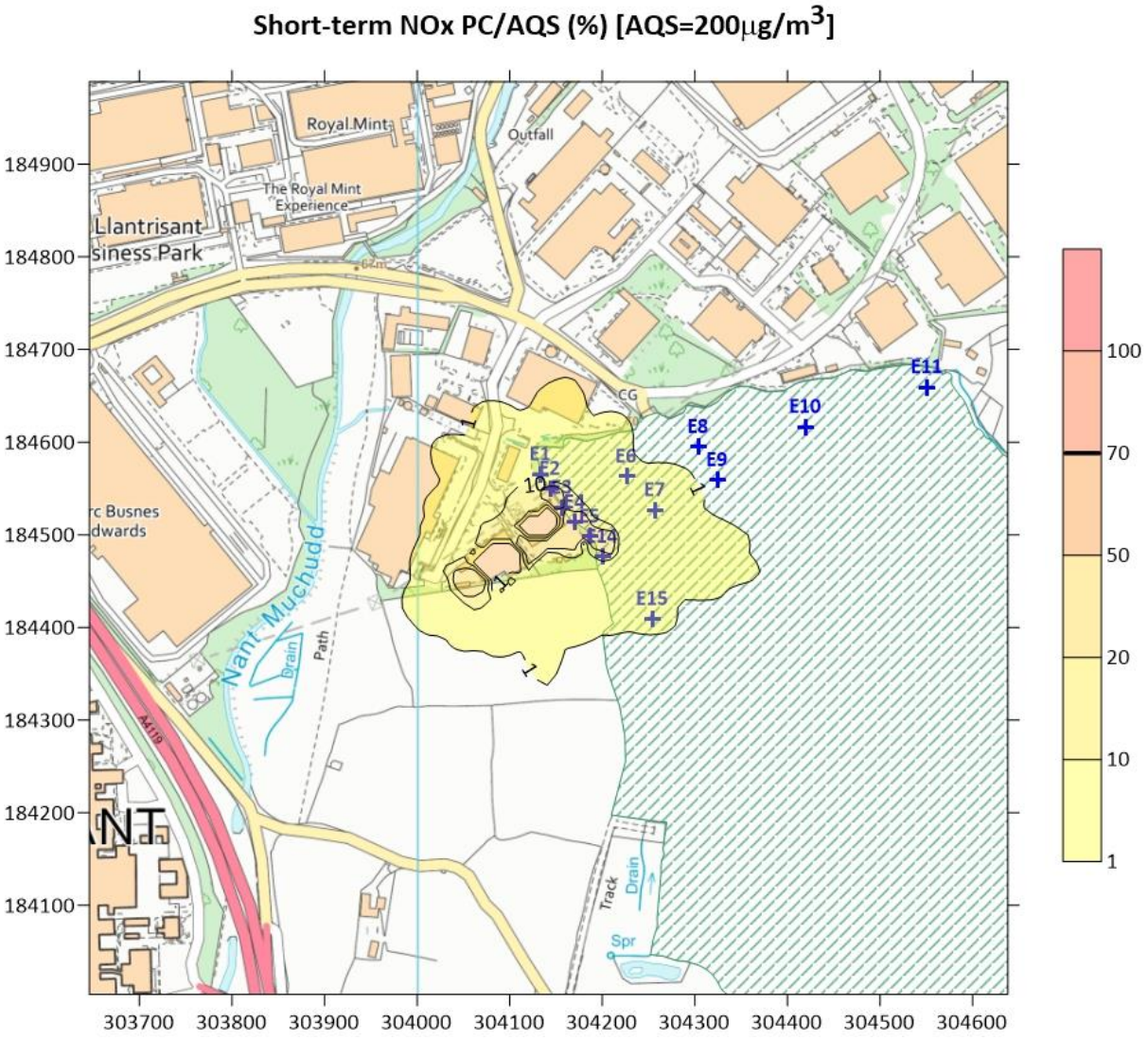
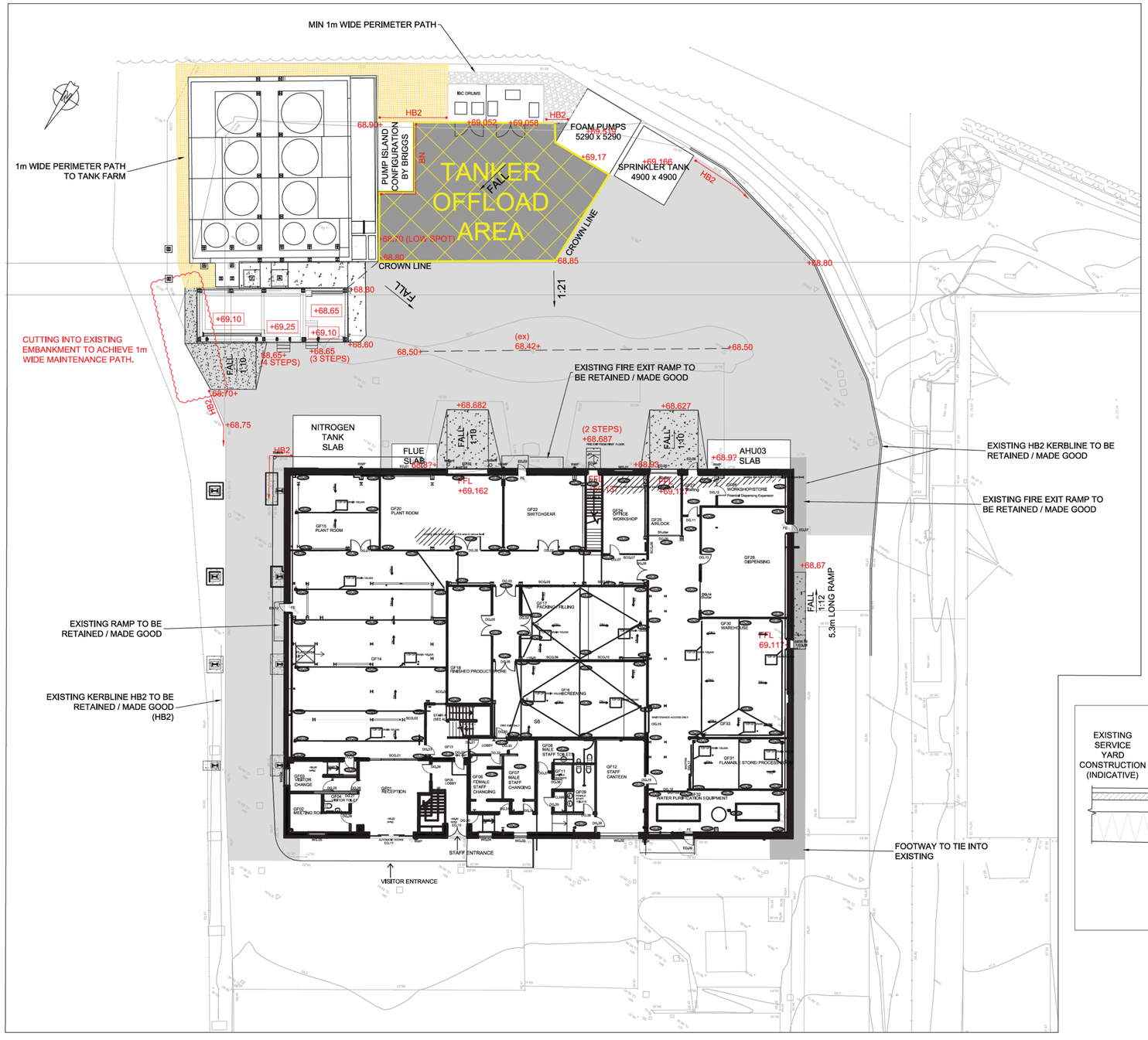


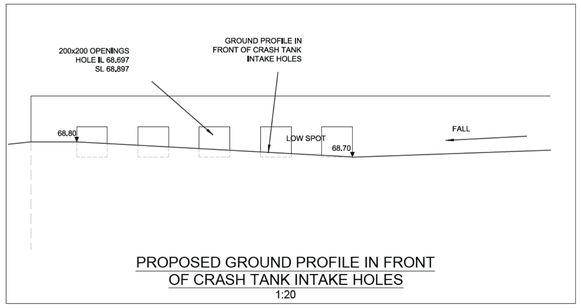
Figure 11 Concentration contour plot, % NOx of short-term (daily) AQS (EAL 200 mg/m^3)



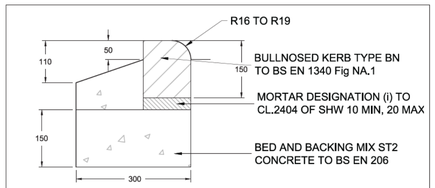
Appendix A Site Plans

- Site Layout

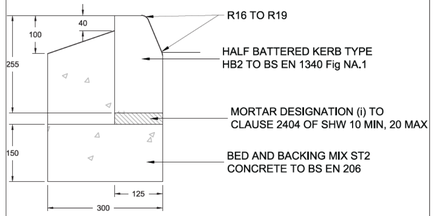




PROPOSED GROUND PROFILE IN FRONT OF CRASH TANK INTAKE HOLES
1:20



BULLNOSED KERB TYPE BN



HALF BATTERED KERB TYPE HB2

SAFETY, HEALTH AND ENVIRONMENTAL INFORMATION

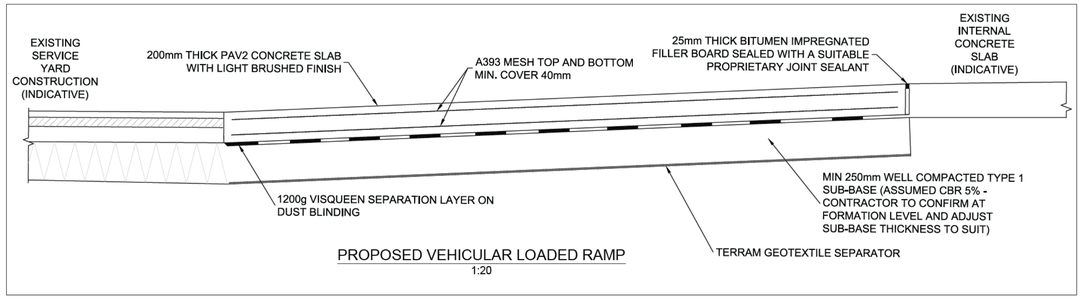
ALL WORK TO BE CARRIED OUT IN ACCORDANCE WITH CURRENT CDM REGULATIONS 2015 AND HSG150. IN ADDITION TO THE HAZARDS/RISKS NORMALLY ASSOCIATED WITH THE TYPES OF WORK DETAILED ON THIS DRAWING, PLEASE NOTE THE FOLLOWING:

LEGEND / KEY TO SYMBOLS

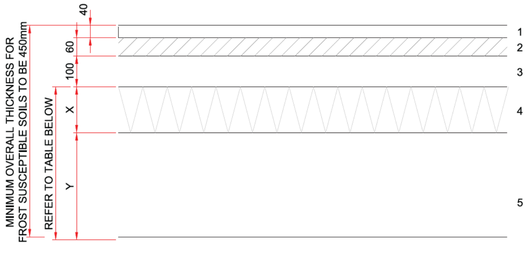
- TARMAC SURFACE: REGRADING REQUIRED TO CREATE OPPOSING FALLS BETWEEN TANKER OFFLOAD AREA AND MAIN SERVICE YARD
- AREA OF MAKING GOOD / RESURFACING TO REGULATED LEVEL DIFFERENCE
- PAVING SLABS - PEDESTRIAN LOADING
- HB2 HALF BATTERED KERB
- BN BULLNOSED KERB LAID FLUSH
- PRIMROSE ROAD MARKINGS
- PROPOSED CONCRETE RAMP
- GRAVEL FILLED AREA
- +x.xx PROPOSED LEVEL

NOTES

1. DESIGN ASSUMES THAT TANKER OFFLOADING IS UNDERTAKEN ONLY WHEN TANKER IS STATIONARY AND WHOLLY POSITIONED WITHIN HATCHED AREA.
2. ASSUMED TANKER DIMENSIONS AND TYPICAL MANOUEVERS / SWEPT PATH ANALYSIS ARE ILLUSTRATED ON DRAWING CDGA-9021-100.
3. FOR SETTING OUT CO-ORDINATES REFER TO DRAWING CDGA-9021-105.
4. WHERE FULL CONSTRUCTION MAKE-UP IS REQUIRED CONTRACTOR TO UNDERTAKE CBR TESTING AT FORMATION LEVEL OF NEW SURFACE AND ADJUST SUB-BASE THICKNESS TO SUIT
5. WHERE FULL CONSTRUCTION MAKE-UP IS NOT REQUIRED & EXTERNALS ARE TO BE REGULATED TO SUIT NEW LEVELS ONLY; ON THE BASIS THAT THE EXISTING SERVICE YARD CONSTRUCTION IS FIT FOR PURPOSE FOR EQUIVALENT LOADING IN PROPOSED APPLICATION SURFACE COURSE TO BE USED AS REGULATING LAYER - 40mm MINIMUM THICKNESS OF ANY RE-SURFACED AREA.
6. FIRE EXIT RAMP WIDTHS, LENGTHS, GRADIENTS AND LANDING WIDTHS DO NOT ACHIEVE BUILDING REGS PART M DDA COMPLIANCE AND THE ARRANGEMENT IS SUBJECT TO REVIEW BY THE ARCHITECT INLINE WITH THEIR ACCESS AND FIRE STRATEGY.



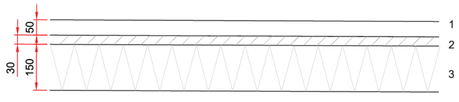
PROPOSED VEHICULAR LOADED RAMP
1:20



CBR VALUE	BELOW 2%	2% - 5%	ABOVE 5% SUB
BASE	150mm	150mm	255mm
CAPPING LAYER	600mm	350mm	0mm

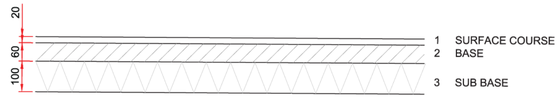
1. 40mm CONSOLIDATED 10mm AGGREGATE CLOSE GRADED WEARING COURSE B.S.4987 PART 1 (200 PEN BITUMEN) (CLAUSE 912).
2. 60mm CONSOLIDATED 20mm AGGREGATE DENSE BASE COURSE B.S.4987 PART 1 (100 PEN BITUMEN) (CLAUSE 906).
3. 100mm 28mm AGGREGATE DENSE ROAD BASE B.S.4987 PART 1 (100 PEN BITUMEN) (CLAUSE 903).
4. GRANULAR SUB-BASE SUBJECT TO CBR VALUE (CLAUSE 803)
5. CAPPING LAYER SUBJECT TO CBR VALUE (CLAUSE 613)

SERVICE YARD CONSTRUCTION MAKE-UP
SCALE 1:10



PAVING SLAB DETAIL
SCALE 1:10

1. 5Omm SAXON CONCRETE PAVING SLABS BY MARSHALLS OR SIMILAR APPROVED (COLOUR TBC)
2. 50mm SHARP SAND COMPRESSED TO 30mm CONSOLIDATED THICKNESS
3. 150mm CONSOLIDATED THICKNESS GRANULAR SUB BASE TYPE 1 TABLE 8/2 AND CLAUSE 803 (SPEC. FOR HIGHWAY WORKS)



FOOTPATH DETAIL
SCALE 1:10

1. 2Omm CONSOLIDATED THICKNESS DENSE GRADED MACADAM WEARING COURSE. 6mm NOMINAL AGGREGATE SIZE. 200 PEN BITUMEN. (B.S. 4987 PART 1)
2. 60mm CONSOLIDATED THICKNESS DENSE MACADAM BASE COURSE. 20mm NOMINAL AGGREGATE SIZE. 100 PEN BITUMEN. (BS 4987 PART 1). (CLAUSE 906)
3. 100mm CONSOLIDATED THICKNESS GRANULAR SUB BASE TYPE 1 TABLE 8/2 AND CLAUSE 803 (SPEC. FOR HIGHWAY WORKS)

C3	CLIENT COMMENTS-RAMPS REVISED	GJ	04/12/2017
C2	CLIENT COMMENTS-RAMPS ADDED	GJ	28/11/17
C1	FIRST ISSUE	GJ	26/10/17
REV	DESCRIPTION	BY	DATE

status: FOR CONSTRUCTION

CDGray CIVIL & STRUCTURAL ENGINEERS
5-6 Deryn Court, Wharfedale Road, Pentwyn, Cardiff, CF23 7HB
Tel: 02920 733181
Web: www.cdgray.co.uk

client: PUROLITE

project: PUROLITE UNIT C, LLANTRISANT

drawing title: SERVICE YARD PROPOSED EXTERNALS

drawn	LKJ	chkd	NF
date drawn	26/10/17	project no.	9021
scale @A1	1:200	drg no.	106
		rev.	C3

F:\Jobs\9000-9099\9021 - Purolite, Bridgend\05-Documents\02-Drawings\CDG\ACD\GA-9021-106-C3-SERVICE YARD EXTERNALS

Appendix B Existing Permit

Permit with introductory note

The Environmental Permitting (England & Wales) Regulations 2016

Purolite Limited

Unit C
Llantrisant Business Park
Llantrisant
CF72 8LF

Permit number

EPR/AB3894ZF

Purolite
Permit number EPR/AB3894ZF

Introductory note

This introductory note does not form a part of the permit

The main features of the permit are as follows:

The operator has developed a range of chromatographic resins; these resins are based on agarose for sale into the pharmaceutical industry where they are used in the production of biosimilars and antibody therapies. The resin is manufactured from agarose, a naturally occurring polysaccharide.

The manufacturing process involves taking the powdered polysaccharide and making an aqueous solution with a specific concentration to give the final properties of the product. The solution is then mixed with an immiscible organic phase using a viscosity modifier to create an emulsion. The process is highly controlled to use the agitation speed in the emulsion to give highly specific particle size distributions. The emulsion is then cooled to create the solid resin bead. The organic phase and viscosity modifier is washed out using a solvent and then water.

The next stage of the process is to take the washed resin and crosslink the batch to increase the rigidity. This process uses a crosslinking agent which is accurately dosed into the process along with reagents to control the pH and added to prevent discolouration of the resin. Temperature control of this stage of the process is essential to achieve optimum crosslinking. The resin is then washed with water to remove excess reagents. During the process of creating the resin beads, a wide normal distribution of particle sizes is formed. For optimum performance in customer processes, the range of particles is reduced to a specification for each product. Screening removes the fine and coarse resin from the batch.

There are several emission points to air associated with the main process. These are listed in the site permit, however all emissions to air are insignificant and therefore no monitoring is required. All process effluents are discharged to foul sewer in-line with an authorised trade effluent consent, there are no direct discharges to surface water or land from the installation.

The site has a small gas fired boiler used to produce steam for the process.

The status log of the permit sets out the permitting history, including any changes to the permit reference number

Status Log of the permit		
Detail	**Date**	**Comments**
Application PAN-000869	Duly made 23/01/18	Application for an organic chemical manufacturing plant
Permit Issued EPR/AB3894ZF	31/05/18	

End of Introductory Note

Permit

The Environmental Permitting (England and Wales) Regulations 2016

Permit number
EPR/AB3894ZF

The Natural Resources Body for Wales ("Natural Resources Wales") authorises, under regulation 13 of the Environmental Permitting (England and Wales) Regulations 2016

Purolite Limited ("the operator"),

whose registered office is
Unit D
Llantrisant Business Park
Llantrisant
Rhondda Cynon Taff
CF72 8LF

company registration number **01840987**

to operate an installation at
Unit C
Llantrisant Business Park
Llantrisant
Rhondda Cynon Taff
CF72 8LF

to the extent authorised by and subject to the conditions of this permit.

Name	Date
A. M. Lewis	**31/05/18**

Anna Lewis, Principal Permitting Officer

Authorised on behalf of Natural Resources Wales

Conditions

1 Management

1.1 General management

1.1.1 The operator shall manage and operate the activities:

(a) in accordance with a written management system that identifies and minimises risks of pollution, including those arising from operations, maintenance, accidents, incidents, non-conformances, closure and those drawn to the attention of the operator as a result of complaints; and

(b) using sufficient competent persons and resources.

1.1.2 Records demonstrating compliance with condition 1.1.1 shall be maintained.

1.1.3 Any person having duties that are or may be affected by the matters set out in this permit shall have convenient access to a copy of it kept at or near the place where those duties are carried out.

1.2 Energy efficiency

1.2.1 The operator shall:

(a) take appropriate measures to ensure that energy is recovered with a high level of energy efficiency and energy is used efficiently in the activities.

(b) review and record at least every four years whether there are suitable opportunities to improve the energy efficiency of the activities; and

(c) take any further appropriate measures identified by a review.

1.3 Efficient use of raw materials

1.3.1 The operator shall:

(a) take appropriate measures to ensure that raw materials and water are used efficiently in the activities;

(b) maintain records of raw materials and water used in the activities;

(c) review and record at least every four years whether there are suitable alternative materials that could reduce environmental impact or opportunities to improve the efficiency of raw material and water use; and

(d) take any further appropriate measures identified by a review.

1.4 Avoidance, recovery and disposal of wastes produced by the activities

1.4.1 The operator shall take appropriate measures to ensure that:

(a) the waste hierarchy referred to in Article 4 of the Waste Framework Directive is applied to the generation of waste by the activities; and

(b) any waste generated by the activities is treated in accordance with the waste hierarchy referred to in Article 4 of the Waste Framework Directive; and

(c) where disposal is necessary, this is undertaken in a manner which minimises its impact on the environment.

1.4.2 The operator shall review and record at least every four years whether changes to those measures should be made and take any further appropriate measures identified by a review.

2 Operations

2.1 Permitted activities

2.1.1 The operator is only authorised to carry out the activities specified in schedule 1 table S1.1 (the "activities").

2.2 The site

2.2.1 The activities shall not extend beyond the site, being the land shown edged in green on the site plan at schedule 7 to this permit.

2.3 Operating techniques

2.3.1 (a) The activities shall, subject to the conditions of this permit, be operated using the techniques and in the manner described in the documentation specified in schedule 1, table S1.2, unless otherwise agreed in writing by the Natural Resources Wales.

(b) If notified by Natural Resources Wales that the activities are giving rise to pollution, the operator shall submit to Natural Resources Wales for approval within the period specified, a revision of any plan specified in schedule 1, table S1.2 or otherwise required under this permit which identifies and minimises the risks of pollution relevant to that plan , and shall implement the approved revised plan in place of the original from the date of approval, unless otherwise agreed in writing by Natural Resources Wales.

2.3.2 Any raw materials or fuels listed in schedule 2 table S2.1 shall conform to the specifications set out in that table.

2.3.3 The operator shall ensure that where waste produced by the activities is sent to a relevant waste operation, that operation is provided with the following information, prior to the receipt of the waste:

(a) the nature of the process producing the waste;

(b) the composition of the waste;

(c) the handling requirements of the waste;

(d) the hazardous property associated with the waste, if applicable; and

(e) the waste code of the waste.

2.3.4 The operator shall ensure that where waste produced by the activities is sent to a landfill site, it meets the waste acceptance criteria for that landfill.

2.4 Improvement programme

2.4.1 The operator shall complete the improvements specified in Schedule 1 Table S1.3 by the date specified in that table unless otherwise agreed in writing by Natural Resources Wales.

2.4.2 Except in the case of an improvement which consists only of a submission to Natural Resources Wales, the operator shall notify Natural Resources Wales within 14 days of completion of each improvement.

3 Emissions and monitoring

3.1 Emissions to water, air or land

3.1.1 There shall be no point source emissions to water, air or land except from the sources and emission points listed in schedule 3 tables S3.1, S3.2 and S3.3.

3.1.2 The limits given in schedule 3 shall not be exceeded.

3.1.3 For the following activities referenced in schedule 1, table S1.1 (A1 to A2) where a substance is specified in schedule 3 tables S3.2 or S3.3 but no limit is set for it, the concentration of such substance in emissions to water from the relevant emission point shall be no greater than the background concentration.

3.1.4 Periodic monitoring shall be carried out at least once every 5 years for groundwater and 10 years for soil, unless such monitoring is based on a systematic appraisal of the risk of contamination.

3.2 Emissions of substances not controlled by emission limits

3.2.1 Emissions of substances not controlled by emission limits (excluding odour) shall not cause pollution. The operator shall not be taken to have breached this condition if appropriate measures, including, but not limited to, those specified in any approved emissions management plan, have been taken to prevent or where that is not practicable, to minimise, those emissions.

3.2.2 The operator shall:

(a) if notified by Natural Resources Wales that the activities are giving rise to pollution, submit to Natural Resources Wales for approval within the period specified, an emissions management plan which identifies and minimises the risks of pollution from emissions of substances not controlled by emission limits;

(b) implement the approved emissions management plan, from the date of approval, unless otherwise agreed in writing by Natural Resources Wales.

3.2.3 All liquids in containers, whose emission to water or land could cause pollution, shall be provided with secondary containment, unless the operator has used other appropriate measures to prevent or where that is not practicable, to minimise, leakage and spillage from the primary container.

3.3 Odour

3.3.1 Emissions from the activities shall be free from odour at levels likely to cause pollution outside the site, as perceived by an authorised officer of Natural Resources Wales, unless the operator has used appropriate measures, including, but not limited to, those specified in any approved odour management plan, to prevent or where that is not practicable to minimise the odour.

3.3.2 The operator shall:

(a) if notified by Natural Resources Wales that the activities are giving rise to pollution outside the site due to odour, submit to Natural Resources Wales for approval within the period specified, an odour management plan which identifies and minimises the risks of pollution from odour;

(b) implement the approved odour management plan, from the date of approval, unless otherwise agreed in writing by Natural Resources Wales.

3.4 Noise and vibration

3.4.1 Emissions from the activities shall be free from noise and vibration at levels likely to cause pollution outside the site, as perceived by an authorised officer of Natural Resources Wales, unless the operator has used appropriate measures, including, but not limited to, those specified in any approved noise and vibration management plan to prevent or where that is not practicable to minimise the noise and vibration.

3.4.2 The operator shall:

(a) if notified Natural Resources Wales that the activities are giving rise to pollution outside the site due to noise and vibration, submit to Natural Resources Wales for approval within the period specified, a noise and vibration management plan which identifies and minimises the risks of pollution from noise and vibration;

(b) implement the approved noise and vibration management plan, from the date of approval, unless otherwise agreed in writing by Natural Resources Wales.

3.5 Monitoring

3.5.1 The operator shall, unless otherwise agreed in writing by Natural Resources Wales, undertake the monitoring specified in the following tables in schedule 3 to this permit:

(a) point source emissions specified in tables S3.1, S3.2 and S3.3;

3.5.2 The operator shall maintain records of all monitoring required by this permit including records of the taking and analysis of samples, instrument measurements (periodic and continual), calibrations, examinations, tests and surveys and any assessment or evaluation made on the basis of such data.

3.5.3 Monitoring equipment, techniques, personnel and organisations employed for the emissions monitoring programme and the environmental or other monitoring specified in condition 3.5.1 shall have either MCERTS certification or MCERTS accreditation (as appropriate), where available, unless otherwise agreed in writing by Natural Resources Wales.

3.5.4 Permanent means of access shall be provided to enable sampling/monitoring to be carried out in relation to the emission points specified in Schedule 3 Tables S3.1, S3.2, S3.3 unless otherwise agreed in writing by Natural Resources Wales.

4 Information

4.1 Records

4.1.1 All records required to be made by this permit shall:

(a) be legible;

(b) be made as soon as reasonably practicable;

(c) if amended, be amended in such a way that the original and any subsequent amendments remain legible, or are capable of retrieval; and

(d) be retained, unless otherwise agreed in writing by Natural Resources Wales, for at least 6 years from the date when the records were made, or in the case of the following records until permit surrender:

(i) off-site environmental effects; and

(ii) matters which affect the condition of the land and groundwater.

4.1.2 The operator shall keep on site all records, plans and the management system required to be maintained by this permit, unless otherwise agreed in writing by Natural Resources Wales.

4.2 Reporting

4.2.1 The operator shall send all reports and notifications required by the permit to Natural Resources Wales using the contact details supplied in writing by Natural Resources Wales.

4.2.2 A report or reports on the performance of the activities over the previous year shall be submitted to Natural Resources Wales by 31 January (or other date agreed in writing by Natural Resources Wales) each year. The report(s) shall include as a minimum:

(a) a review of the results of the monitoring and assessment carried out in accordance with the permit including an interpretive review of that data;

(b) the annual production /treatment data set out in schedule 4 table S4.2;

(c) the performance parameters set out in schedule 4 table S4.3 using the forms specified in table S4.4 of that schedule.

4.2.3 Within 28 days of the end of the reporting period the operator shall, unless otherwise agreed in writing by Natural Resources Wales, submit reports of the monitoring and assessment carried out in accordance with the conditions of this permit, as follows:

(a) in respect of the parameters and emission points specified in schedule 4 table S4.1;

(b) for the reporting periods specified in schedule 4 table S4.1 and using the forms specified in schedule 4 table S4.4; and

(c) giving the information from such results and assessments as may be required by the forms specified in those tables.

4.2.4 The operator shall, unless notice under this condition has been served within the preceding four years, submit to Natural Resources Wales, within six months of receipt of a written notice, a report assessing whether there are other appropriate measures that could be taken to prevent, or where that is not practicable, to minimise pollution.

4.3 Notifications

4.3.1 The Operator shall

(a) in the event that the operation of the activities gives rise to an incident or accident which significantly affects or may significantly affect the environment, the operator must immediately—

(i) inform Natural Resources Wales,

(ii) take the measures necessary to limit the environmental consequences of such an incident or accident, and

(iii) take the measures necessary to prevent further possible incidents or accidents;

(b) in the event of a breach of any permit condition, the operator must immediately—

(i) inform Natural Resources Wales, and

(ii) take the measures necessary to ensure that compliance is restored within the shortest possible time;

(c) in the event of a breach of permit condition which poses an immediate danger to human health or threatens to cause an immediate significant adverse effect on the environment, the operator must immediately suspend the operation of the activities or the relevant part of it until compliance with the permit conditions has been restored.

4.3.2 Any information provided under condition 4.3.1(a)(i), or 4.3.1 (b)(i) where the information relates to the breach of a limit specified in the permit, shall be confirmed by sending the information listed in schedule 5 to this permit within the time period specified in that schedule.

4.3.3 Where Natural Resources Wales has requested in writing that it shall be notified when the operator is to undertake monitoring and/or spot sampling, the operator shall inform Natural Resources Wales when the relevant monitoring and/or spot sampling is to take place. The operator shall provide this information to Natural Resources Wales at least 14 days before the date the monitoring is to be undertaken.

4.3.4 Natural Resources Wales shall be notified within 14 days of the occurrence of the following matters, except where such disclosure is prohibited by Stock Exchange rules:

Where the operator is a registered company:

(a) any change in the operator's trading name, registered name or registered office address; and

(b) any steps taken with a view to the operator going into administration, entering into a company voluntary arrangement or being wound up.

Where the operator is a corporate body other than a registered company:

(a) any change in the operator's name or address; and

(b) any steps taken with a view to the dissolution of the operator.

In any other case:

(a) the death of any of the named operators (where the operator consists of more than one named individual);

(b) any change in the operator's name(s) or address(es); and

(c) any steps taken with a view to the operator, or any one of them, going into bankruptcy, entering into a composition or arrangement with creditors, or, in the case of them being in a partnership, dissolving the partnership.

4.3.5 Where the operator proposes to make a change in the nature or functioning, or an extension of the activities, which may have consequences for the environment and the change is not otherwise the subject of an application for approval under the Regulations or this permit:

(a) Natural Resources Wales shall be notified at least 14 days before making the change; and

(b) the notification shall contain a description of the proposed change in operation.

4.3.6 Natural Resources Wales shall be given at least 14 days' notice before implementation of any part of the site closure plan.

4.4 Interpretation

4.4.1 In this permit the expressions listed in schedule 6 shall have the meaning given in that schedule.

4.4.2 In this permit references to reports and notifications mean written reports and notifications, except where reference is made to notification being made "immediately", in which case it may be provided by telephone.

Schedule 1 - Operations

Activity ref.	Activity listed in Schedule 1 of the EP Regulations	Description of specified activity and WFD Annex I and II operations	Limits of specified activity and waste types
A1	S4.1 A1 (a)(viii) Producing organic chemicals such as – plastic materials (for example polymers, synthetic fibres and cellulose based fibres)	Manufacture of agarose based resins for pharmaceutical use.	100 tonnes of product produced per annum All activities to be carried out within a dedicated building All activities to be carried out on an impermeable surface with sealed drainage
Directly Associated Activities			
A2	Raw materials and waste tanks	Tank farms	Storage of raw materials, intermediates, products & waste and associated emissions. All storage tanks are contained within a bund complying with CIRIA C736 and in an area with sealed drainage.

Table S1.2 Operating techniques

Description	Parts	Date Received
Application	The response to questions 3a and 3b in application form B3	20/12/2017
Application	The response to question 4 in application form B3	20/12/2017
Application	The response to Appendix 2 of application form B3	20/12/2017
Application	Air quality and odour impact assessment. Doc ref – ED 62380131	20/12/2017
Application	Best Available Techniques assessment. Doc ref – SPC0055/ME17.11.23/BAT Assessment/Purolite/December 2017	20/12/2017
Application	Emissions Management Plan (EMP) for an organic chemical manufacturing plant. Doc Ref - SPC0055/ME17.11.23/Emissions Management Plan/V1/December 2017	20/12/2017

Table S1.3 Improvement programme requirements

Ref.	Requirement	Date
1	The operator shall carry out monthly emission testing of AGE and Epichlorohydrin for 3 months from the main stack (A1) to ensure that the predictions made in the application are accurate and emissions are insignificant. The emissions will be compared to the emission benchmark for Benzene as quoted in the *'Additional guidance for Speciality Organic Chemicals Sector guidance EPR 4.02'* A report shall be submitted to NRW within 6 months for approval, if the results show emissions are not insignificant then additional measures will be proposed.	3 months of emission monitoring from date of commencement of operation.

Schedule 2 - Waste types, raw materials and fuels

Table S2.1 Raw materials and fuels	
Raw materials and fuel description	**Specification**
-	-

Schedule 3 – Emissions and monitoring

Table S3.1 Point source emissions to air – emission limits and monitoring requirements

Emission point ref. & location	Source	Parameter	Limit (including unit)	Reference period	Monitoring frequency	Monitoring standard(s) or method(s)
A1	Main vent stack					
A2	Hydrogen vent routing					
A3	Epichlorohydrin tank vent			No Monitoring Required		
A4	Steam boiler					

Table S3.2 Point Source emissions to water (other than sewer) and land – emission limits and monitoring requirements

Emission point ref. & location	Source	Parameter	Limit (incl. unit)	Reference Period	Monitoring frequency	Monitoring standard or method
W1 – tributary of the Nant Muchudd on the Eastern boundary of the site	Accumulated surface and roof water run-off			No Monitoring Required		

Table S3.3 Point source emissions to sewer, effluent treatment plant or other transfers off-site– emission limits and monitoring requirements

Emission point ref. & location	Source	Parameter	Limit (incl. unit)	Reference Period	Monitoring frequency	Monitoring standard or method
S1 (trade effluent discharge to Dŵr Cymru Welsh Water Sewer	Process Effluent			No Monitoring Required		

Schedule 4 - Reporting

Parameters, for which reports shall be made, in accordance with conditions of this permit, are listed below.

Table S4.1 Reporting of monitoring data			
Parameter	**Emission or monitoring point/reference**	**Reporting period**	**Period begins**
Emissions to air Parameters as required by condition 3.5.1		No Monitoring Required	
Emissions to water Parameters as required by condition 3.5.1		No Monitoring Required	

Table S4.2: Annual production/treatment	
Parameter	**Units**
Total amount of product produced	tonnes

Table S4.3 Performance parameters		
Parameter	**Frequency of assessment**	**Units**
Water usage	Annually	tonnes
Energy usage	Annually	MWh
Total raw material used	Annually	tonnes
Waste disposal and/or recovery	Annually	tonnes

Table S4.4 Reporting forms		
Media/parameter	**Reporting format**	**Date of form**
Energy Usage	Form Energy1 or other form as agreed in writing with Natural Resources Wales	31/05/18
Water Usage	Form Water Usage1 or other form as agreed in writing with Natural Resources Wales	31/05/18
Performance Indicators	Form Performance1 or other form as agreed in writing with Natural Resources Wales	31/05/18

Schedule 5 - Notification

These pages outline the information that the operator must provide.

Units of measurement used in information supplied under Part A and B requirements shall be appropriate to the circumstances of the emission. Where appropriate, a comparison should be made of actual emissions and authorised emission limits.

If any information is considered commercially confidential, it should be separated from non-confidential information, supplied on a separate sheet and accompanied by an application for commercial confidentiality under the provisions of the EP Regulations.

Part A

Permit Number	
Name of operator	**Purolite Limited**
Location of Facility	**Unit C, Llantrisant Business Park, Llantrisant**
Time and date of the detection	

(a) Notification requirements for any malfunction, breakdown or failure of equipment or techniques, accident, or emission of a substance not controlled by an emission limit which has caused, is causing or may cause significant pollution	
To be notified within 24 hours of detection	
Date and time of the event	
Reference or description of the location of the event	
Description of where any release into the environment took place	
Substances(s) potentially released	
Best estimate of the quantity or rate of release of substances	
Measures taken, or intended to be taken, to stop any emission	
Description of the failure or accident.	

(b) Notification requirements for the breach of a limit	
To be notified within 24 hours of detection unless otherwise specified below	
Emission point reference/ source	
Parameter(s)	
Limit	
Measured value and uncertainty	
Date and time of monitoring	
Measures taken, or intended to be taken, to stop the emission	

Time periods for notification following detection of a breach of a limit	
Parameter	**Notification period**

(c) Notification requirements for the detection of any significant adverse environmental effect	
To be notified within 24 hours of detection	
Description of where the effect on the environment was detected	
Substances(s) detected	
Concentrations of substances detected	
Date of monitoring/sampling	

Part B - to be submitted as soon as practicable

Any more accurate information on the matters for notification under Part A.	
Measures taken, or intended to be taken, to prevent a recurrence of the incident	
Measures taken, or intended to be taken, to rectify, limit or prevent any pollution of the environment which has been or may be caused by the emission	
The dates of any unauthorised emissions from the facility in the preceding 24 months.	

Name*	
Post	
Signature	
Date	

* authorised to sign on behalf of the operator

Schedule 6 - Interpretation

"abatement equipment" means that equipment dedicated to the removal of polluting substances from releases from the installation to air or water media.

"accident" means an accident that may result in pollution.

"application" means the application for this permit, together with any additional information supplied by the operator as part of the application and any response to a notice served under Schedule 5 to the EP Regulations.

"authorised officer" means any person authorised by Natural Resources Wales under section 108(1) of The Environment Act 1995 to exercise, in accordance with the terms of any such authorisation, any power specified in section 108(4) of that Act.

"bi-annual" means twice per year with at least five months between tests;

"CEM" Continuous emission monitor

"CEN" means Commité Européen de Normalisation

"daily average" for releases of substances to air means the average of valid half-hourly averages over a calendar day during normal operation.

"EP Regulations" means The Environmental Permitting (England and Wales) Regulations SI 2016 No.1154 and words and expressions used in this permit which are also used in the Regulations have the same meanings as in those Regulations.

"emissions of substances not controlled by emission limits" means emissions of substances to air, water or land from the activities, either from the emission points specified in schedule 3 or from other localised or diffuse sources, which are not controlled by an emission limit**.**

"groundwater" means all water, which is below the surface of the ground in the saturation zone and in direct contact with the ground or subsoil.

"Industrial Emissions Directive" means DIRECTIVE 2010/75/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 24 November 2010 on industrial emissions

"ISO" means International Standards Organisation.

"MCERTS" means the Environment Agency's Monitoring Certification Scheme.

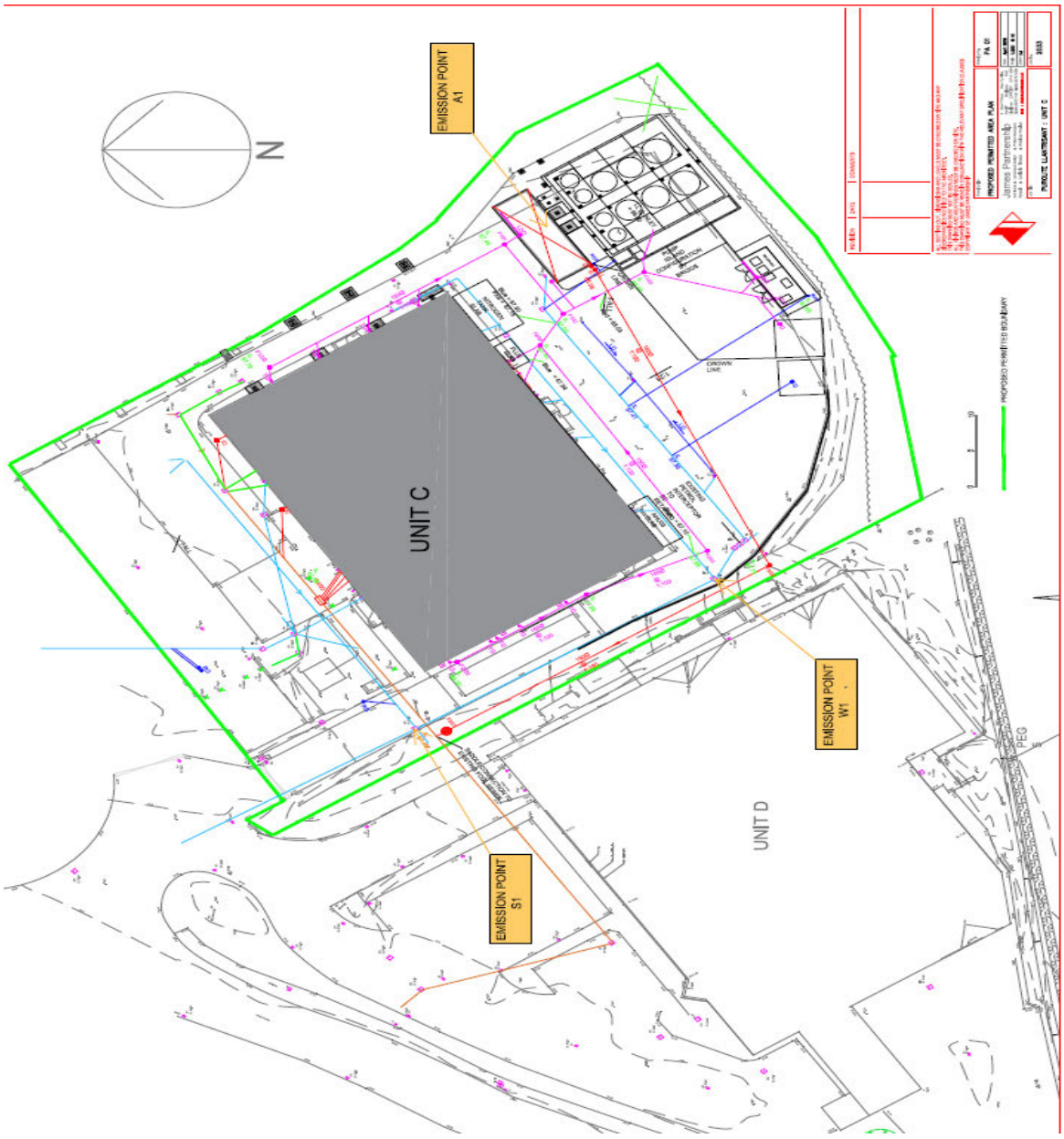
"quarter" means a calendar year quarter commencing on 1 January, 1 April, 1 July or 1 October.

"quarterly" for reporting/sampling means after/during each 3-month period, January to March; April to June; July to September and October to December and, when sampling, with at least 2 months between each sampling date.

Waste Framework Directive" or "WFD" means Waste Framework Directive 2008/98/EC of the European Parliament and of the Council on waste

"year" means calendar year ending 31 December.

Schedule 7 - Site plan



END OF PERMIT

Appendix C - Main Stack (A1)

- Briggs of Burton Estimated Data
- Monitoring Results

Project No	MG1939
Project Title	Purolite Agarose Manufacturing Facility
Doc Title	Emissions Summary Rev B
Doc Date	10-Nov-16

Rev	By	Checked	App (Briggs)	Date
A	GY / TDS	JLB	JLB	07-Nov-16
B	GY	TDS	TDS	10-Nov-16

Notes
1. Cells highlighted in light orange are latest figures following process review for PURE, SP and Q, as well as emission data for bulk and waste tanks breathing. These should be used for subsequent emissions calculations.
2. Volumetric flow rates are calculated based on 101.3 kPa and 20°C.
3. Any changes / updates in the latest issue will be highlighted in blue.

Assumptions
1. No regular repeats of beads washing for all steps. No requirements for regular nitrogen backflushing to loosen packed bed of agarose beads during filtering.
2. Negligible emissions for screening process with water.
3. Filling of bulk tanks and emptying of waste tanks will be vented back into tankers.
4. Nitrogen flow at 21 Nm3/hr (for a 2 hours window - per reaction batch) for dilution of hydrogen gas generated during process will be completed prior to epichlorohydrin addition (for PURE process).

Stack parameters	**Coordinates**	
	x	**y**
Main stack	304170	184500

* Grid reference = ST 04170 84500
i.e. 51.5512°N, 3.3835°W.

Height information (from floor level of existing building)

Height of building (to roof apex)	approx	9.7 m
Height of building (to top of side wall)	approx	6.4 m
Height of tank farm gantry (to floor)	approx	6.0 m
Max height of any vessel in tank farm	approx	10.0 m

Pollutant	**Estimated Average Emissions (annually) (kg/yr)**		**Estimated Average Emissions (annually) (g/s)**		**Estimated Average Emissions (hourly) (kg/hr)**		**Estimated Average Emissions (hourly) (g/s)**		**Estimated Mean Gas Flow (hourly) (m3/hr)**	**Estimated Mean Gas Flow (hourly) (m3/s)**	**Estimated Peak Emissions (hourly) (kg/hr)**	**Estimated Peak Emissions (hourly) (g/s)**	**Estimated Peak Gas Flow (hourly) (m3/hr)**		**Estimated Peak Gas Flow (hourly) (m3/s)**		**Velocity (m/s)**	**Diameter (m)**	**Temp (°C)**
	Previous	**Current**	**Previous**	**Current**	**Previous**	**Current**	**Previous**	**Current**	**Current**	**Current**	**Current**	**Current**	**Previous**	**Current**	**Previous**	**Current**			
[redacted] **Acid**	0.3	5.81	9.51E-06	1.84E-04	0.21	7.21E-04	6.66E-06	2.00E-04	2.89E-04	8.01E-08	0.07	1.86E-05	4	0.03	0.001	7.44E-06	15		50
[redacted]	0.9	118.39	2.85E-05	3.75E-03	1.35	1.47E-02	4.28E-05	4.08E-03	3.09E-03	8.59E-07	0.32	8.75E-05	60	0.07	0.017	1.84E-05	15		45
[redacted]	3.6	7.11	1.14E-04	2.26E-04	0.46	8.82E-04	1.46E-05	2.45E-04	2.29E-04	6.37E-08	0.03	6.94E-06	5.4	0.01	0.002	1.80E-06	15		50
[redacted]	5.8	131.93	1.84E-04	4.18E-03	0.25	1.64E-02	7.93E-06	4.56E-03	8.54E-03	2.37E-06	3.85	1.07E-03	4	2.01	0.001	5.58E-04	15		Now - 25, Prev - 35
[redacted] (as [redacted] - [redacted]	177.6	579.28	5.63E-03	1.84E-02	3.89	7.18E-02	1.23E-04	2.00E-02	3.75E-02	1.04E-05	2.27	6.30E-04	60	1.18	0.017	3.29E-04	15		70
[redacted]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15		35
Hydrogen	67	97.50	2.12E-03	3.09E-03	3.18	1.21E-02	1.01E-04	3.36E-03	1.44E-01	4.00E-05	0.93	2.58E-04	42.4	11.07	0.012	3.07E-03	15		50
[redacted] (as [redacted] - [redacted]	14.9	49.81	4.72E-04	1.58E-03	8.02	6.18E-03	2.54E-04	1.72E-03	4.64E-03	1.29E-06	0.19	5.38E-05	60	0.15	0.017	4.04E-05	15		70
[redacted]	40.8	225.93	1.29E-03	7.16E-03	4.12	2.80E-02	1.31E-04	7.78E-03	7.31E-03	2.03E-06	1.40	3.89E-04	60	0.37	0.017	1.01E-04	15		70
Total							**0.0007**	**0.0419**	**0.21**	**0.0001**	**9.0492**	**0.0025**	**295.8000**	**14.8715**	**0.0822**	**0.0041**	15	**0.08**	-
																		Diameter based on current data	**0.02**
																		Diameter to use for modelling (incorporating a fan to assist flow)	0.10

Other Information
1. Nitrogen flow at 21 Nm3/hr to dilute hydrogen gas generated during process. This applies for 2 hours window for AGE emissions (per reaction batch). Original emission value was for 15 mins only.

Information used by Ricardo, provided by Briggs previously - 11Oct16

Material	CAS	Concentration (w/w)	Estimated Emissions (annually)	Estimated Peak Emissions (hourly)	Estimated Peak Gas Flow (hourly)	Temperature	Pressure	Target (tbc)	Comments
[redacted]	64-19-7	60%	**0.3 kg/yr**	0.21 kg/hr	4.0 m^3/hr	50 °C	Atmos.	**25 mg/m^3**	
[redacted]	106-92-3	100%	**0.9 kg/yr**	1.35 kg/hr	60.0 m^3/hr	45 °C	Atmos.	**23 mg/m^3**	
[redacted]	106-89-8	100%	**3.6 kg/yr**	0.46 kg/hr	5.4 m^3/hr	50 °C	Atmos.	**2 mg/m^3**	
[redacted]	64-17-5	100%	**5.8 kg/yr**	0.25 kg/hr	4.0 m^3/hr	35 °C	Atmos.	**1920 mg/m^3**	
[redacted]	64-17-5	96%	**177.6 kg/yr**	3.89 kg/hr	60.0 m^3/hr	70 °C	Atmos.	**1920 mg/m^3**	
[redacted]	3033-77-0	100%	0.0 kg/yr	0.00 kg/hr	0.0 m^3/hr	35 °C	Atmos.	**n/a**	Trace amounts only anticipated
Hydrogen	133-74-0	100%	**67.0 kg/yr**	**3.18 kg/hr**	42.4 m^3/hr	50 °C	Atmos.	**n/a**	
[redacted]	67-56-0	4%	**14.9 kg/yr**	8.02 kg/hr	60.0 m^3/hr	70 °C	Atmos.	**266 mg/m^3**	
[redacted]	108-88-3	100%	**40.8 kg/yr**	4.12 kg/hr	60.0 m^3/hr	70 °C	Atmos.	**191 mg/m^3**	

UKAS ISO/IEC 17025 Accredited Testing Laboratory No. 4279
Exova Environmental (UK) Ltd trading as Exova Catalyst & Exova Catalyst Ireland
Unit C5, Emery Court, The Embankment Business Park, Stockport, SK4 3GL

Exova Catalyst, Unit 37, Evans Business Centre, Western Industrial Estate, Caerphilly, CF83 1BE
Your Exova Catalyst Contact: Paul Martin (07827 332 630)
E: paul.martin@exova.com

Stack Emissions Testing Report Commissioned by
Purolite Ltd

Installation Name & Address
Purolite Ltd
Unit C
Llantrisant Business Park
Llantrisant
CF72 8LF

EPR Permit: AB3894ZF

Stack Reference
Main Stack

Dates of the Monitoring Campaign
1st March 2019

Job Reference Number
CSW-3562

Report Written by
Martin Futter Team Leader MCERTS Level 2 MM 03 216 TE1 TE2 TE3 TE4

Report Approved by
Martin Futter Team Leader MCERTS Level 2 MM 03 216 TE1 TE2 TE3 TE4

Report Date
27th March 2019

Version
Version 1

Signature of Report Approver


CONTENTS

Opinions and interpretations expressed herein are outside the scope of Exova Catalyst's ISO 17025 accreditation.

MONITORING OBJECTIVES

Purolite Ltd, Llantrisant
Main Stack
1st March 2019

Overall Aim of the Monitoring Campaign

Exova Catalyst were commissioned by Purolite Ltd to carry out stack emissions testing on the Main Stack at Llantrisant.

The aim of the monitoring campaign was to perform testing of an investigative nature under trial operation.

Special Requirements

There were no special requirements.

Target Parameters

[redacted]

Executive Summary

(Page 2 of 7)

MONITORING RESULTS

Purolite Ltd, Llantrisant
Main Stack
1st March 2019

where MU = Measurement Uncertainty associated with the Result

	Concentration				Mass Emission			
Parameter	**Units**	**Result**	**MU +/-**	**Limit**	**Units**	**Result**	**MU +/-**	**Limit**
[redacted] [1]	mg/m³	5299.9	1490.8	-	g/hr	1786.9	546.7	-
[redacted] [1]	mg/m³	9.45	2.66	-	g/hr	3.2	1.0	-
[redacted] - [redacted] [1]	mg/m³	2.67	0.75	-	g/hr	0.9	0.3	-
Water Vapour	% v/v	3.5	0.2					
Stack Gas Temperature	°C	9.4						
Stack Gas Velocity	m/s	15.2	1.69					
Volumetric Flow Rate (ACTUAL)	m³/hr	348	42					
Volumetric Flow Rate (REF) [1]	m³/hr	337	41					

NOTE: VOLUMETRIC FLOW RATE & VELOCITY DATA TAKEN FROM THE PRELIMINARY VELOCITY TRAVERSE.

[1] Reference Conditions (REF) are: 273K, 101.3kPa, without correction for water vapour content.

Executive Summary

MONITORING DATE(S) & TIMES

Purolite Ltd, Llantrisant
Main Stack
1st March 2019

Parameter		Units	Concentration	Units	Mass Emission	Sampling Date(s)	Sampling Times	Duration mins
[redacted]	R1	mg/m³	5301.1	g/hr	1787.3	01/03/2019	09:46 - 11:46	120
[redacted]	R2	mg/m³	5518.3	g/hr	1860.5	01/03/2019	11:48 - 13:48	120
[redacted]	R3	mg/m³	5080.3	g/hr	1712.9	01/03/2019	13:50 - 15:50	120
[redacted]	R1	mg/m³	11.97	g/hr	4.0	01/03/2019	09:46 - 11:46	120
[redacted]	R2	mg/m³	9.13	g/hr	3.1	01/03/2019	11:48 - 13:48	120
[redacted]	R3	mg/m³	7.23	g/hr	2.4	01/03/2019	13:50 - 15:50	120
[redacted]	R1	mg/m³	3.59	g/hr	1.2	01/03/2019	09:46 - 11:46	120
[redacted]	R2	mg/m³	2.69	g/hr	0.9	01/03/2019	11:48 - 13:48	120
[redacted]	R3	mg/m³	1.72	g/hr	0.6	01/03/2019	13:50 - 15:50	120
Water Vapour	R1	% v/v	3.5			01/03/2019	15:55 - 16:15	20
Velocity Traverse	R1					01/03/2019	09:15 - 09:17	

All results are expressed at the respective reference conditions.

PROCESS DETAILS

Purolite Ltd, Llantrisant
Main Stack
1st March 2019

Standard Operating Conditions

Parameter	Value
Process Status	Operational
Capacity (of 100%) and Tonnes / Hour	Normal
Continuous or Batch Process	Batch
Feedstock (if applicable)	Solvent / Resin mix
Abatement System	None
Abatement System Running Status	N/A
Fuel	N/A
Plume Appearance	None visible

[redacted]agarose solution transfer out and water cleaning
emulsification process (toluene at 60 °C)
empty
: IMS washing (settling phase, ambient)
: IMS washing (washing phase, ambient)
water cleaning
neutralized crosslinking process (50 °C)
: empty
empty
empty
empty
empty
empty
empty
level in vessel 4700 L

Executive Summary

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MONITORING & ANALYTICAL METHODS

Purolite Ltd, Llantrisant
Main Stack
1st March 2019

	Monitoring				Analysis					
Parameter	**Standard**	**Technical Procedure**	**ISO 17025 Testing**	**Testing Lab**	**Analytical Procedure**	**Analytical Technique**	**ISO 17025 Analysis**	**Analysis Lab**	**MCERTS Testing**	**LOD (Average)**
Toluene	CEN/TS 13649	CAT-TP-16	Yes	CAT	O8 (U)	GC-FID	Yes	RPS	Yes	0.125 mg/m³
[redacted]	CEN/TS 13649	CAT-TP-16	Yes	CAT	G8 (N)	GC-FID	No	RPS	No	0.094 mg/m³
[redacted] - [redacted]	CEN/TS 13649	CAT-TP-16	Yes	CAT	G8 (N)	GC-FID	No	RPS	No	0.625 mg/m³
Water Vapour	EN 14790	CAT-TP-05	Yes	CAT	CAT-TP-05	Gravimetric	Yes	CAT	Yes	0.1 % v/v
Velocity & Vol. Flow Rate	EN 16911-1 (MID)	CAT-TP-41	Yes	CAT	Pitot Tube and Thermocouple				Yes	1 2 m/s

ANALYSIS LABORATORIES

(with short name reference as appears in the table above)

Exova Catalyst (CAT)	ISO 17025 Accreditation Number: 4279
RPS Laboratories Ltd (RPS)	ISO 17025 Accreditation Number: 0605

SUMMARY OF SAMPLING DEVIATIONS

Parameter	Run	Deviation
[redacted] & IMS	All	The absorption efficiency was less than the required 95%.

SUITABILITY OF SAMPLING LOCATION

Duct Characteristics

Parameter	Units	Value
Type	-	Circular
Depth	m	0.09
Width	m	-
Area	m²	0.01
Port Depth	cm	9
Orientation of Duct	-	Vertical
Number of Ports	-	1
Sample Port Size	-	3" Flange

Location of Sampling Platform

General Platform Information	Value
Permanent / Temporary Platform	Permanent
Inside / Outside	Outside

Platform Details

EA Technical Guidance Note M1 / EN 15259 Platform Requirements	Value
Sufficient working area to manipulate probe and operate the measuring instruments	Yes
Platform has 2 levels of handrails (approx. 0.5m & 1.0m high)	Yes
Platform has vertical base boards (approx. 0.25m high)	Yes
Platform has chains / self closing gates at top of ladders	No
There are no obstructions present which hamper insertion of sampling equipment	No
Safe Access Available	Yes
Easy Access Available	Yes

Sampling Location / Platform Improvement Recommendations

The sampling location meets all the requirements specified in EA Guidance Note M1 and EN 15259, and therefore there are no improvement recommendations.

EN 15259 Homogeneity Test Requirements

There is no requirement to perform a EN 15259 Homogeneity Test on this Stack.

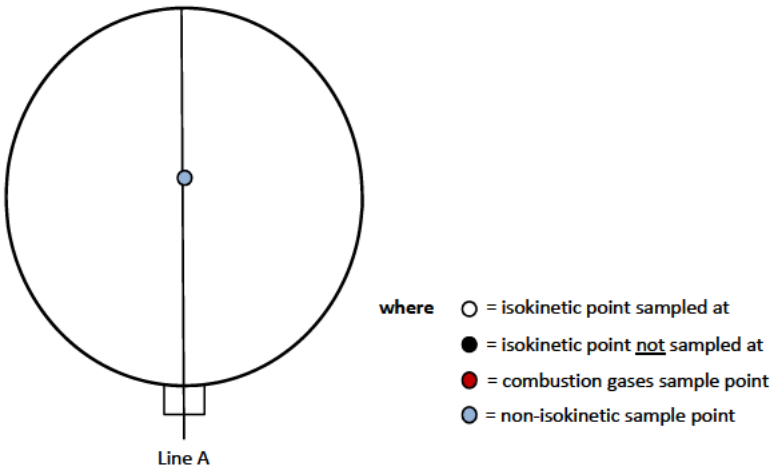
Sampling Plane Validation Criteria (from EN 15259)

Criteria in EN 15259	Units	Traverse 1	Required	Compliant
Lowest Differential Pressure	Pa	193.0	> 5 Pa	Yes
Mean Velocity	m/s	15.19	-	-
Lowest Gas Velocity	m/s	14.85	-	-
Highest Gas Velocity	m/s	15.78	-	-
Ratio of Above	: 1	1.06	< 3 : 1	Yes
Maximum Angle of Swirl	°	5.00	< 15°	Yes
No Local Negative Flow	-	Yes	-	Yes

PLANT PHOTOS

No Photos Allowed

SAMPLE POINTS



APPENDIX CONTENTS

STACK EMISSIONS MONITORING PERSONNEL

Position	Name	MCERTS Accreditation	MCERTS Number	Technical Endorsements
Team Leader	Dale Padfield	MCERTS Level 2	MM 13 1244	TE1 TE2 TE3 TE4
Team Leader	Martin Futter	MCERTS Level 2	MM 03 216	TE1 TE2 TE3 TE4

LIST OF EQUIPMENT

Extractive Sampling	
Equipment Type	**Equipment I.D.**
Control Box DGM (1)	-
Control Box DGM (2)	-
Box Thermocouples (1)	-
Box Thermocouples (2)	-
Umbilical (1)	-
Umbilical (2)	-
Oven Box (1)	-
Oven Box (2)	-
Heated Probe (1)	-
Heated Probe (2)	-
Heated Probe (3)	-
S-Pitot (1)	-
S-Pitot (2)	-
L-Pitot	-
Site Balance	-
500g / 1Kg Check Weights	-
Last Impinger Arm	-
Callipers	-
Tubes Kit Thermocouple	-

Instrumental Analysers	
Equipment Type	**Equipment I.D.**
Horiba PG-250	-
Horiba PG-250	-
Servomex 4900	-
Eco Physics CLD 822Mh	-
ABB AO2020-URAS26	-
Testo 350 XL	-
JCT JCC P1 Cooler	-
Gasmet DX4000	-
Gasmet Sampling System	-
Bernath 3006 FID	-
M&C PSS	-
Mass Flow Controller (1)	CAT 6.34
Mass Flow Controller (2)	CAT 6.35
Mass View (1)	CAT 25.14
Mass View (2)	CAT 25.13
Easylogger EN-EL-12 Bit	-
Easylogger EN-EL-12 Bit	-
Bioaerosols Temperature Logger	-
Electronic Refrigerator	-

Miscellaneous Items	
Equipment Type	**Equipment I.D.**
Digital Manometer (1)	-
Digital Manometer (2)	CAT 3.177
Digital Temperature Meter	-
Stopwatch	-
Barometer	-
Stack Thermocouple (1)	-
Stack Thermocouple (2)	-
Stack Thermocouple (3)	-
1m Heated Line (1)	-
1m Heated Line (2)	-
1m Heated Line (3)	-
5m Heated Line (1)	-
15m Heated Line (1)	-
20m Heated Line (1)	-
20m Heated Line (2)	-
Dual Channel Heater Controller	-
Single Channel Heater Controller	-
Laboratory Balance	
Tape Measure	CAT 16.22

METHODS & TECHNICAL PROCEDURES USED

Parameter	Standard	Technical Procedure
[redacted]	CEN/TS 13649	CAT-TP-16
[redacted]	CEN/TS 13649	CAT-TP-16
[redacted] - [redacted]	CEN/TS 13649	CAT-TP-16
Water Vapour	EN 14790	CAT-TP-05
Velocity & Vol. Flow Rate	EN 16911-1 (MID)	CAT-TP-41

PRELIMINARY STACK SURVEY: CALCULATIONS

General Stack Details

Stack Details (from Traverse)	Units	Value
Stack Diameter / Depth, D	m	0.09
Stack Width, W	m	-
Stack Area, A	m^2	0.01
Average Stack Gas Temperature, T_a	°C	9.4
Average Stack Gas Pressure	Pa	202.3
Average Stack Static Pressure, P_{static}	kPa	0.020
Average Barometric Pressure, P_b	kPa	101.5
Average Pitot Tube Calibration Coefficient, C_p	-	0.84

Stack Gas Composition & Molecular Weights

Component	Conc ppm	Conc Dry % v/v	Conc Wet % v/v	Volume Fraction r	Molar Mass M	Density kg/m³ p	Conc kg/m³ p_i
CO_2 (Estimated)	-	0.06	0.06	0.0006	44.01	1.9635	0.00118
O_2 (Estimated)	-	20.80	20.07	0.2080	32.00	1.4277	0.29696
N_2	-	79.14	76.37	0.7914	28.01	1.2498	0.98913
Moisture (H_2O)	-	-	3.50	0.0350	18.02	0.8037	0.02815

Where: p = M / 22.41

p_i = r x p

Calculation of Stack Gas Densities

Determinand	Units	Result
Dry Density (STP), P_{STD}	kg/m³	1.287
Wet Density (STP), P_{STW}	kg/m³	1.270
Dry Density (Actual), P_{Actual}	kg/m³	1.247
Average Wet Density (Actual), $P_{ActualW}$	kg/m³	1.231

Where: P_{STD} = sum of component concentrations, kg/m³ (not including water vapour)

P_{STW} = sum of all wet concentrations / 100 x density, kg/m³ (including water vapour)

$P_{Actual} = P_{STD} \times (T_{STP} / (P_{STP})) \times ((P_{static} + P_b) / T_a)$

$P_{ActualW}$ (at each sampling point) $= P_{STW} \times (T_s / P_s) \times (P_a / T_a)$

Calculation of Stack Gas Volumetric Flowrate, Q

Duct gas flow conditions	Units	Actual	REF [1]
Temperature	°C	9.4	0.0
Total Pressure	kPa	101.5	101.3
Moisture	%	3.50	3.50

Gas Volumetric Flowrate (from Traverse)	Units	Result
Gas Volumetric Flowrate (Actual)	m³/hr	348
Gas Volumetric Flowrate (STP, Wet)	m³/hr	337
Gas Volumetric Flowrate (STP, Dry)	m³/hr	325
Gas Volumetric Flowrate REF [1]	m³/hr	337

PRELIMINARY STACK SURVEY: VELOCITY TRAVERSE TO EN 16911-1 (MID)

(1 of 1)

Parameter	Units	Value
Date of Survey	-	01/03/2019
Time of Survey	-	09:15 - 09:17
Atmospheric Pressure	kPa	101 5
Average Stack Static Pressure	Pa	20
Result of Pitot Stagnation Test	-	Pass
Are Water Droplets Present?	-	No
Device Used	S-Type Pitot with KIMO MP 200 (500Pa)	

Parameter	Units	Value
Initial Pitot Leak Check	-	Pass
Final Pitot Leak Check	-	Pass
Orientation of Duct	-	Vertical
Pitot Tube, C_p	-	0.84
Number of Lines Available	-	1
Number of Lines Used	-	1

Sampling Line A

Traverse Point	Depth m	ΔP Pa	Temp °C	Wet Density kg/m³	Velocity m/s	Swirl °
STATIC (Units: Pa)		*20.0*				
Mean		**202.3**	**9.4**	**1.231**	**15.19**	
1	0.01	195.0	9.4	1.231	14.92	5.0
2	0.02	218.0	9.4	1.231	15.78	5.0
3	0.07	193.0	9.4	1.231	14.85	5.0
4	0.08	203.0	9.4	1.231	15 23	5.0

PRELIMINARY STACK SURVEY: VELOCITY TRAVERSE TO EN 16911-1 (MID) - MEASUREMENT UNCERTAINTY

(1 of 1)

Performance characteristics (Uncertainty Components)	Uncertainty	Value	Units
Standard Uncertainty on the coefficient of the Pitot Tube	u(k)	0.005	-
Standard Uncertainty associated with the mean local dynamic pressures	u(Δpi)	3.434	Pa
- Resolution	u(res)	0.00087	
- Calibration	u(cal)	4 259	
- Drift	u(drift)	0.083	
- Lack of Fit	u(fit)	6.450	
- Overall corrections to dynamic measurements	u(Cf)	10.793	
Standard uncertainty associated with the molar mass of the gas	u(M)	0.00003	-
- $\varphi O_2,w$	-	20.072	
- $\varphi CO_2,w$	-	0.058	
- Oxygen, dry	u(ϕO_2,d)	0.637	
- Carbon Dioxide, dry	u(ϕCO_2,d)	0.002	
- Water Vapour	u(ϕH_2O)	0.179	
- Oxygen, wet	u(ϕO_2,w)	0.616	
- Carbon Dioxide, wet	u(ϕCO_2,w)	0.002	
Standard uncertainty associated with the stack temperature	u(Tc)	1.441	K
Standard uncertainty associated with the absolute pressure in the duct	u(pc)	175.726	Pa
- Atmospheric Pressure	u(patm)	175.692	
- Static Pressure	u(pstat)	3.434	
Standard uncertainty associated with the density in the duct	u(ρ)	0.00663	-
Standard uncertainty associated with the local velocities	u(vi)	0.872	Pa
Standard uncertainty associated with the mean velocity	u(v)	0.865	m/s
Standard uncertainty associated with the mean velocity (95% Confidence)	Uc(v)	1.695	m/s
Standard uncertainty associated with the mean velocity (95% Confidence), relative	Uc,rel(v)	11.15	%
Standard uncertainty associated with the volume flow rate (95% Confidence)	Uc(qV,w)	41.9	m^3/hr
- $u^2(a)/a^2$	-	0.00053	
- $u^2(qV,w)/q^2V,w$	-	0.00377	
- $u^2(qV,w)$	-	457	
- $u(qV,w)$	-	21.4	
Standard uncertainty associated with the volume flow rate (95% Confidence), relative	Uc,rel(qV,w)	12.04	%

WATER VAPOUR: RESULTS SUMMARY

Purolite Ltd, Llantrisant

Main Stack

Sample Runs

Parameter	Units	Run 1		Mean
Concentration	% v/v	3.50		3.50
Uncertainty	±% v/v	0.21		0.21

General Sampling Information

Parameter	Value
Standard	EN 14790
Technical Procedure	CAT-TP-05

WATER VAPOUR: SAMPLING DETAILS

Sample Runs

Parameter	Units	Run 1
Sampling Times	-	15:55 - 16:15
Sampling Dates	-	01/03/2019
Sampling Device	-	MFC / MV
Duration	mins	20
Volume Sampled (STP, Dry)	m^3	0.1888
Volume Sampled (STP, Wet)	m^3	0.1957
Sample Flow Rate	l/min	9.44
Liquid Trap Start Mass	g	4300.4
Liquid Trap End Mass	g	4304.0
Silica Trap Start Mass	g	1535.0
Silica Trap End Mass	g	1536.9
Total Mass Of Water Vapour	g	5.5
Calculated Water Vapour	% v/v	3.50

Where: MFC stands for Mass Flow Controller, MV stands for Mass View Flowmeter

WATER VAPOUR: QUALITY ASSURANCE

Sample Runs

Leak Test Results	Units	Run 1
Mean Sampling Rate	l/min	9.4
Pre-Sampling Leak Rate	l/min	0.10
Post-Sampling Leak Rate	l/min	0.10
Allowable Leak Rate	l/min	0.19
Leak Test Acceptable	-	Yes

Water Droplets	Units	Run 1
Are Water Droplets Present	-	No

Measurement Uncertainty	Units	Run 1
Measurement Uncertainty (MU)	%	6.0
Allowable MU	%	20.0
MU Acceptable	%	Yes

Silica Gel	Units	Run 1
Less than 50% Faded	%	Yes

Test Conditions	Units	Run 1
Ambient Temperature Recorded?	-	Yes

Method Deviations

Nature of Deviation (x = deviation applies to the associated run)	Run Number 1	
There are no deviations associated with the sampling employed.	x	

WATER VAPOUR: MEASUREMENT UNCERTAINTY CALCULATIONS

	Value		Standard uncertainty		
Measured Quantities	**Symbol**	**Run 1**	**Symbol**	**Units**	**Run 1**
Sampled Volume (STP)	V_m	0.1888	uV_m	m^3	0.0038
Repeatability of Weighing	R_w	5.50	uR_w	g	0.12
Reading of Balance	R_b	5.50	uR_b	g	0.03
Leak	L	1.06		%	-

	Uncertainty as a Percentage		
Measured Quantities	**Units**	**Run 1**	**Requirement of Standard**
Sampled Volume (STP)	%	2.00	≤2%
Repeatability of Weighing	%	2.18	No Requirement
Reading of Balance	%	0.50	No Requirement
Leak	%	1.06	≤2%

	Uncertainty in Measurement Units			Sensitivity Coefficient
Measured Quantities	**Symbol**	**Units**	**Run 1**	**Run 1**
Sampled Volume (STP)	V_m	m^3	0.1888	18.55
Repeatability of Weighing	R_w	g	5.50	0.64
Reading of Balance	R_b	g	5.50	0.64
Leak	L	% v/v	0.02	1.00

	Uncertainty in Result	
Measured Quantities	**Units**	**Run 1**
Sampled Volume (STP)	% v/v	0.070
Repeatability of Weighing	% v/v	0.076
Reading of Balance	% v/v	0.018
Leak	% v/v	0.021

Parameter	**Units**	**Run 1**
Combined uncertainty	% v/v	0.11
Expanded uncertainty (95% confidence)	% v/v	0.21
Expanded uncertainty (95% confidence), estimated with Method Deviations	% v/v	0.21
Uncertainty if Water Droplets are present	% v/v	N/A
Reported Uncertainty	% v/v	0.21
Expanded uncertainty (95% confidence)	%	6.0
Expanded uncertainty (95% confidence), estimated with Method Deviations	%	6.0
Uncertainty if Water Droplets are present	%	N/A
Reported Uncertainty	%	6.0

TOLUENE, IMS, AGE : RESULTS SUMMARY

Purolite Ltd, Llantrisant

Main Stack

Sample Runs

Parameter	Units	Run 1	Run 2	Run 3		Mean
[redacted]	mg/m³	5301.1	5518.3	5080.3		5299.9
[redacted]	mg/m³	11.97	9.13	7.23		9.45
[redacted] - [redacted]	mg/m³	3.59	2.69	1.72		2.67

General Sampling Information

Parameter	Value	
Standard	CEN/TS 13649	
Technical Procedure	CAT-TP-16	
Name of Analytical Laboratory	RPS	
Analytical Laboratory's Procedure	O8 (U) G8 (N)	
ISO 17025 Accredited Analysis?	See Executive Summary	
Date of Sample Analysis	13/03/2019	
Probe Material	Stainless Steel	
Sample Tube Type	Coconut Shell Charcoal	
Dynamic Dilution Employed	Yes	
Number of Sampling Lines Used	1 / 1	FORMAT: Number Used / Number Required
Number of Sampling Points Used	1 / 1	FORMAT: Number Used / Number Required
Sample Point I.D.'s	A1	

Reference Conditions

Reference Conditions are: 273K, 101.3kPa, without correction for water vapour content.

TOLUENE, IMS, AGE : SAMPLING DETAILS

RUN 1

Parameter	Units	Value
Sampling Times	-	09:46 - 11:46
Sampling Dates	-	01/03/2019
Sampling Device	-	MV
Duration	mins	120
N_2 to Stack Gas Dilution Ratio	: 1	1
Volume Sampled (REF)	m^3	0.0321

Where: MV stands for Mass View (Mass Flow Controller Technology)

Parameter	Lab Result (Front) µg	Lab Result (Back) µg	Lab Result (Total) µg	LOD (Front) µg	LOD (Back) µg	LOD (Total) µg	Concentration mg/m³	Reported Concentration (Blank Reviewed) mg/m³	Reported LOD mg/m³	Adsorption Efficiency %
[redacted]	107000	63000	170000	2.0	2.0	4.0	5301.1	5301.1	0.125	62.9
[redacted]	225.0	159.0	384.0	1.5	1.5	3.0	11.97	11.97	0.094	58.6
[redacted] - [redacted]	105.0	< 10.0	115.0	10.0	10.0	20.0	3.59	3.59	0.624	100.0

Reference Conditions are: 273K, 101.3kPa, without correction for water vapour content.

TOLUENE, IMS, AGE : SAMPLING DETAILS

RUN 2

Parameter	Units	Value
Sampling Times	-	11:48 - 13:48
Sampling Dates	-	01/03/2019
Sampling Device	-	MV
Duration	mins	120
N_2 to Stack Gas Dilution Ratio	: 1	1
Volume Sampled (REF)	m^3	0.0320

Where: MV stands for Mass View (Mass Flow Controller Technology)

Parameter	Lab Result (Front) µg	Lab Result (Back) µg	Lab Result (Total) µg	LOD (Front) µg	LOD (Back) µg	LOD (Total) µg	Concentration mg/m³	Reported Concentration (Blank Reviewed) mg/m³	Reported LOD mg/m³	Adsorption Efficiency %
[redacted]	113300	63100	176400	2.0	2.0	4.0	5518.3	5518.3	0.125	64.2
[redacted]	184.0	108.0	292.0	1.5	1.5	3.0	9.13	9.13	0.094	63.0
[redacted] - [redacted]	76.0	< 10.0	86.0	10.0	10.0	20.0	2.690	2.690	0.626	100.0

Reference Conditions are: 273K, 101.3kPa, without correction for water vapour content.

TOLUENE, IMS, AGE : SAMPLING DETAILS

RUN 3

Parameter	Units	Value
Sampling Times	-	13:50 - 15:50
Sampling Dates	-	01/03/2019
Sampling Device	-	MV
Duration	mins	120
N_2 to Stack Gas Dilution Ratio	: 1	1
Volume Sampled (REF)	m^3	0.0320

Where: MV stands for Mass View (Mass Flow Controller Technology)

Parameter	Lab Result (Front) µg	Lab Result (Back) µg	Lab Result (Total) µg	LOD (Front) µg	LOD (Back) µg	LOD (Total) µg	Concentration mg/m³	Reported Concentration (Blank Reviewed) mg/m³	Reported LOD mg/m³	Adsorption Efficiency %
[redacted]	103900	58500	162400	2.0	2.0	4.0	5080.3	5080.3	0.125	64.0
[redacted]	145.0	86.0	231.0	1.5	1.5	3.0	7.23	7.23	0.094	62.8
[redacted] - [redacted]	45.0	< 10.0	55.0	10.0	10.0	20.0	1.72	1.72	0.626	100.0

Reference Conditions are: 273K, 101.3kPa, without correction for water vapour content.

TOLUENE, IMS, AGE : SAMPLING DETAILS

BLANK 1

Parameter	Units	Value
Sampling Dates	-	01/03/2019
Sampling Device	-	MV
Average Volume Sampled (REF)	m^3	0.0320

Where: MV stands for Mass View (Mass Flow Controller Technology)

Parameter	Lab Result (Front) µg	Lab Result (Back) µg	Lab Result (Total) µg	Concentration mg/m^3
[redacted]	2.5	2.5	5.0	0.156
[redacted]	1.5	1.5	3.0	0.094
[redacted] - [redacted]	10.0	10.0	20.0	0.625

Reference Conditions are: 273K, 101.3kPa, without correction for water vapour content.

TOLUENE, IMS, AGE : QUALITY ASSURANCE

Sample Runs

Leak Test Results	Units	Run 1	Run 2	Run 3
Mean Sampling Rate	l/min	0.5	0.5	0.5
Pre-Sampling Leak Rate	l/min	0.01	0.01	0.01
Post-Sampling Leak Rate	l/min	0.01	0.01	0.01
Allowable Leak Rate	l/min	0.03	0.03	0.03
Leak Test Acceptable	-	Yes	Yes	Yes

Adsorption Efficiency	Units	Run 1	Run 2	Run 3	Adsorption Efficiency Acceptable
[redacted]	%	62.9	64.2	64.0	No
[redacted]	%	58.6	63.0	62.8	No
[redacted] - [redacted]	%	100.0	100.0	100.0	Yes
Allowable Adsorption Efficiency	%	95	95	95	

Temperature at Sample Tubes	Units	Run 1	Run 2	Run 3
Temperature	°C	15	14	14
Allowable Temperature	°C	40	40	40
Temperature Acceptable	-	Yes	Yes	Yes

Test Conditions	Units	Run 1	Run 2	Run 3
Ambient Temperature Recorded?	-	Yes	Yes	Yes

TOLUENE, IMS, AGE : QUALITY ASSURANCE

Blank Runs

Leak Test Results	Units	Blank 1
Expected Sampling Rate	l/min	0.5
Sampling Leak Rate	l/min	0.01
Allowable Leak Rate	l/min	0.03
Leak Test Acceptable	-	Yes

Validity of Blank vs ELV	Units	Blank 1	Allowed
Allowable for Toluene	mg/m³	0.2	N/A
Allowable for IMS	mg/m³	0.1	N/A
Allowable for AGE - (Allyl Glycidyl Ether)	mg/m³	0.6	N/A

Method Deviations

Nature of Deviation (x = deviation applies to the associated run)	Run Number 1	2	3	
The absorption efficiency was less than the required 95%.	x	x	x	

TOLUENE, IMS, AGE : MEASUREMENT UNCERTAINTY CALCULATIONS

	Value				Standard uncertainty				
Measured Quantities	**Symbol**	**Run 1**	**Run 2**	**Run 3**	**Symbol**	**Units**	**Run 1**	**Run 2**	**Run 3**
Sampled Volume (STP)	V_m	0.0309	0.0308	0.0308	uV_m	m^3	0.0006	0.0006	0.0006
Leak	L	1.80	1.80	1.80	uL	%	-	-	-
Laboratory Result	L_r	10.00	10.00	10.00	uL_r	%	-	-	-

	Uncertainty as a Percentage				
Measured Quantities	**Units**	**Run 1**	**Run 2**	**Run 3**	**Requirement of Standard**
Sampled Volume (STP)	%	2.00	2.00	2.00	≤2%
Leak	%	1.80	1.80	1.80	≤5%
Laboratory Result	%	10.00	10.00	10.00	No Requirement

	Uncertainty in Measurement Units					Sensitivity Coefficient		
Measured Quantities	**Symbol**	**Units**	**Run 1**	**Run 2**	**Run 3**	**Run 1**	**Run 2**	**Run 3**
Sampled Volume (STP)	V_m	m^3	0.0	0.0	0.0	171808	179274	164983
Leak	L	mg/m^3	55.3	57.5	52.9	1.00	1.00	1.00
Laboratory Result	L_r	mg/m^3	531.7	553.0	508.9	1.00	1.00	1.00

	Uncertainty in Result			
Measured Quantities	**Units**	**Run 1**	**Run 2**	**Run 3**
Sampled Volume (STP)	mg/m^3	106.3	110.6	101.8
Leak	mg/m^3	55.3	57.5	52.9
Laboratory Result	mg/m^3	531.7	553.0	508.9

	Oxygen Correction Part of MU Budget			
Measured Quantities	**Units**	**Run 1**	**Run 2**	**Run 3**
O_2 Correction Factor	-	N/A	N/A	N/A
Stack Gas O_2 Content	% v/v	N/A	N/A	N/A
MU for O_2 Correction	-	N/A	N/A	N/A
Overall MU For O_2 Measurement	%	N/A	N/A	N/A

Parameter	**Units**	**Run 1**	**Run 2**	**Run 3**
Combined uncertainty	mg/m^3	545	567	522
Expanded uncertainty (95% confidence), without Oxygen Correction	mg/m^3	1068	1111	1023
Expanded uncertainty (95% confidence), with Oxygen Correction	mg/m^3	N/A	N/A	N/A
Expanded uncertainty (95% confidence), estimated with Method Deviations	mg/m^3	1495	1556	1432
Reported Uncertainty	mg/m^3	1495	1556	1432
Expanded uncertainty (95% confidence), without Oxygen Correction	%	20.1	20.1	20.1
Expanded uncertainty (95% confidence), with Oxygen Correction	%	N/A	N/A	N/A
Expanded uncertainty (95% confidence), estimated with Method Deviations	%	28.1	28.1	28.1
Reported Uncertainty	%	28.1	28.1	28.1

NOTE: Uncertainties reported in mg/m ³ are based upon the summation of all Speciated VOCs Measured.

Element Materials Technology, Unit 37, Evans Business Centre, Western Industrial Estate, Caerphilly, CF83 1BE
Your Element Contact: Paul Martin (07827 332 630)
E: paul.martin@element.com

Stack Emissions Testing Report Commissioned by
Purolite Ltd

Installation Name & Address
Purolite Ltd
Unit C
Llantrisant Business Park
Llantrisant
CF72 8LF

EPR Permit: AB3894ZF

Stack Reference
Main Stack

Dates of the Monitoring Campaign
24th June 2019

Job Reference Number
ESW-3661

Report Written by
Dale Padfield Team Leader MCERTS Level 2 MM 13 1244 TE1 TE2 TE3 TE4

Report Approved by
Martin Futter Team Leader MCERTS Level 2 MM 03 216 TE1 TE2 TE3 TE4

Report Date
19th July 2019

Version
Version 1

Signature of Report Approver


CONTENTS

Opinions and interpretations expressed herein are outside the scope of Element's ISO 17025 accreditation.

MONITORING OBJECTIVES

Purolite Ltd, Llantrisant
Main Stack
24th June 2019

Overall Aim of the Monitoring Campaign

Element were commissioned by Purolite Ltd to carry out stack emissions testing on the Main Stack at Llantrisant.

The aim of the monitoring campaign was to perform testing of an investigative nature under trial operation.

Special Requirements

There were no special requirements.

Target Parameters

[redacted]

Executive Summary

MONITORING RESULTS

Purolite Ltd, Llantrisant

Main Stack

24th June 2019

where MU = Measurement Uncertainty associated with the Result

	Concentration				Mass Emission			
Parameter	**Units**	**Result**	**MU +/-**	**Limit**	**Units**	**Result**	**MU +/-**	**Limit**
[redacted] [1]	mg/m³	1911.7	394.3	-	g/hr	610.0	146.0	-
[redacted] [1]	mg/m³	196.5	42.3	-	g/hr	62.7	15.5	-
[redacted] [1]	mg/m³	2.36	0.48	-	g/hr	0.8	0.2	-
[redacted] [1]	mg/m³	1.58	0.33	-	g/hr	0.5	0.1	-
Water Vapour	% v/v	2.0	0.1					
Stack Gas Temperature	°C	23.0						
Stack Gas Velocity	m/s	15.1	1.70					
Volumetric Flow Rate (ACTUAL)	m³/hr	346	42					
Volumetric Flow Rate (REF) [1]	m³/hr	319	39					

NOTE: VOLUMETRIC FLOW RATE & VELOCITY DATA TAKEN FROM THE PRELIMINARY VELOCITY TRAVERSE.

[1] Reference Conditions (REF) are: 273K, 101.3kPa, without correction for water vapour content.

MONITORING DATE(S) & TIMES

Purolite Ltd, Llantrisant

Main Stack

24th June 2019

Parameter		Units	Concentration	Units	Mass Emission	Sampling Date(s)	Sampling Times	Duration mins
[redacted]	R1	mg/m³	957.5	g/hr	305.5	24/06/2019	09:10 - 10:10	60
[redacted]	R2	mg/m³	2621.0	g/hr	836.4	24/06/2019	10:13 - 11:13	60
[redacted]	R3	mg/m³	1622.1	g/hr	517.6	24/06/2019	11:15 - 13:15	120
[redacted]	R4	mg/m³	2446.4	g/hr	780.6	24/06/2019	13:18 - 15:18	120
[redacted]	R1	mg/m³	11.0	g/hr	3.5	24/06/2019	09:10 - 10:10	60
[redacted]	R2	mg/m³	56.6	g/hr	18.0	24/06/2019	10:13 - 11:13	60
[redacted]	R3	mg/m³	123.7	g/hr	39.5	24/06/2019	11:15 - 13:15	120
[redacted]	R4	mg/m³	594.8	g/hr	189.8	24/06/2019	13:18 - 15:18	120
[redacted]	R1	mg/m³	< 5.19	g/hr	< 1.7	24/06/2019	09:10 - 10:10	60
[redacted]	R2	mg/m³	< 1.67	g/hr	< 0.5	24/06/2019	10:13 - 11:13	60
[redacted]	R3	mg/m³	< 1.29	g/hr	< 0.4	24/06/2019	11:15 - 13:15	120
[redacted]	R4	mg/m³	1.29	g/hr	0.4	24/06/2019	13:18 - 15:18	120
[redacted]	R1	mg/m³	1.04	g/hr	0.3	24/06/2019	09:10 - 10:10	60
[redacted]	R2	mg/m³	1.76	g/hr	0.6	24/06/2019	10:13 - 11:13	60
[redacted]	R3	mg/m³	1.48	g/hr	0.5	24/06/2019	11:15 - 13:15	120
[redacted]	R4	mg/m³	2.03	g/hr	0.6	24/06/2019	13:18 - 15:18	120
Water Vapour	R1	% v/v	2.0			24/06/2019	13:50 - 14:30	40
Velocity Traverse	R1					24/06/2019	15:20 - 15:21	

All results are expressed at the respective reference conditions.

PROCESS DETAILS

Purolite Ltd, Llantrisant
Main Stack
24th June 2019

Standard Operating Conditions

Parameter	Value
Process Status	Operational
Capacity (of 100%) and Tonnes / Hour	Normal
Continuous or Batch Process	Batch
Feedstock (if applicable)	Solvent / Resin mix
Abatement System	None
Abatement System Running Status	N/A
Fuel	N/A
Plume Appearance	None visible

[redacted]Agarose solution prep (AP+ INT 1)
emulsification process (toluene at 60 °C)
empty
IMS washing
empty
AMF 1-8 crosslinking
empty
empty
empty
empty
empty
empty
empty
empty
level in vessel 3650 L

MONITORING & ANALYTICAL METHODS

Purolite Ltd, Llantrisant
Main Stack
24th June 2019

	Monitoring				Analysis					
Parameter	**Standard**	**Technical Procedure**	**ISO 17025 Testing**	**Testing Lab**	**Analytical Procedure**	**Analytical Technique**	**ISO 17025 Analysis**	**Analysis Lab**	**MCERTS Testing**	**LOD (Average)**
[redacted]	CEN/TS 13649	CAT-TP-16	Yes	EET	O8 (U)	GC-FID	Yes	RPS	Yes	0.322 mg/m³
[redacted]	CEN/TS 13649	CAT-TP-16	Yes	EET	G8 (N)	GC-FID	No	RPS	No	0.322 mg/m³
[redacted] - [redacted]	CEN/TS 13649	CAT-TP-16	Yes	EET	G8 (N)	GC-FID	No	RPS	No	2.149 mg/m³
[redacted]	CEN/TS 13649	CAT-TP-16	Yes	EET	G8 (N)	GC-FID	No	RPS	No	0.43 mg/m³
Water Vapour	EN 14790	CAT-TP-05	Yes	EET	CAT-TP-05	Gravimetric	Yes	EET	Yes	0.1 % v/v
Velocity & Vol. Flow Rate	EN 16911-1 (MID)	CAT-TP-41	Yes	EET	Pitot Tube and Thermocouple				Yes	1.2 m/s

ANALYSIS LABORATORIES

(with short name reference as appears in the table above)

RPS Laboratories Ltd (RPS)	ISO 17025 Accreditation Number: 0605
Element Stockport (EET)	ISO 17025 Accreditation Number: 4279

SUMMARY OF SAMPLING DEVIATIONS

Parameter	Run	Deviation
[redacted]	4	The absorption efficiency was less than the required 95%.

SUITABILITY OF SAMPLING LOCATION

Duct Characteristics

Parameter	Units	Value
Type	-	Circular
Depth	m	0.09
Width	m	-
Area	m²	0.01
Port Depth	cm	9
Orientation of Duct	-	Vertical
Number of Ports	-	1
Sample Port Size	-	3" Flange

Location of Sampling Platform

General Platform Information	Value
Permanent / Temporary Platform	Permanent
Inside / Outside	Outside

Platform Details

EA Technical Guidance Note M1 / EN 15259 Platform Requirements	Value
Sufficient working area to manipulate probe and operate the measuring instruments	Yes
Platform has 2 levels of handrails (approx. 0.5m & 1.0m high)	Yes
Platform has vertical base boards (approx. 0.25m high)	Yes
Platform has chains / self closing gates at top of ladders	No
There are no obstructions present which hamper insertion of sampling equipment	No
Safe Access Available	Yes
Easy Access Available	Yes

Sampling Location / Platform Improvement Recommendations

The sampling location meets all the requirements specified in EA Guidance Note M1 and EN 15259, and therefore there are no improvement recommendations.

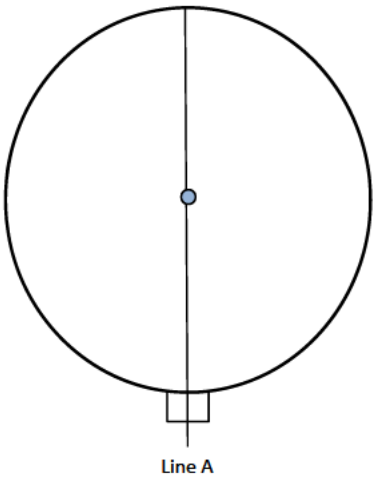
EN 15259 Homogeneity Test Requirements

There is no requirement to perform a EN 15259 Homogeneity Test on this Stack.

Sampling Plane Validation Criteria (from EN 15259)

Criteria in EN 15259	Units	Traverse 1	Required	Compliant
Lowest Differential Pressure	Pa	195.0	> 5 Pa	Yes
Mean Velocity	m/s	15.11	-	-
Lowest Gas Velocity	m/s	15.11	-	-
Highest Gas Velocity	m/s	15.11	-	-
Ratio of Above	: 1	1.00	< 3 : 1	Yes
Maximum Angle of Swirl	°	0.00	< 15°	Yes
No Local Negative Flow	-	Yes	-	Yes

SAMPLE POINTS



where
- ○ = isokinetic point sampled at
- ● = isokinetic point not sampled at
- ● = combustion gases sample point
- ● = non-isokinetic sample point

APPENDIX CONTENTS

STACK EMISSIONS MONITORING PERSONNEL

Position	Name	MCERTS Accreditation	MCERTS Number	Technical Endorsements
Team Leader	Martin Futter	MCERTS Level 2	MM 03 216	TE1 TE2 TE3 TE4
Team Leader	Dale Padfield	MCERTS Level 2	MM 13 1244	TE1 TE2 TE3 TE4

LIST OF EQUIPMENT

Extractive Sampling	
Equipment Type	**Equipment I.D.**
Control Box DGM (1)	-
Control Box DGM (2)	-
Box Thermocouples (1)	-
Box Thermocouples (2)	-
Umbilical (1)	-
Umbilical (2)	-
Oven Box (1)	-
Oven Box (2)	-
Heated Probe (1)	-
Heated Probe (2)	-
Heated Probe (3)	-
S-Pitot (1)	CAT 21S-18
S-Pitot (2)	-
L-Pitot	-
Site Balance	-
500g / 1Kg Check Weights	-
Last Impinger Arm	-
Callipers	-
Tubes Kit Thermocouple	-

Instrumental Analysers	
Equipment Type	**Equipment I.D.**
Horiba PG-250	-
Horiba PG-250	-
Servomex 4900	-
Eco Physics CLD 822Mh	-
ABB AO2020-URAS26	-
Testo 350 XL	-
JCT JCC P1 Cooler	-
Gasmet DX4000	-
Gasmet Sampling System	-
Bernath 3006 FID	-
M&C PSS	-
Mass Flow Controller (1)	CAT 6.13
Mass Flow Controller (2)	CAT 6.14
Mass View (1)	CAT 25.78
Mass View (2)	CAT 25.79
Easylogger EN-EL-12 Bit	-
Easylogger EN-EL-12 Bit	-
Bioaerosols Temperature Logger	-
Electronic Refrigerator	-

Miscellaneous Items	
Equipment Type	**Equipment I.D.**
Digital Manometer (1)	-
Digital Manometer (2)	CAT 3.177
Digital Temperature Meter	-
Stopwatch	-
Barometer	-
Stack Thermocouple (1)	-
Stack Thermocouple (2)	-
Stack Thermocouple (3)	-
1m Heated Line (1)	-
1m Heated Line (2)	-
1m Heated Line (3)	-
5m Heated Line (1)	-
15m Heated Line (1)	-
20m Heated Line (1)	-
20m Heated Line (2)	-
Dual Channel Heater Controller	-
Single Channel Heater Controller	-
Laboratory Balance	
Tape Measure	CAT 16.22

METHODS & TECHNICAL PROCEDURES USED

Parameter	Standard	Technical Procedure
[redacted]	CEN/TS 13649	CAT-TP-16
[redacted]	CEN/TS 13649	CAT-TP-16
[redacted] - [redacted]	CEN/TS 13649	CAT-TP-16
[redacted]	CEN/TS 13649	CAT-TP-16
Water Vapour	EN 14790	CAT-TP-05
Velocity & Vol. Flow Rate	EN 16911-1 (MID)	CAT-TP-41

PRELIMINARY STACK SURVEY: CALCULATIONS

General Stack Details

Stack Details (from Traverse)	Units	Value
Stack Diameter / Depth, D	m	0.09
Stack Width, W	m	-
Stack Area, A	m^2	0.01
Average Stack Gas Temperature, T_a	°C	23.0
Average Stack Gas Pressure	Pa	195.0
Average Stack Static Pressure, P_{static}	kPa	0.080
Average Barometric Pressure, P_b	kPa	101.2
Average Pitot Tube Calibration Coefficient, C_p	-	0.83

Stack Gas Composition & Molecular Weights

Component	Conc ppm	Conc Dry % v/v	Conc Wet % v/v	Volume Fraction r	Molar Mass M	Density kg/m³ p	Conc kg/m³ p_i
CO_2 (Estimated)	-	0.06	0.06	0.0006	44.01	1.9635	0.00118
O_2 (Estimated)	-	20.80	20.38	0.2080	32.00	1.4277	0.29696
N_2	-	79.14	77.55	0.7914	28.01	1.2498	0.98913
Moisture (H_2O)	-	-	2.01	0.0201	18.02	0.8037	0.01614

Where: p = M / 22.41

p_i = r x p

Calculation of Stack Gas Densities

Determinand	Units	Result
Dry Density (STP), P_{STD}	kg/m³	1.287
Wet Density (STP), P_{STW}	kg/m³	1.278
Dry Density (Actual), P_{Actual}	kg/m³	1.187
Average Wet Density (Actual), $P_{ActualW}$	kg/m³	1.178

Where: P_{STD} = sum of component concentrations, kg/m³ (not including water vapour)

P_{STW} = sum of all wet concentrations / 100 x density, kg/m³ (including water vapour)

$P_{Actual} = P_{STD} \times (T_{STP} / (P_{STP})) \times ((P_{static} + P_b) / T_a)$

$P_{ActualW}$ (at each sampling point) $= P_{STW} \times (T_s / P_s) \times (P_a / T_a)$

Calculation of Stack Gas Volumetric Flowrate, Q

Duct gas flow conditions	Units	Actual	REF [1]
Temperature	°C	23.0	0.0
Total Pressure	kPa	101.3	101.3
Moisture	%	2.01	2.01

Gas Volumetric Flowrate (from Traverse)	Units	Result
Gas Volumetric Flowrate (Actual)	m³/hr	346
Gas Volumetric Flowrate (STP, Wet)	m³/hr	319
Gas Volumetric Flowrate (STP, Dry)	m³/hr	313
Gas Volumetric Flowrate REF [1]	m³/hr	319

PRELIMINARY STACK SURVEY: VELOCITY TRAVERSE TO EN 16911-1 (MID)

(1 of 1)

Parameter	Units	Value
Date of Survey	-	24/06/2019
Time of Survey	-	15:20 - 15:21
Atmospheric Pressure	kPa	101.2
Average Stack Static Pressure	Pa	80
Result of Pitot Stagnation Test	-	Pass
Are Water Droplets Present?	-	Yes
Device Used	S-Type Pitot with KIMO MP 200 (500Pa)	

Parameter	Units	Value
Initial Pitot Leak Check	-	Pass
Final Pitot Leak Check	-	Pass
Orientation of Duct	-	Vertical
Pitot Tube, C_p	-	0.83
Number of Lines Available	-	1
Number of Lines Used	-	1

Sampling Line A

Traverse Point	Depth m	ΔP Pa	Temp °C	Wet Density kg/m³	Velocity m/s	Swirl °
STATIC (Units: Pa)		*80.0*				
Mean		**195.0**	**23.0**	**1.178**	**15.11**	
1	0.05	195.0	23.0	1.178	15.11	0.0

PRELIMINARY STACK SURVEY: VELOCITY TRAVERSE TO EN 16911-1 (MID) - MEASUREMENT UNCERTAINTY

(1 of 1)

Performance characteristics (Uncertainty Components)	Uncertainty	Value	Units
Standard Uncertainty on the coefficient of the Pitot Tube	u(k)	0.005	-
Standard Uncertainty associated with the mean local dynamic pressures	u(Δpi)	3.323	Pa
- Resolution	u(res)	0.00087	
- Calibration	u(cal)	3.959	
- Drift	u(drift)	0.083	
- Lack of Fit	u(fit)	5.996	
- Overall corrections to dynamic measurements	u(Cf)	10.039	
Standard uncertainty associated with the molar mass of the gas	u(M)	0.00003	-
- φO_2,w	-	20.382	
- φCO_2,w	-	0.059	
- Oxygen, dry	u(ϕO_2,d)	0.637	
- Carbon Dioxide, dry	u(ϕCO_2,d)	0.002	
- Water Vapour	u(ϕH_2O)	0.102	
- Oxygen, wet	u(ϕO_2,w)	0.624	
- Carbon Dioxide, wet	u(ϕCO_2,w)	0.002	
Standard uncertainty associated with the stack temperature	u(Tc)	1.510	K
Standard uncertainty associated with the absolute pressure in the duct	u(pc)	175.723	Pa
- Atmospheric Pressure	u(patm)	175.692	
- Static Pressure	u(pstat)	3.323	
Standard uncertainty associated with the density in the duct	u(ρ)	0.00635	-
Standard uncertainty associated with the local velocities	u(vi)	0.867	Pa
Standard uncertainty associated with the mean velocity	u(v)	0.867	m/s
Standard uncertainty associated with the mean velocity (95% Confidence)	Uc(v)	1.699	m/s
Standard uncertainty associated with the mean velocity (95% Confidence), relative	Uc,rel(v)	11.25	%
Standard uncertainty associated with the volume flow rate (95% Confidence)	Uc(qV,w)	42.0	m^3/hr
- $u^2(a)/a^2$	-	0.00053	
- $u^2(qV,w)/q^2V,w$	-	0.00383	
- $u^2(qV,w)$	-	458	
- u(qV,w)	-	21.4	
Standard uncertainty associated with the volume flow rate (95% Confidence), relative	Uc,rel(qV,w)	12.12	%

WATER VAPOUR: RESULTS SUMMARY

Purolite Ltd, Llantrisant

Main Stack

Sample Runs

Parameter	Units	Run 1		Mean
Concentration	% v/v	2.01		2.01
Uncertainty	±% v/v	0.11		0.11

General Sampling Information

Parameter	Value
Standard	EN 14790
Technical Procedure	CAT-TP-05

WATER VAPOUR: SAMPLING DETAILS

Sample Runs

Parameter	Units	Run 1
Sampling Times	-	13:50 - 14:30
Sampling Dates	-	24/06/2019
Sampling Device	-	MFC / MV
Duration	mins	40
Volume Sampled (STP, Dry)	m^3	0.3831
Volume Sampled (STP, Wet)	m^3	0.3910
Sample Flow Rate	l/min	9.58
Liquid Trap Start Mass	g	3881.1
Liquid Trap End Mass	g	3881.9
Silica Trap Start Mass	g	1449.9
Silica Trap End Mass	g	1455.4
Total Mass Of Water Vapour	g	6.3
Calculated Water Vapour	% v/v	2.01

Where: MFC stands for Mass Flow Controller, MV stands for Mass View Flowmeter

WATER VAPOUR: QUALITY ASSURANCE

Sample Runs

Leak Test Results	Units	Run 1
Mean Sampling Rate	l/min	9.6
Pre-Sampling Leak Rate	l/min	0.10
Post-Sampling Leak Rate	l/min	0.10
Allowable Leak Rate	l/min	0.19
Leak Test Acceptable	-	Yes

Water Droplets	Units	Run 1
Are Water Droplets Present	-	No

Measurement Uncertainty	Units	Run 1
Measurement Uncertainty (MU)	%	5.4
Allowable MU	%	20.0
MU Acceptable	%	Yes

Silica Gel	Units	Run 1
Less than 50% Faded	%	Yes

Test Conditions	Units	Run 1
Ambient Temperature Recorded?	-	Yes

Method Deviations

Nature of Deviation (x = deviation applies to the associated run)	Run Number 1
There are no deviations associated with the sampling employed.	x

WATER VAPOUR: MEASUREMENT UNCERTAINTY CALCULATIONS

	Value		Standard uncertainty		
Measured Quantities	**Symbol**	**Run 1**	**Symbol**	**Units**	**Run 1**
Sampled Volume (STP)	V_m	0.3831	uV_m	m^3	0.0077
Repeatability of Weighing	R_w	6.30	uR_w	g	0.11
Reading of Balance	R_b	6.30	uR_b	g	0.03
Leak	L	1.04		%	-

	Uncertainty as a Percentage		
Measured Quantities	**Units**	**Run 1**	**Requirement of Standard**
Sampled Volume (STP)	%	2.00	≤2%
Repeatability of Weighing	%	1.75	No Requirement
Reading of Balance	%	0.50	No Requirement
Leak	%	1.04	≤2%

	Uncertainty in Measurement Units			Sensitivity Coefficient
Measured Quantities	**Symbol**	**Units**	**Run 1**	**Run 1**
Sampled Volume (STP)	V_m	m^3	0.3831	5.24
Repeatability of Weighing	R_w	g	6.30	0.32
Reading of Balance	R_b	g	6.30	0.32
Leak	L	% v/v	0.01	1.00

	Uncertainty in Result	
Measured Quantities	**Units**	**Run 1**
Sampled Volume (STP)	% v/v	0.040
Repeatability of Weighing	% v/v	0.035
Reading of Balance	% v/v	0.010
Leak	% v/v	0.012

Parameter	**Units**	**Run 1**
Combined uncertainty	% v/v	0.06
Expanded uncertainty (95% confidence)	% v/v	0.11
Expanded uncertainty (95% confidence), estimated with Method Deviations	% v/v	0.11
Uncertainty if Water Droplets are present	% v/v	N/A
Reported Uncertainty	% v/v	0.11
Expanded uncertainty (95% confidence)	%	5.4
Expanded uncertainty (95% confidence), estimated with Method Deviations	%	5.4
Uncertainty if Water Droplets are present	%	N/A
Reported Uncertainty	%	5.4

TOLUENE, IMS, AGE : RESULTS SUMMARY

Purolite Ltd, Llantrisant

Main Stack

Sample Runs

Parameter	Units	Run 1	Run 2	Run 3	Run 4		Mean
[redacted]	mg/m³	957.5	2621.0	1622.1	2446.4		1911.7
[redacted]	mg/m³	11.0	56.6	123.7	594.8		196.5
[redacted] - [redacted] [redacted]	mg/m³	< 5.19	< 1.67	< 1.29	1.29		2.36
[redacted]	mg/m³	1.04	1.76	1.48	2.03		1.58

General Sampling Information

Parameter	Value	
Standard	CEN/TS 13649	
Technical Procedure	CAT-TP-16	
Name of Analytical Laboratory	RPS	
Analytical Laboratory's Procedure	O8 (U) G8 (N)	
ISO 17025 Accredited Analysis?	See Executive Summary	
Date of Sample Analysis	05/07/2019	
Probe Material	Stainless Steel	
Sample Tube Type	Coconut Shell Charcoal	
Dynamic Dilution Employed	Yes	
Number of Sampling Lines Used	1 / 1	FORMAT: Number Used / Number Required
Number of Sampling Points Used	1 / 1	FORMAT: Number Used / Number Required
Sample Point I.D.'s	A1	

Reference Conditions

Reference Conditions are: 273K, 101.3kPa, without correction for water vapour content.

TOLUENE, IMS, AGE : SAMPLING DETAILS

RUN 1

Parameter	Units	Value
Sampling Times	-	09:10 - 10:10
Sampling Dates	-	24/06/2019
Sampling Device	-	MV
Duration	mins	60
N_2 to Stack Gas Dilution Ratio	: 1	4
Volume Sampled (REF)	m^3	0.0039

Where: MV stands for Mass View (Mass Flow Controller Technology)

Parameter	Lab Result (Front) µg	Lab Result (Back) µg	Lab Result (Total) µg	LOD (Front) µg	LOD (Back) µg	LOD (Total) µg	Concentration mg/m³	Reported Concentration (Blank Reviewed) mg/m³	Reported LOD mg/m³	Adsorption Efficiency %
[redacted]	3691.0	< 1.5	3692.5	1.5	1.5	3.0	957.5	957.5	0.78	100.0
[redacted]	41.0	< 1.5	42.5	1.5	1.5	3.0	11.0	11.0	0.78	100.0
[redacted]	< 10.0	< 10.0	20.0	10.0	10.0	20.0	< 5.19	< 5.19	5.19	100.0
[redacted]	2.0	< 2.0	4.0	2.0	2.0	4.0	1.04	1.04	1.04	100.0

Reference Conditions are: 273K, 101.3kPa, without correction for water vapour content.

TOLUENE, IMS, AGE : SAMPLING DETAILS

RUN 2

Parameter	Units	Value
Sampling Times	-	10:13 - 11:13
Sampling Dates	-	24/06/2019
Sampling Device	-	MV
Duration	mins	60
N_2 to Stack Gas Dilution Ratio	: 1	1.5
Volume Sampled (REF)	m^3	0.0119

Where: MV stands for Mass View (Mass Flow Controller Technology)

Parameter	Lab Result (Front) µg	Lab Result (Back) µg	Lab Result (Total) µg	LOD (Front) µg	LOD (Back) µg	LOD (Total) µg	Concentration mg/m³	Reported Concentration (Blank Reviewed) mg/m³	Reported LOD mg/m³	Adsorption Efficiency %
[redacted]	31300.0	4.0	31304.0	1.5	1.5	3.0	2621.0	2621.0	0.25	100.0
[redacted]	674.0	< 1.5	675.5	1.5	1.5	3.0	56.6	56.6	0.25	100.0
[redacted] - [redacted]	< 10.0	< 10.0	20.0	10.0	10.0	20.0	< 1.67	< 1.67	1.67	100.0
[redacted]	19.0	< 2.0	21.0	2.0	2.0	4.0	1.76	1.76	0.33	100.0

Reference Conditions are: 273K, 101.3kPa, without correction for water vapour content.

TOLUENE, IMS, AGE : SAMPLING DETAILS

RUN 3

Parameter	Units	Value
Sampling Times	-	11:15 - 13:15
Sampling Dates	-	24/06/2019
Sampling Device	-	MV
Duration	mins	120
N_2 to Stack Gas Dilution Ratio	: 1	1.5
Volume Sampled (REF)	m^3	0.0230

Where: MV stands for Mass View (Mass Flow Controller Technology)

Parameter	Lab Result (Front) µg	Lab Result (Back) µg	Lab Result (Total) µg	LOD (Front) µg	LOD (Back) µg	LOD (Total) µg	Concentration mg/m³	Reported Concentration (Blank Reviewed) mg/m³	Reported LOD mg/m³	Adsorption Efficiency %
[redacted]	37310.0	4.0	37314.0	1.5	1.5	3.0	1622.1	1622.1	0.13	100.0
[redacted]	2830.0	15.0	2845.0	1.5	1.5	3.0	123.7	123.7	0.13	99.5
[redacted] - [redacted]	< 10.0	< 10.0	20.0	10.0	10.0	20.0	< 0.87	< 1.29	0.87	100.0
[redacted]	32.0	< 2.0	34.0	2.0	2.0	4.0	1.48	1.48	0.17	100.0

Reference Conditions are: 273K, 101.3kPa, without correction for water vapour content.

TOLUENE, IMS, AGE : SAMPLING DETAILS

RUN 4

Parameter	Units	Value
Sampling Times	-	13:18 - 15:18
Sampling Dates	-	24/06/2019
Sampling Device	-	MV
Duration	mins	120
N_2 to Stack Gas Dilution Ratio	: 1	1.5
Volume Sampled (REF)	m^3	0.0231

Where: MV stands for Mass View (Mass Flow Controller Technology)

Parameter	Lab Result (Front) µg	Lab Result (Back) µg	Lab Result (Total) µg	LOD (Front) µg	LOD (Back) µg	LOD (Total) µg	Concentration mg/m³	Reported Concentration (Blank Reviewed) mg/m³	Reported LOD mg/m³	Adsorption Efficiency %
[redacted]	56510.0	6.0	56516.0	1.5	1.5	3.0	2446.4	2446.4	0.13	100.0
[redacted]	10870.0	2872.0	13742.0	1.5	1.5	3.0	594.8	594.8	0.13	79.1
[redacted] - [redacted]	13.0	< 10.0	23.0	10.0	10.0	20.0	1.00	1.29	0.87	100.0
[redacted]	45.0	< 2.0	47.0	2.0	2.0	4.0	2.03	2.03	0.17	100.0

Reference Conditions are: 273K, 101.3kPa, without correction for water vapour content.

TOLUENE, IMS, AGE : SAMPLING DETAILS

BLANK 1

Parameter	Units	Value
Sampling Dates	-	24/06/19
Sampling Device	-	MV
Average Volume Sampled (REF)	m^3	0.0155

Where: MV stands for Mass View (Mass Flow Controller Technology)

Parameter	Lab Result (Front) µg	Lab Result (Back) µg	Lab Result (Total) µg	Concentration mg/m^3
[redacted]	< 1.5	< 1.5	3.0	< 0.194
[redacted]	< 1.5	< 1.5	3.0	< 0.194
[redacted]	< 10.0	< 10.0	20.0	< 1.292
[redacted]	< 2.0	< 2.0	4.0	< 0.258

Reference Conditions are: 273K, 101.3kPa, without correction for water vapour content.

TOLUENE, IMS, AGE : QUALITY ASSURANCE

(PAGE 1 OF 2)

Sample Runs

Leak Test Results	Units	Run 1	Run 2	Run 3	Run 4
Mean Sampling Rate	l/min	0.1	0.2	0.2	0.2
Pre-Sampling Leak Rate	l/min	0.00	0.00	0.00	0.00
Post-Sampling Leak Rate	l/min	0.00	0.00	0.00	0.00
Allowable Leak Rate	l/min	0.00	0.01	0.01	0.01
Leak Test Acceptable	-	Yes	Yes	Yes	Yes

Adsorption Efficiency	Units	Run 1	Run 2	Run 3	Run 4
[redacted]	%	100.0	100.0	100.0	100.0
[redacted]	%	100.0	100.0	99.5	79.1
[redacted] - [redacted]	%	100.0	100.0	100.0	100.0
[redacted]	%	100.0	100.0	100.0	100.0
Allowable Adsorption Efficiency	%	95	95	95	95
Adsorption Efficiency Acceptable	-	Yes	Yes	Yes	No

Temperature at Sample Tubes	Units	Run 1	Run 2	Run 3	Run 4
Temperature	°C	15	14	14	15
Allowable Temperature	°C	40	40	40	40
Temperature Acceptable	-	Yes	Yes	Yes	Yes

Test Conditions	Units	Run 1	Run 2	Run 3	Run 4
Ambient Temperature Recorded?	-	Yes	Yes	Yes	Yes

TOLUENE, IMS, AGE : QUALITY ASSURANCE

(PAGE 2 OF 2)

Blank Runs

Leak Test Results	Units	Blank 1
Expected Sampling Rate	l/min	0.5
Sampling Leak Rate	l/min	0.00
Allowable Leak Rate	l/min	0.03
Leak Test Acceptable	-	Yes

Validity of Blank vs ELV	Units	Blank 1	Allowed
Allowable for Toluene	mg/m³	0.2	N/A
Allowable for IMS	mg/m³	0.2	N/A
Allowable for AGE - (Allyl Glycidyl Ether)	mg/m³	1.3	N/A
Allowable for Epichlorohydrin	mg/m³	0.3	N/A

Method Deviations

Nature of Deviation	Run Number				
(x = deviation applies to the associated run)	1	2	3	4	
The absorption efficiency was less than the required 95%.				x	

TOLUENE, IMS, AGE : MEASUREMENT UNCERTAINTY CALCULATIONS

	Value					Standard uncertainty					
Measured Quantities	**Symbol**	**Run 1**	**Run 2**	**Run 3**	**Run 4**	**Symbol**	**Units**	**Run 1**	**Run 2**	**Run 3**	**Run 4**
Sampled Volume (STP)	V_m	0.0038	0.0117	0.0225	0.0226	uV_m	m^3	0.0001	0.0002	0.0005	0.0005
Leak	L	0.00	0.00	0.00	0.00	uL	%	-	-	-	-
Laboratory Result	L_r	10.00	10.00	10.00	10.00	uL_r	%	-	-	-	-

	Uncertainty as a Percentage					
Measured Quantities	**Units**	**Run 1**	**Run 2**	**Run 3**	**Run 4**	**Requirement of Standard**
Sampled Volume (STP)	%	2.00	2.00	2.00	2.00	≤2%
Leak	%	0.00	0.00	0.00	0.00	≤5%
Laboratory Result	%	10.00	10.00	10.00	10.00	No Requirement

	Uncertainty in Measurement Units						Sensitivity Coefficient			
Measured Quantities	**Symbol**	**Units**	**Run 1**	**Run 2**	**Run 3**	**Run 4**	**Run 1**	**Run 2**	**Run 3**	**Run 4**
Sampled Volume (STP)	V_m	m^3	0.0038	0.0117	0.0225	0.0226	257915	229072	77547	134485
Leak	L	mg/m^3	0.000	0.000	0.000	0.000	1.00	1.00	1.00	1.00
Laboratory Result	L_r	mg/m^3	97.5	268.1	174.8	304.5	1.00	1.00	1.00	1.00

	Uncertainty in Result				
Measured Quantities	**Units**	**Run 1**	**Run 2**	**Run 3**	**Run 4**
Sampled Volume (STP)	mg/m^3	19.5	53.6	35.0	60.9
Leak	mg/m^3	0.0000	0.0000	0.0000	0.0000
Laboratory Result	mg/m^3	97.47	268.10	174.81	304.45

	Oxygen Correction Part of MU Budget				
Measured Quantities	**Units**	**Run 1**	**Run 2**	**Run 3**	**Run 4**
O_2 Correction Factor	-	N/A	N/A	N/A	N/A
Stack Gas O_2 Content	% v/v	N/A	N/A	N/A	N/A
MU for O_2 Correction	-	N/A	N/A	N/A	N/A
Overall MU For O_2 Measurement	%	N/A	N/A	N/A	N/A

Parameter	**Units**	**Run 1**	**Run 2**	**Run 3**	**Run 4**
Combined uncertainty	mg/m^3	99.4	273.4	178.3	310.5
Expanded uncertainty (95% confidence), without Oxygen Correction	mg/m^3	194.8	535.9	349.4	608.5
Expanded uncertainty (95% confidence), with Oxygen Correction	mg/m^3	N/A	N/A	N/A	N/A
Expanded uncertainty (95% confidence), estimated with Method Deviations	mg/m^3	194.8	535.9	349.4	669.4
Reported Uncertainty	mg/m^3	194.8	535.9	349.4	669.4
Expanded uncertainty (95% confidence), without Oxygen Correction	%	20.0	20.0	20.0	20.0
Expanded uncertainty (95% confidence), with Oxygen Correction	%	N/A	N/A	N/A	N/A
Expanded uncertainty (95% confidence), estimated with Method Deviations	%	20.0	20.0	20.0	22.0
Reported Uncertainty	%	20.0	20.0	20.0	22.0

NOTE: Uncertainties reported in mg/m ³ are based upon the summation of all Speciated VOCs Measured.

Element Materials Technology, Unit 37, Evans Business Centre, Western Industrial Estate, Caerphilly, CF83 1BE
Your Element Contact: Paul Martin (07827 332 630)
E: paul.martin@element.com

Stack Emissions Testing Report Commissioned by
Purolite Ltd

Installation Name & Address
Purolite Ltd
Unit C
Llantrisant Business Park
Llantrisant
CF72 8LF

EPR Permit: AB3894ZF

Stack Reference
Main Stack

Dates of the Monitoring Campaign
12th September 2019

Job Reference Number
ESW-3737

Report Written by
Martin Futter Team Leader MCERTS Level 2 MM 03 216 TE1 TE2 TE3 TE4

Report Approved by
Martin Futter Deputy Regional Manager MCERTS Level 2 MM 03 216 TE1 TE2 TE3 TE4

Report Date
8th October 2019

Version
Version 1

Signature of Report Approver


CONTENTS

Opinions and interpretations expressed herein are outside the scope of Element's ISO 17025 accreditation.

MONITORING OBJECTIVES

Purolite Ltd, Llantrisant
Main Stack
12th September 2019

Overall Aim of the Monitoring Campaign

Element were commissioned by Purolite Ltd to carry out stack emissions testing on the Main Stack at Llantrisant.

The aim of the monitoring campaign was to perform testing of an investigative nature under trial operation.

Special Requirements

There were no special requirements.

Target Parameters

[redacted]

Executive Summary

MONITORING RESULTS

Purolite Ltd, Llantrisant

Main Stack

12th September 2019

where MU = Measurement Uncertainty associated with the Result

	Concentration				Mass Emission			
Parameter	**Units**	**Result**	**MU +/-**	**Limit**	**Units**	**Result**	**MU +/-**	**Limit**
[redacted] [1]	mg/m³	57.4	11.5	-	g/hr	19.1	4.5	-
[redacted] [1]	mg/m³	4.5	0.9	-	g/hr	1.5	0.3	-
[redacted] [1]	mg/m³	1.1	0.2	-	g/hr	0.4	0.1	-
[redacted] [1]	mg/m³	3.0	0.6	-	g/hr	1.0	0.2	-
Water Vapour	% v/v	1.9	0.1					
Stack Gas Temperature	°C	19.5						
Stack Gas Velocity	m/s	15.4	1.73					
Volumetric Flow Rate (ACTUAL)	m³/hr	353	43					
Volumetric Flow Rate (REF) [1]	m³/hr	332	40					

NOTE: VOLUMETRIC FLOW RATE & VELOCITY DATA TAKEN FROM THE PRELIMINARY VELOCITY TRAVERSE.

[1] Reference Conditions (REF) are: 273K, 101.3kPa, without correction for water vapour content.

MONITORING DATE(S) & TIMES

Purolite Ltd, Llantrisant
Main Stack
12th September 2019

Parameter		Units	Concentration	Units	Mass Emission	Sampling Date(s)	Sampling Times	Duration mins
[redacted]	R1	mg/m³	3.3	g/hr	1.1	12/09/2019	08:47 - 10:47	120
[redacted]	R2	mg/m³	119.6	g/hr	39.7	12/09/2019	10:51 - 12:51	120
[redacted]	R3	mg/m³	49.3	g/hr	16.4	12/09/2019	12:55 - 14:55	120
[redacted]	R1	mg/m³	2.46	g/hr	0.8	12/09/2019	08:47 - 10:47	120
[redacted]	R2	mg/m³	4.38	g/hr	1.5	12/09/2019	10:51 - 12:51	120
[redacted]	R3	mg/m³	6.63	g/hr	2.2	12/09/2019	12:55 - 14:55	120
[redacted] - [redacted]	R1	mg/m³	< 0.79	g/hr	< 0.3	12/09/2019	08:47 - 10:47	120
[redacted]	R2	mg/m³	1.27	g/hr	0.4	12/09/2019	10:51 - 12:51	120
[redacted]	R3	mg/m³	1.38	g/hr	0.5	12/09/2019	12:55 - 14:55	120
[redacted]	R1	mg/m³	0.24	g/hr	0.1	12/09/2019	08:47 - 10:47	120
[redacted]	R2	mg/m³	1.83	g/hr	0.6	12/09/2019	10:51 - 12:51	120
[redacted]	R3	mg/m³	6.91	g/hr	2.3	12/09/2019	12:55 - 14:55	120
Water Vapour	R1	% v/v	1.9			12/09/2019	10:00 - 10:30	30
Velocity Traverse	R1					12/09/2019	14:59 - 15:00	

All results are expressed at the respective reference conditions.

PROCESS DETAILS

Purolite Ltd, Llantrisant
Main Stack
12th September 2019

Standard Operating Conditions

Parameter	Value
Process Status	Operational
Capacity (of 100%) and Tonnes / Hour	Normal
Continuous or Batch Process	Batch
Feedstock (if applicable)	Solvent / Resin mix
Abatement System	None
Abatement System Running Status	N/A
Fuel	N/A
Plume Appearance	None visible

MONITORING & ANALYTICAL METHODS

Purolite Ltd, Llantrisant
Main Stack
12th September 2019

	Monitoring				Analysis					
Parameter	**Standard**	**Technical Procedure**	**ISO 17025 Testing**	**Testing Lab**	**Analytical Procedure**	**Analytical Technique**	**ISO 17025 Analysis**	**Analysis Lab**	**MCERTS Testing**	**LOD (Average)**
[redacted]	CEN/TS 13649	CAT-TP-16	Yes	EET	O8 (U) G8 (N)	GC-FID	Yes	RPS	Yes	0.119 mg/m³
[redacted]	CEN/TS 13649	CAT-TP-16	Yes	EET	O8 (U) G8 (N)	GC-FID	No	RPS	No	0.238 mg/m³
[redacted]	CEN/TS 13649	CAT-TP-16	Yes	EET	O8 (U) G8 (N)	GC-FID	No	RPS	No	0.793 mg/m³
[redacted]	CEN/TS 13649	CAT-TP-16	Yes	EET	O8 (U) G8 (N)	GC-FID	No	RPS	No	0.159 mg/m³
Water Vapour	EN 14790	CAT-TP-05	Yes	EET	CAT-TP-05	Gravimetric	Yes	EET	Yes	0.1 % v/v
Velocity & Vol. Flow Rate	EN 16911-1 (MID)	CAT-TP-41	Yes	EET	Pitot Tube and Thermocouple				Yes	1.2 m/s

ANALYSIS LABORATORIES

(with short name reference as appears in the table above)

RPS Laboratories Ltd (RPS)	ISO 17025 Accreditation Number: 0605
Element Stockport (EET)	ISO 17025 Accreditation Number: 4279

SUMMARY OF SAMPLING DEVIATIONS

Parameter	Run	Deviation
All	All	There are no deviations associated with the sampling employed.

SUITABILITY OF SAMPLING LOCATION

Duct Characteristics

Parameter	Units	Value
Type	-	Circular
Depth	m	0.09
Width	m	-
Area	m²	0.01
Port Depth	cm	9
Orientation of Duct	-	Vertical
Number of Ports	-	1
Sample Port Size	-	3" Flange

Location of Sampling Platform

General Platform Information	Value
Permanent / Temporary Platform	Permanent
Inside / Outside	Outside

Platform Details

EA Technical Guidance Note M1 / EN 15259 Platform Requirements	Value
Sufficient working area to manipulate probe and operate the measuring instruments	Yes
Platform has 2 levels of handrails (approx. 0.5m & 1.0m high)	Yes
Platform has vertical base boards (approx. 0.25m high)	Yes
Platform has chains / self closing gates at top of ladders	No
There are no obstructions present which hamper insertion of sampling equipment	No
Safe Access Available	Yes
Easy Access Available	Yes

Sampling Location / Platform Improvement Recommendations

The sampling location meets all the requirements specified in EA Guidance Note M1 and EN 15259, and therefore there are no improvement recommendations.

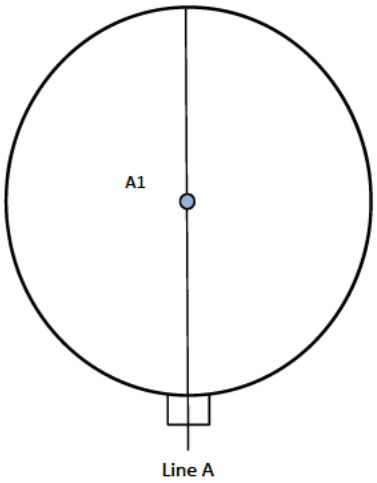
EN 15259 Homogeneity Test Requirements

There is no requirement to perform a EN 15259 Homogeneity Test on this Stack.

Sampling Plane Validation Criteria (from EN 15259)

Criteria in EN 15259	Units	Traverse 1	Required	Compliant
Lowest Differential Pressure	Pa	207.0	> 5 Pa	Yes
Mean Velocity	m/s	15.40	-	-
Lowest Gas Velocity	m/s	15.40	-	-
Highest Gas Velocity	m/s	15.40	-	-
Ratio of Above	: 1	1.00	< 3 : 1	Yes
Maximum Angle of Swirl	°	0.00	< 15°	Yes
No Local Negative Flow	-	Yes	-	Yes

SAMPLE POINTS



where ○ = isokinetic point sampled at
● = isokinetic point not sampled at
● = combustion gases sample point
● = non-isokinetic sample point

APPENDIX CONTENTS

STACK EMISSIONS MONITORING PERSONNEL

Position	Name	MCERTS Accreditation	MCERTS Number	Technical Endorsements
Team Leader	Martin Futter	MCERTS Level 2	MM 03 216	TE1 TE2 TE3 TE4

LIST OF EQUIPMENT

Extractive Sampling	
Equipment Type	**Equipment I.D.**
Control Box DGM (1)	-
Control Box DGM (2)	-
Box Thermocouples (1)	-
Box Thermocouples (2)	-
Umbilical (1)	-
Umbilical (2)	-
Oven Box (1)	-
Oven Box (2)	-
Heated Probe (1)	-
Heated Probe (2)	-
Heated Probe (3)	-
S-Pitot (1)	CAT 21S-18
S-Pitot (2)	-
L-Pitot	-
Site Balance	-
500g / 1Kg Check Weights	-
Last Impinger Arm	-
Callipers	-
Tubes Kit Thermocouple	-

Instrumental Analysers	
Equipment Type	**Equipment I.D.**
Horiba PG-250	-
Horiba PG-250	-
Servomex 4900	-
Eco Physics CLD 822Mh	-
ABB AO2020-URAS26	-
Testo 350 XL	-
JCT JCC P1 Cooler	-
Gasmet DX4000	-
Gasmet Sampling System	-
Bernath 3006 FID	-
M&C PSS	-
Mass Flow Controller (1)	CAT 6.13
Mass Flow Controller (2)	CAT 6.14
Mass View (1)	CAT 25.78
Mass View (2)	CAT 25.79
Easylogger EN-EL-12 Bit	-
Easylogger EN-EL-12 Bit	-
Bioaerosols Temperature Logger	-
Electronic Refrigerator	-

Miscellaneous Items	
Equipment Type	**Equipment I.D.**
Digital Manometer (1)	-
Digital Manometer (2)	CAT 3.177
Digital Temperature Meter	-
Stopwatch	-
Barometer	-
Stack Thermocouple (1)	-
Stack Thermocouple (2)	-
Stack Thermocouple (3)	-
1m Heated Line (1)	-
1m Heated Line (2)	-
1m Heated Line (3)	-
5m Heated Line (1)	-
15m Heated Line (1)	-
20m Heated Line (1)	-
20m Heated Line (2)	-
Dual Channel Heater Controller	-
Single Channel Heater Controller	-
Laboratory Balance	
Tape Measure	CAT 16.22

METHODS & TECHNICAL PROCEDURES USED

Parameter	Standard	Technical Procedure
[redacted]	CEN/TS 13649	CAT-TP-16
[redacted]	CEN/TS 13649	CAT-TP-16
[redacted] - [redacted])	CEN/TS 13649	CAT-TP-16
[redacted]	CEN/TS 13649	CAT-TP-16
Water Vapour	EN 14790	CAT-TP-05
Velocity & Vol. Flow Rate	EN 16911-1 (MID)	CAT-TP-41

PRELIMINARY STACK SURVEY: CALCULATIONS

General Stack Details

Stack Details (from Traverse)	Units	Value
Stack Diameter / Depth, D	m	0.09
Stack Width, W	m	-
Stack Area, A	m^2	0.01
Average Stack Gas Temperature, T_a	°C	19.5
Average Stack Gas Pressure	Pa	207.0
Average Stack Static Pressure, P_{static}	kPa	-0.088
Average Barometric Pressure, P_b	kPa	102.3
Average Pitot Tube Calibration Coefficient, C_p	-	0.83

Stack Gas Composition & Molecular Weights

Component	Conc ppm	Conc Dry % v/v	Conc Wet % v/v	Volume Fraction r	Molar Mass M	Density kg/m^3 p	Conc kg/m^3 p_i
CO_2 (Estimated)	-	0.06	0.06	0.0006	44.01	1.9635	0.00118
O_2 (Estimated)	-	20.80	20.40	0.2080	32.00	1.4277	0.29696
N_2	-	79.14	77.63	0.7914	28.01	1.2498	0.98913
Moisture (H_2O)	-	-	1.91	0.0191	18.02	0.8037	0.01534

Where: $p = M / 22.41$

$p_i = r \times p$

Calculation of Stack Gas Densities

Determinand	Units	Result
Dry Density (STP), P_{STD}	kg/m^3	1.287
Wet Density (STP), P_{STW}	kg/m^3	1.278
Dry Density (Actual), P_{Actual}	kg/m^3	1.212
Average Wet Density (Actual), $P_{ActualW}$	kg/m^3	1.204

Where: P_{STD} = sum of component concentrations, kg/m^3 (not including water vapour)

P_{STW} = sum of all wet concentrations / 100 x density, kg/m^3 (including water vapour)

$P_{Actual} = P_{STD} \times (T_{STP} / (P_{STP})) \times ((P_{static} + P_b) / T_a)$

$P_{ActualW}$ (at each sampling point) $= P_{STW} \times (T_s / P_s) \times (P_a / T_a)$

Calculation of Stack Gas Volumetric Flowrate, Q

Duct gas flow conditions	Units	Actual	REF [1]
Temperature	°C	19.5	0.0
Total Pressure	kPa	102.2	101.3
Moisture	%	1.91	1.91

Gas Volumetric Flowrate (from Traverse)	Units	Result
Gas Volumetric Flowrate (Actual)	m^3/hr	353
Gas Volumetric Flowrate (STP, Wet)	m^3/hr	332
Gas Volumetric Flowrate (STP, Dry)	m^3/hr	326
Gas Volumetric Flowrate REF [1]	m^3/hr	332

PRELIMINARY STACK SURVEY: VELOCITY TRAVERSE TO EN 16911-1 (MID)

(1 of 1)

Parameter	Units	Value
Date of Survey	-	12/09/2019
Time of Survey	-	14:59 - 15:00
Atmospheric Pressure	kPa	102.3
Average Stack Static Pressure	Pa	-88
Result of Pitot Stagnation Test	-	Pass
Are Water Droplets Present?	-	Yes
Device Used	S-Type Pitot with KIMO MP 200 (500Pa)	

Parameter	Units	Value
Initial Pitot Leak Check	-	Pass
Final Pitot Leak Check	-	Pass
Orientation of Duct	-	Vertical
Pitot Tube, C_p	-	0.83
Number of Lines Available	-	1
Number of Lines Used	-	1

Sampling Line A

Traverse Point	Depth m	ΔP Pa	Temp °C	Wet Density kg/m³	Velocity m/s	Swirl °
STATIC (Units: Pa)		*-88.0*				
Mean		**207.0**	**19.5**	**1.204**	**15.40**	
1	0.05	207.0	19.5	1.204	15.40	0.0

PRELIMINARY STACK SURVEY: VELOCITY TRAVERSE TO EN 16911-1 (MID) - MEASUREMENT UNCERTAINTY

(1 of 1)

Performance characteristics (Uncertainty Components)	Uncertainty	Value	Units
Standard Uncertainty on the coefficient of the Pitot Tube	u(k)	0.005	-
Standard Uncertainty associated with the mean local dynamic pressures	u(Δpi)	3.507	Pa
- Resolution	u(res)	0.00087	
- Calibration	u(cal)	4.462	
- Drift	u(drift)	0.083	
- Lack of Fit	u(fit)	6.757	
- Overall corrections to dynamic measurements	u(Cf)	11.302	
Standard uncertainty associated with the molar mass of the gas	u(M)	0.00003	-
- $\varphi O_2,w$	-	20.403	
- $\varphi CO_2,w$	-	0.059	
- Oxygen, dry	u(ϕO_2,d)	0.637	
- Carbon Dioxide, dry	u(ϕCO_2,d)	0.002	
- Water Vapour	u(ϕH_2O)	0.097	
- Oxygen, wet	u(ϕO_2,w)	0.625	
- Carbon Dioxide, wet	u(ϕCO_2,w)	0.002	
Standard uncertainty associated with the stack temperature	u(Tc)	1.492	K
Standard uncertainty associated with the absolute pressure in the duct	u(pc)	175.727	Pa
- Atmospheric Pressure	u(patm)	175.692	
- Static Pressure	u(pstat)	3.507	
Standard uncertainty associated with the density in the duct	u(ρ)	0.00648	-
Standard uncertainty associated with the local velocities	u(vi)	0.884	Pa
Standard uncertainty associated with the mean velocity	u(v)	0.884	m/s
Standard uncertainty associated with the mean velocity (95% Confidence)	Uc(v)	1.732	m/s
Standard uncertainty associated with the mean velocity (95% Confidence), relative	Uc,rel(v)	11.25	%
Standard uncertainty associated with the volume flow rate (95% Confidence)	Uc(qV,w)	42.8	m^3/hr
- $u^2(a)/a^2$	-	0.00053	
- $u^2(qV,w)/q^2V,w$	-	0.00383	
- $u^2(qV,w)$	-	476	
- u(qV,w)	-	21.8	
Standard uncertainty associated with the volume flow rate (95% Confidence), relative	Uc,rel(qV,w)	12.12	%

WATER VAPOUR: RESULTS SUMMARY

Purolite Ltd, Llantrisant

Main Stack

Sample Runs

Parameter	Units	Run 1		Mean
Concentration	% v/v	1.91		1.91
Uncertainty	±% v/v	0.12		0.12

General Sampling Information

Parameter	Value
Standard	EN 14790
Technical Procedure	CAT-TP-05

WATER VAPOUR: SAMPLING DETAILS

Sample Runs

Parameter	Units	Run 1
Sampling Times	-	10:00 - 10:30
Sampling Dates	-	12/09/2019
Sampling Device	-	MFC / MV
Duration	mins	30
Volume Sampled (STP, Dry)	m^3	0.2819
Volume Sampled (STP, Wet)	m^3	0.2873
Sample Flow Rate	l/min	9.39
Liquid Trap Start Mass	g	4032.4
Liquid Trap End Mass	g	4034.5
Silica Trap Start Mass	g	1343.6
Silica Trap End Mass	g	1345.9
Total Mass Of Water Vapour	g	4.4
Calculated Water Vapour	% v/v	1.91

Where: MFC stands for Mass Flow Controller, MV stands for Mass View Flowmeter

WATER VAPOUR: QUALITY ASSURANCE

Sample Runs

Leak Test Results	Units	Run 1
Mean Sampling Rate	l/min	9.4
Pre-Sampling Leak Rate	l/min	0.10
Post-Sampling Leak Rate	l/min	0.10
Allowable Leak Rate	l/min	0.19
Leak Test Acceptable	-	Yes

Water Droplets	Units	Run 1
Are Water Droplets Present	-	No

Measurement Uncertainty	Units	Run 1
Measurement Uncertainty (MU)	%	6.5
Allowable MU	%	20.0
MU Acceptable	%	Yes

Silica Gel	Units	Run 1
Less than 50% Faded	%	Yes

Test Conditions	Units	Run 1
Ambient Temperature Recorded?	-	Yes

Method Deviations

Nature of Deviation (x = deviation applies to the associated run)	Run Number 1
There are no deviations associated with the sampling employed.	x

WATER VAPOUR: MEASUREMENT UNCERTAINTY CALCULATIONS

	Value			Standard uncertainty		
Measured Quantities	**Symbol**	**Run 1**		**Symbol**	**Units**	**Run 1**
Sampled Volume (STP)	V_m	0.2819		uV_m	m^3	0.0056
Repeatability of Weighing	R_w	4.40		uR_w	g	0.11
Reading of Balance	R_b	4.40		uR_b	g	0.02
Leak	L	1.06			%	-

	Uncertainty as a Percentage		
Measured Quantities	**Units**	**Run 1**	**Requirement of Standard**
Sampled Volume (STP)	%	2.00	≤2%
Repeatability of Weighing	%	2.50	No Requirement
Reading of Balance	%	0.50	No Requirement
Leak	%	1.06	≤2%

	Uncertainty in Measurement Units			Sensitivity Coefficient
Measured Quantities	**Symbol**	**Units**	**Run 1**	**Run 1**
Sampled Volume (STP)	V_m	m^3	0.2819	6.77
Repeatability of Weighing	R_w	g	4.40	0.43
Reading of Balance	R_b	g	4.40	0.43
Leak	L	% v/v	0.01	1.00

	Uncertainty in Result	
Measured Quantities	**Units**	**Run 1**
Sampled Volume (STP)	% v/v	0.038
Repeatability of Weighing	% v/v	0.048
Reading of Balance	% v/v	0.010
Leak	% v/v	0.012

Parameter	**Units**	**Run 1**
Combined uncertainty	% v/v	0.06
Expanded uncertainty (95% confidence)	% v/v	0.12
Expanded uncertainty (95% confidence), estimated with Method Deviations	% v/v	0.12
Uncertainty if Water Droplets are present	% v/v	N/A
Reported Uncertainty	% v/v	0.12
Expanded uncertainty (95% confidence)	%	6.5
Expanded uncertainty (95% confidence), estimated with Method Deviations	%	6.5
Uncertainty if Water Droplets are present	%	N/A
Reported Uncertainty	%	6.5

[redacted] : RESULTS SUMMARY

Purolite Ltd, Llantrisant

Main Stack

Sample Runs

Parameter	Units	Run 1	Run 2	Run 3	Mean
[redacted]	mg/m³	3.3	119.6	49.3	57.4
[redacted]	mg/m³	2.5	4.4	6.6	4.5
[redacted]	mg/m³	< 0.79	1.27	1.38	1.15
[redacted]	mg/m³	0.24	1.83	6.91	2.99

General Sampling Information

Parameter	Value	
Standard	CEN/TS 13649	
Technical Procedure	CAT-TP-16	
Name of Analytical Laboratory	RPS	
Analytical Laboratory's Procedure	O8 (U) G8 (N)	
ISO 17025 Accredited Analysis?	See Executive Summary	
Date of Sample Analysis	03/10/2019	
Probe Material	Stainless Steel	
Sample Tube Type	Coconut Shell Charcoal	
Dynamic Dilution Employed	Yes	
Number of Sampling Lines Used	1 / 1	FORMAT: Number Used / Number Required
Number of Sampling Points Used	1 / 1	FORMAT: Number Used / Number Required
Sample Point I.D.'s	A1	

Reference Conditions

Reference Conditions are: 273K, 101.3kPa, without correction for water vapour content.

[redacted] : SAMPLING DETAILS

RUN 1

Parameter	Units	Value
Sampling Times	-	08:47 - 10:47
Sampling Dates	-	12/09/2019
Sampling Device	-	MV
Duration	mins	120
N_2 to Stack Gas Dilution Ratio	: 1	1.5
Volume Sampled (REF)	m^3	0.0252

Where: MV stands for Mass View (Mass Flow Controller Technology)

Parameter	Lab Result (Front) µg	Lab Result (Back) µg	Lab Result (Total) µg	LOD (Front) µg	LOD (Back) µg	LOD (Total) µg	Concentration mg/m³	Reported Concentration (Blank Reviewed) mg/m³	Reported LOD mg/m³	Adsorption Efficiency %
[redacted]	66.0	6.0	72.0	1.5	1.5	3.0	2.854	3.329	0.119	91.7
[redacted]	59.0	< 3.0	62.0	3.0	3.0	6.0	2.457	2.457	0.238	100.0
[redacted]	< 10.0	< 10.0	20.0	10.0	10.0	20.0	< 0.793	< 0.793	0.793	100.0
[redacted]	4.0	< 2.0	6.0	2.0	2.0	4.0	0.238	0.238	0.159	100.0

Reference Conditions are: 273K, 101.3kPa, without correction for water vapour content.

[redacted] : SAMPLING DETAILS

RUN 2

Parameter	Units	Value
Sampling Times	-	10:51 - 12:51
Sampling Dates	-	12/09/2019
Sampling Device	-	MV
Duration	mins	120
N_2 to Stack Gas Dilution Ratio	: 1	1.5
Volume Sampled (REF)	m^3	0.0251

Where: MV stands for Mass View (Mass Flow Controller Technology)

Parameter	Lab Result (Front) µg	Lab Result (Back) µg	Lab Result (Total) µg	LOD (Front) µg	LOD (Back) µg	LOD (Total) µg	Concentration mg/m³	Reported Concentration (Blank Reviewed) mg/m³	Reported LOD mg/m³	Adsorption Efficiency %
[redacted]	2989.0	15.0	3004.0	1.5	1.5	3.0	119.6	119.6	0.1	99.5
[redacted]	103.0	7.0	110.0	3.0	3.0	6.0	4.4	4.4	0.2	93.6
[redacted]	22.0	< 10.0	32.0	10.0	10.0	20.0	1.27	1.27	0.80	100.0
[redacted]	44.0	< 2.0	46.0	2.0	2.0	4.0	1.83	1.83	0.16	100.0

Reference Conditions are: 273K, 101.3kPa, without correction for water vapour content.

[redacted] : SAMPLING DETAILS

RUN 3

Parameter	Units	Value
Sampling Times	-	12:55 - 14:55
Sampling Dates	-	12/09/2019
Sampling Device	-	MV
Duration	mins	120
N_2 to Stack Gas Dilution Ratio	: 1	1.5
Volume Sampled (REF)	m^3	0.0253

Where: MV stands for Mass View (Mass Flow Controller Technology)

Parameter	Lab Result (Front) µg	Lab Result (Back) µg	Lab Result (Total) µg	LOD (Front) µg	LOD (Back) µg	LOD (Total) µg	Concentration mg/m³	Reported Concentration (Blank Reviewed) mg/m³	Reported LOD mg/m³	Adsorption Efficiency %
[redacted]	1186.0	62.0	1248.0	1.5	1.5	3.0	49.259	49.259	0.118	95.0
[redacted]	165.0	< 3.0	168.0	3.0	3.0	6.0	6.631	6.631	0.237	100.0
[redacted]	25.0	< 10.0	35.0	10.0	10.0	20.0	1.381	1.381	0.789	100.0
[redacted]	173.0	< 2.0	175.0	2.0	2.0	4.0	6.907	6.907	0.158	100.0

Reference Conditions are: 273K, 101.3kPa, without correction for water vapour content.

[redacted] : SAMPLING DETAILS

BLANK 1

Parameter	Units	Value
Sampling Dates	-	12/09/2019
Sampling Device	-	MV
Average Volume Sampled (REF)	m^3	0.0252

Where: MV stands for Mass View (Mass Flow Controller Technology)

Parameter	Lab Result (Front) µg	Lab Result (Back) µg	Lab Result (Total) µg	Concentration mg/m^3
Toluene	45.0	39.0	84.0	3.329
IMS	< 3.0	< 3.0	6.0	< 0.238
AGE - (Allyl Glycidyl Ether)	< 10.0	< 10.0	20.0	< 0.793
Epichlorohydrin	< 2.0	< 2.0	4.0	< 0.159

Reference Conditions are: 273K, 101.3kPa, without correction for water vapour content.

[redacted] : QUALITY ASSURANCE

Sample Runs

Leak Test Results	Units	Run 1	Run 2	Run 3
Mean Sampling Rate	l/min	0.2	0.2	0.2
Pre-Sampling Leak Rate	l/min	0.00	0.00	0.00
Post-Sampling Leak Rate	l/min	0.00	0.00	0.00
Allowable Leak Rate	l/min	0.01	0.01	0.01
Leak Test Acceptable	-	Yes	Yes	Yes

Adsorption Efficiency	Units	Run 1	Run 2	Run 3
Toluene	%	91.7	99.5	95.0
IMS	%	100.0	93.6	100.0
AGE - (Allyl Glycidyl Ether)	%	100.0	100.0	100.0
Epichlorohydrin	%	100.0	100.0	100.0
Allowable Adsorption Efficiency	%	95	95	95
Adsorption Efficiency Acceptable	-	No	No	Yes

Temperature at Sample Tubes	Units	Run 1	Run 2	Run 3
Temperature	°C	13	14	14
Allowable Temperature	°C	40	40	40
Temperature Acceptable	-	Yes	Yes	Yes

Test Conditions	Units	Run 1	Run 2	Run 3
Ambient Temperature Recorded?	-	Yes	Yes	Yes

[redacted] : QUALITY ASSURANCE

Blank Runs

Leak Test Results	Units	Blank 1
Expected Sampling Rate	l/min	0.5
Sampling Leak Rate	l/min	0.00
Allowable Leak Rate	l/min	0.03
Leak Test Acceptable	-	Yes

Validity of Blank vs ELV	Units	Blank 1	Allowed
Allowable for Toluene	mg/m³	3.3	N/A
Allowable for IMS	mg/m³	0.2	N/A
Allowable for AGE - (Allyl Glycidyl Ether)	mg/m³	0.8	N/A
Allowable for Epichlorohydrin	mg/m³	0.2	N/A

Method Deviations

Nature of Deviation (x = deviation applies to the associated run)	Run Number 1	2	3	
Toluene absorption efficiency was less than the required 95%.	x			
IMS absorption efficiency was less than the required 95%.		x		
There are no deviations associated with the sampling employed.			x	

[redacted] : MEASUREMENT UNCERTAINTY CALCULATIONS

	Value				Standard uncertainty				
Measured Quantities	**Symbol**	**Run 1**	**Run 2**	**Run 3**	**Symbol**	**Units**	**Run 1**	**Run 2**	**Run 3**
Sampled Volume (STP)	V_m	0.0247	0.0246	0.0249	uV_m	m^3	0.0005	0.0005	0.0005
Leak	L	0.00	0.00	0.00	uL	%	-	-	-
Laboratory Result	L_r	10.00	10.00	10.00	uL_r	%	-	-	-

	Uncertainty as a Percentage				
Measured Quantities	**Units**	**Run 1**	**Run 2**	**Run 3**	**Requirement of Standard**
Sampled Volume (STP)	%	2.00	2.00	2.00	≤2%
Leak	%	0.00	0.00	0.00	≤5%
Laboratory Result	%	10.00	10.00	10.00	No Requirement

	Uncertainty in Measurement Units					Sensitivity Coefficient		
Measured Quantities	**Symbol**	**Units**	**Run 1**	**Run 2**	**Run 3**	**Run 1**	**Run 2**	**Run 3**
Sampled Volume (STP)	V_m	m^3	0.0247	0.0246	0.0249	275.44	5154.22	2582.43
Leak	L	mg/m^3	0.000	0.000	0.000	1.00	1.00	1.00
Laboratory Result	L_r	mg/m^3	0.682	12.704	6.418	1.00	1.00	1.00

	Uncertainty in Result			
Measured Quantities	**Units**	**Run 1**	**Run 2**	**Run 3**
Sampled Volume (STP)	mg/m^3	0.136	2.541	1.284
Leak	mg/m^3	0.0000	0.0000	0.0000
Laboratory Result	mg/m^3	0.6817	12.7037	6.4179

	Oxygen Correction Part of MU Budget			
Measured Quantities	**Units**	**Run 1**	**Run 2**	**Run 3**
O_2 Correction Factor	-	N/A	N/A	N/A
Stack Gas O_2 Content	% v/v	N/A	N/A	N/A
MU for O_2 Correction	-	N/A	N/A	N/A
Overall MU For O_2 Measurement	%	N/A	N/A	N/A

Parameter	**Units**	**Run 1**	**Run 2**	**Run 3**
Combined uncertainty	mg/m^3	0.695	12.955	6.545
Expanded uncertainty (95% confidence), without Oxygen Correction	mg/m^3	1.363	25.392	12.828
Expanded uncertainty (95% confidence), with Oxygen Correction	mg/m^3	N/A	N/A	N/A
Expanded uncertainty (95% confidence), estimated with Method Deviations	mg/m^3	1.363	25.392	12.828
Reported Uncertainty	mg/m^3	1.363	25.392	12.828
Expanded uncertainty (95% confidence), without Oxygen Correction	%	20.0	20.0	20.0
Expanded uncertainty (95% confidence), with Oxygen Correction	%	N/A	N/A	N/A
Expanded uncertainty (95% confidence), estimated with Method Deviations	%	20.0	20.0	20.0
Reported Uncertainty	%	20.0	20.0	20.0

NOTE: Uncertainties reported in mg/m ³ are based upon the summation of all Speciated VOCs Measured.

Element, Unit C6, Emery Court, The Embankment Business Park, Heaton Mersey, Stockport, SK4 3GL
Your Element Contact: Paul Martin (07827 332 630)
E: paul.martin@element.com

Stack Emissions Testing Report Commissioned by
Purolite Ltd

Installation Name & Address
Purolite Ltd
Unit C
Llantrisant Business Park
Llantrisant
CF72 8LF

EPR Permit: AB3894ZF

Stack Reference
Main Stack

Dates of the Monitoring Campaign
1st April 2022

Job Reference Number
EMT02936

Report Written by
Martin Futter Assistant Operations Manager MCERTS Level 2 MM 03 216 TE1 TE2 TE3 TE4

Report Approved by
Martin Futter Assistant Operations Manager MCERTS Level 2 MM 03 216 TE1 TE2 TE3 TE4

Report Date
20th April 2022

Version
Version 1

Signature of Report Approver


CONTENTS

Opinions and interpretations expressed herein are outside the scope of Element's ISO 17025 accreditation.

Executive Summary

MONITORING OBJECTIVES

Purolite Ltd, Llantrisant
Main Stack
1st April 2022

Overall Aim of the Monitoring Campaign

Element were commissioned by Purolite Ltd to carry out stack emissions testing on the Main Stack at Llantrisant.

The aim of the monitoring campaign was to perform testing of an investigative nature under trial operation.

Special Requirements

There were no special requirements.

Target Parameters

[redacted]

Executive Summary

MONITORING RESULTS

Purolite Ltd
Main Stack
1st April 2022

where MU = Measurement Uncertainty associated with the Result

		Concentration			Mass Emission			
Parameter	**Units**	**Result**	**MU +/-**	**Limit**	**Units**	**Result**	**MU +/-**	**Limit**
[redacted] [1]	mg/m³	651.9	130.3	-	g/hr	208.3	48.7	-
[redacted] [1]	mg/m³	1124.2	224.7	-	g/hr	359.2	84.0	-
[redacted] [1]	mg/m³	< 0.36	0.07	-	g/hr	< 0.12	0.03	-
[redacted] [1]	mg/m³	73.6	14.7	-	g/hr	23.5	5.5	-
Stack Gas Temperature	°C	8.5						
Stack Gas Velocity	m/s	14.3	1.61					
Volumetric Flow Rate (ACTUAL)	m³/hr	328	40					
Volumetric Flow Rate (REF) [1]	m³/hr	320	39					

NOTE: VOLUMETRIC FLOW RATE & VELOCITY DATA TAKEN FROM THE PRELIMINARY VELOCITY TRAVERSE.

[1] Reference Conditions (REF) are: 273K, 101.3kPa, without correction for water vapour content.

Executive Summary

(Page 3 of 7)

MONITORING DATE(S) & TIMES

Purolite Ltd, Llantrisant

Main Stack

1st April 2022

Parameter		Units	Concentration	Units	Mass Emission	Sampling Date(s)	Sampling Times	Duration mins
[redacted]	R1	mg/m³	671.8	g/hr	214.7	01/04/2022	11:18 - 12:48	90
[redacted]	R2	mg/m³	632.1	g/hr	202.0	01/04/2022	12:52 - 14:22	90
[redacted]	R1	mg/m³	1050.9	g/hr	335.8	01/04/2022	11:18 - 12:48	90
[redacted]	R2	mg/m³	1197.5	g/hr	382.6	01/04/2022	12:52 - 14:22	90
[redacted]	R1	mg/m³	< 0.36	g/hr	< 0.12	01/04/2022	11:18 - 12:48	90
[redacted]	R2	mg/m³	< 0.36	g/hr	< 0.12	01/04/2022	12:52 - 14:22	90
[redacted]	R1	mg/m³	73.4	g/hr	23.5	01/04/2022	11:18 - 12:48	90
[redacted]	R2	mg/m³	73.7	g/hr	23.5	01/04/2022	12:52 - 14:22	90
Velocity Traverse	R1					01/04/2022	10:00 - 10:01	

All results are expressed at the respective reference conditions.

PROCESS DETAILS

Purolite Ltd, Llantrisant
Main Stack
1st April 2022

Standard Operating Conditions

Parameter	Value
Process Status	Operational
Capacity (of 100%) and Tonnes / Hour	Normal
Continuous or Batch Process	Batch
Feedstock (if applicable)	Resin Mix
Abatement System	None
Abatement System Running Status	N/A
Fuel	N/A
Plume Appearance	None

Executive Summary

MONITORING & ANALYTICAL METHODS

Purolite Ltd, Llantrisant
Main Stack
1st April 2022

	Monitoring				Analysis					
Parameter	**Standard**	**Technical Procedure**	**Sampling Status**	**Testing Lab**	**Analytical Procedure**	**Analytical Technique**	**Analysis Status**	**Analysis Lab**	**Overall Status**	**LOD (Average)**
[redacted]	CEN/TS 13649	CAT-TP-16	MCERTS	EET	O8, G8, M109	GC-MS / GC-FID	MCERTS	RPS	MCERTS	0.072 mg/m³
[redacted]	CEN/TS 13649	CAT-TP-16	MCERTS	EET	O8, G8, M109	GC-MS / GC-FID	17025	RPS	17025	0.217 mg/m³
[redacted]	CEN/TS 13649	CAT-TP-16	MCERTS	EET	O8, G8, M109	GC-MS / GC-FID	None	RPS	None	0.361 mg/m³
[redacted]	CEN/TS 13649	CAT-TP-16	MCERTS	EET	O8, G8, M109	GC-MS / GC-FID	None	RPS	None	0.144 mg/m³
Velocity & Vol. Flow Rate	EN 16911-1 (MID)	CAT-TP-41	MCERTS	EET	Pitot Tube and Thermocouple				MCERTS	1.2 m/s

ANALYSIS LABORATORIES

(with short name reference as appears in the table above)

RPS Laboratories Ltd (RPS)	ISO 17025 Accreditation Number: 0605

SUMMARY OF SAMPLING DEVIATIONS

Parameter	Run	Deviation
All	All	There are no deviations associated with the sampling employed.

SUITABILITY OF SAMPLING LOCATION

Duct Characteristics

Parameter	Units	Value
Type	-	Circular
Depth	m	0.09
Width	m	-
Area	m^2	0.01
Port Depth	cm	9
Orientation of Duct	-	Vertical
Number of Ports	-	1
Sample Port Size	-	3" Flange, 4.5cm opening

Location of Sampling Platform

General Platform Information	Value
Permanent / Temporary Platform	Permanent
Inside / Outside	Outside

Platform Details

EA Technical Guidance Note M1 / EN 15259 Platform Requirements	Value
Sufficient working area to manipulate probe and operate the measuring instruments	Yes
Platform has 2 levels of handrails (approx. 0.5m & 1.0m high)	Yes
Platform has vertical base boards (approx. 0.25m high)	Yes
Platform has chains / self closing gates at top of ladders	Yes
There are no obstructions present which hamper insertion of sampling equipment	No
Safe Access Available	Yes
Easy Access Available	No

Sampling Location / Platform Improvement Recommendations

All platforms should be designed in accordance with the requirements in the Environment Agency's Technical Guidance Note M1 and EN 15259.

EN 15259 Homogeneity Test Requirements

There is no requirement to perform a EN 15259 Homogeneity Test on this Stack.

Sampling Plane Validation Criteria (from EN 15259)

Criteria in EN 15259	Units	Traverse 1		Required	Compliant
Lowest Differential Pressure	Pa	185.0		> 5 Pa	Yes
Mean Velocity	m/s	14.33		-	-
Lowest Gas Velocity	m/s	14.33		-	-
Highest Gas Velocity	m/s	14.33		-	-
Ratio of Above	: 1	1.00		< 3 : 1	Yes
Maximum Angle of Swirl	°	0.00		< 15°	Yes
No Local Negative Flow	-	Yes		-	Yes

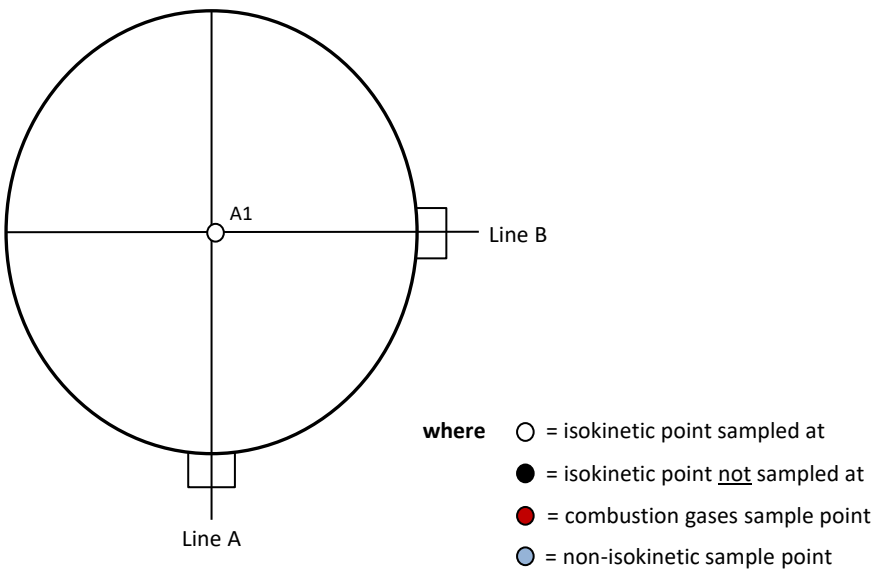
Executive Summary

(Page 7 of 7)

PLANT PHOTOS

No Photo's Available

SAMPLE POINTS



APPENDIX CONTENTS

STACK EMISSIONS MONITORING PERSONNEL

Position	Name	MCERTS Accreditation	MCERTS Number	Technical Endorsements
Team Leader	Martin Futter	MCERTS Level 2	MM 03 216	TE1 TE2 TE3 TE4
Team Leader	Lewis Doughty	MCERTS Level 2	MM 19 1534	TE1 TE2 TE3 TE4

LIST OF EQUIPMENT

Extractive Sampling	
Equipment Type	**Equipment I.D.**
Control Box DGM (1)	-
Control Box DGM (2)	-
Box Thermocouples (1)	-
Box Thermocouples (2)	-
Umbilical (1)	-
Umbilical (2)	-
Oven Box (1)	-
Oven Box (2)	-
Heated Probe (1)	-
Heated Probe (2)	-
Heated Probe (3)	-
S-Pitot (1)	-
S-Pitot (2)	-
L-Pitot	-
Site Balance	-
500g / 1Kg Check Weights	-
Last Impinger Arm	-
Callipers	-
Tubes Kit Thermocouple	-

Instrumental Analysers	
Equipment Type	**Equipment I.D.**
Horiba PG-250	-
Horiba PG-250	-
Servomex 4900	-
Eco Physics CLD 822Mh	-
ABB AO2020-URAS26	-
Testo 350 XL	-
JCT JCC P1 Cooler	-
Gasmet DX4000	-
Gasmet Sampling System	-
Sick 3006	-
M&C PSS	-
Mass Flow Controller (1)	CAT 6.34
Mass Flow Controller (2)	-
Mass View (1)	CAT 25.6
Mass View (2)	-
Easylogger EN-EL-12 Bit	-
Easylogger EN-EL-12 Bit	-
Bioaerosols Temperature Logger	-
Electronic Refrigerator	-

Miscellaneous Items	
Equipment Type	**Equipment I.D.**
Digital Manometer (1)	CAT 3.56
Digital Manometer (2)	-
Digital Temperature Meter	CAT 3.56
Stopwatch	-
Barometer	-
Stack Thermocouple (1)	CAT 4.0092
Stack Thermocouple (2)	-
Stack Thermocouple (3)	-
1m Heated Line (1)	-
1m Heated Line (2)	-
1m Heated Line (3)	-
5m Heated Line (1)	-
15m Heated Line (1)	-
20m Heated Line (1)	-
20m Heated Line (2)	-
Dual Channel Heater Controller	-
Single Channel Heater Controller	-
Laboratory Balance	
Tape Measure	-

METHODS & TECHNICAL PROCEDURES USED

Parameter	Standard	Technical Procedure
[redacted]	CEN/TS 13649	CAT-TP-16
[redacted]	CEN/TS 13649	CAT-TP-16
[redacted] - [redacted]	CEN/TS 13649	CAT-TP-16
[redacted]	CEN/TS 13649	CAT-TP-16
Velocity & Vol. Flow Rate	EN 16911-1 (MID)	CAT-TP-41

PRELIMINARY STACK SURVEY: CALCULATIONS

General Stack Details

Stack Details (from Traverse)	Units	Value
Stack Diameter / Depth, D	m	0.09
Stack Width, W	m	-
Stack Area, A	m^2	0.01
Average Stack Gas Temperature, T_a	°C	8.5
Average Stack Gas Pressure	Pa	185.0
Average Stack Static Pressure, P_{static}	kPa	-0.082
Average Barometric Pressure, P_b	kPa	101.8
Average Pitot Tube Calibration Coefficient, C_p	-	0.83

Stack Gas Composition & Molecular Weights

Component	Conc ppm	Conc Dry % v/v	Conc Wet % v/v	Volume Fraction r	Molar Mass M	Density kg/m^3 p	Conc kg/m^3 p_i
CO_2 (Estimated)	-	0.06	0.06	0.0006	44.01	1.9635	0.00118
O_2 (Estimated)	-	20.80	20.07	0.2080	32.00	1.4277	0.29696
N_2	-	79.14	76.37	0.7914	28.01	1.2498	0.98913
Moisture (H_2O) (Estimated)	-	-	3.50	0.0350	18.02	0.8037	0.02813

NOTE: Moisture has been estimated as no moisture test was performed on the date(s) of testing

Where: p = M / 22.41

p_i = r x p

Calculation of Stack Gas Densities

Determinand	Units	Result
Dry Density (STP), P_{STD}	kg/m^3	1.287
Wet Density (STP), P_{STW}	kg/m^3	1.270
Dry Density (Actual), P_{Actual}	kg/m^3	1.254
Average Wet Density (Actual), $P_{ActualW}$	kg/m^3	1.237

Where: P_{STD} = sum of component concentrations, kg/m^3 (not including water vapour)

P_{STW} = sum of all wet concentrations / 100 x density, kg/m^3 (including water vapour)

$P_{Actual} = P_{STD} \times (T_{STP} / (P_{STP})) \times ((P_{static} + P_b) / T_a)$

$P_{ActualW}$ (at each sampling point) $= P_{STW} \times (T_s / P_s) \times (P_a / T_a)$

Calculation of Stack Gas Volumetric Flowrate, Q

Duct gas flow conditions	Units	Actual	REF [1]
Temperature	°C	8.5	0.0
Total Pressure	kPa	101.7	101.3
Moisture (Estimated)	%	3.50	3.50

Gas Volumetric Flowrate (from Traverse)	Units	Result
Gas Volumetric Flowrate (Actual)	m^3/hr	328
Gas Volumetric Flowrate (STP, Wet)	m^3/hr	320
Gas Volumetric Flowrate (STP, Dry)	m^3/hr	308
Gas Volumetric Flowrate REF [1]	m^3/hr	320

PRELIMINARY STACK SURVEY: VELOCITY TRAVERSE TO EN 16911-1 (MID)

(1 of 1)

Parameter	Units	Value
Date of Survey	-	01/04/2022
Time of Survey	-	10:00 - 10:01
Atmospheric Pressure	kPa	101.8
Average Stack Static Pressure	Pa	-82
Result of Pitot Stagnation Test	-	Pass
Are Water Droplets Present?	-	No
Device Used	S-Type Pitot with KIMO MP 200 (500Pa)	

Parameter	Units	Value
Initial Pitot Leak Check	-	Pass
Final Pitot Leak Check	-	Pass
Orientation of Duct	-	Vertical
Pitot Tube, C_p	-	0.83
Number of Lines Available	-	1
Number of Lines Used	-	1

Sampling Line A

Traverse Point	Depth m	ΔP Pa	Temp °C	Wet Density kg/m³	Velocity m/s	Swirl °
STATIC (Units: Pa)		*-82.0*				
Mean		**185.0**	**8.5**	**1.237**	**14.33**	
1	0.05	185.0	8.5	1.237	14.33	0.0

PRELIMINARY STACK SURVEY: VELOCITY TRAVERSE TO EN 16911-1 (MID) - MEASUREMENT UNCERTAINTY

(1 of 1)

Performance characteristics (Uncertainty Components)	Uncertainty	Value	Units
Standard Uncertainty on the coefficient of the Pitot Tube	u(k)	0.005	-
Standard Uncertainty associated with the mean local dynamic pressures	u(Δpi)	3.169	Pa
- Resolution	u(res)	0.00087	
- Calibration	u(cal)	3.564	
- Drift	u(drift)	0.083	
- Lack of Fit	u(fit)	5.397	
- Overall corrections to dynamic measurements	u(Cf)	9.045	
Standard uncertainty associated with the molar mass of the gas	u(M)	0.00003	-
- $\varphi O_2,w$	-	20.072	
- $\varphi CO_2,w$	-	0.058	
- Oxygen, dry	u(ϕO_2,d)	0.637	
- Carbon Dioxide, dry	u(ϕCO_2,d)	0.002	
- Water Vapour	u(ϕH_2O)	0.179	
- Oxygen, wet	u(ϕO_2,w)	0.616	
- Carbon Dioxide, wet	u(ϕCO_2,w)	0.002	
Standard uncertainty associated with the stack temperature	u(Tc)	1.436	K
Standard uncertainty associated with the absolute pressure in the duct	u(pc)	175.721	Pa
- Atmospheric Pressure	u(patm)	175.692	
- Static Pressure	u(pstat)	3.169	
Standard uncertainty associated with the density in the duct	u(ρ)	0.00666	-
Standard uncertainty associated with the local velocities	u(vi)	0.822	Pa
Standard uncertainty associated with the mean velocity	u(v)	0.822	m/s
Standard uncertainty associated with the mean velocity (95% Confidence)	Uc(v)	1.612	m/s
Standard uncertainty associated with the mean velocity (95% Confidence), relative	Uc,rel(v)	11.25	%
Standard uncertainty associated with the volume flow rate (95% Confidence)	Uc(qV,w)	39.8	m^3/hr
- $u^2(a)/a^2$	-	0.00053	
- $u^2(qV,w)/q^2V,w$	-	0.00383	
- $u^2(qV,w)$	-	412	
- $u(qV,w)$	-	20.3	
Standard uncertainty associated with the volume flow rate (95% Confidence), relative	Uc,rel(qV,w)	12.13	%

APPENDIX 2

TOLUENE, IMS, AGE, EPICHLOROHYDRIN : RESULTS SUMMARY

Purolite Ltd, Llantrisant

Main Stack

Sample Runs

Parameter	Units	Run 1	Run 2	Mean
[redacted]	mg/m³	671.76	632.07	651.91
[redacted]	mg/m³	1050.90	1197.49	1124.19
[redacted]	mg/m³	< 0.36	< 0.36	< 0.36
[redacted]	mg/m³	73.42	73.69	73.55

General Sampling Information

Parameter	Value	
Standard	CEN/TS 13649	
Technical Procedure	CAT-TP-16	
Name of Analytical Laboratory	RPS	
Analytical Laboratory's Procedure	O8, G8, M109	
ISO 17025 Accredited Analysis?	See Executive Summary	
Date of Sample Analysis	14/04/2022	
Probe Material	Titanium	
Sample Tube Type	226-09	
Dynamic Dilution Employed	Yes	
Number of Sampling Lines Used	1 / 1	FORMAT: Number Used / Number Required
Number of Sampling Points Used	1 / 1	FORMAT: Number Used / Number Required
Sample Point I.D.'s	A1	

Reference Conditions

Reference Conditions are: 273K, 101.3kPa, without correction for water vapour content.

APPENDIX 2

TOLUENE, IMS, AGE, EPICHLOROHYDRIN : SAMPLING DETAILS

RUN 1

Parameter	Units	Value
Sampling Times	-	11:18 - 12:48
Sampling Dates	-	01/04/2022
Sampling Device	-	MV
Duration	mins	90
N_2 to Stack Gas Dilution Ratio	: 1	1
Volume Sampled (REF)	m^3	0.0275

Where: MV stands for Mass View (Mass Flow Controller Technology)

Parameter	Lab Result (Front) µg	Lab Result (Back) µg	Lab Result (Total) µg	LOD (Front) µg	LOD (Back) µg	LOD (Total) µg	Concentration mg/m³	Reported Concentration (Blank Reviewed) mg/m³	Reported LOD mg/m³	Adsorption Efficiency %
[redacted]	18500	< 1.0	18501	1.0	1.0	2.0	671.76	671.76	0.073	100.0
[redacted]	28600	343.0	28943	3.0	3.0	6.0	1050.90	1050.90	0.218	98.8
[redacted]	< 5.0	< 5.0	10.0	5.0	5.0	10.0	< 0.36	< 0.36	0.363	100.0
[redacted]	2020.0	< 2.0	2022.0	2.0	2.0	4.0	73.42	73.42	0.145	100.0

Reference Conditions are: 273K, 101.3kPa, without correction for water vapour content.

APPENDIX 2

TOLUENE, IMS, AGE, EPICHLOROHYDRIN : SAMPLING DETAILS

RUN 2

Parameter	Units	Value
Sampling Times	-	12:52 - 14:22
Sampling Dates	-	01/04/2022
Sampling Device	-	MV
Duration	mins	90
N_2 to Stack Gas Dilution Ratio	: 1	1
Volume Sampled (REF)	m^3	0.0278

Where: MV stands for Mass View (Mass Flow Controller Technology)

Parameter	Lab Result (Front) µg	Lab Result (Back) µg	Lab Result (Total) µg	LOD (Front) µg	LOD (Back) µg	LOD (Total) µg	Concentration mg/m³	Reported Concentration (Blank Reviewed) mg/m³	Reported LOD mg/m³	Adsorption Efficiency %
[redacted]	17600	< 1.0	17601	1.0	1.0	2.0	632.07	632.07	0.072	100.0
[redacted]	32900	446.0	33346	3.0	3.0	6.0	1197.49	1197.49	0.215	98.7
[redacted]	< 5.0	< 5.0	10.0	5.0	5.0	10.0	< 0.36	< 0.36	0.359	100.0
[redacted]	2050.0	< 2.0	2052.0	2.0	2.0	4.0	73.69	73.69	0.144	100.0

Reference Conditions are: 273K, 101.3kPa, without correction for water vapour content.

TOLUENE, IMS, AGE, EPICHLOROHYDRIN : SAMPLING DETAILS

BLANK 1

Parameter	Units	Value
Sampling Dates	-	01/04/2022
Sampling Device	-	MV
Average Volume Sampled (REF)	m^3	0.0277

Where: MV stands for Mass View (Mass Flow Controller Technology)

Parameter	Lab Result (Front) µg	Lab Result (Back) µg	Lab Result (Total) µg	Concentration mg/m^3
[redacted]	< 1.0	< 1.0	2.0	< 0.072
[redacted]	< 3.0	< 3.0	6.0	< 0.217
[redacted]	< 5.0	< 5.0	10.0	< 0.361
[redacted]	< 2.0	< 2.0	4.0	< 0.144

Reference Conditions are: 273K, 101.3kPa, without correction for water vapour content.

TOLUENE, IMS, AGE, EPICHLOROHYDRIN : QUALITY ASSURANCE

Sample Runs

Leak Test Results	Units	Run 1	Run 2
Mean Sampling Rate	l/min	0.3	0.3
Pre-Sampling Leak Rate	l/min	0.00	0.00
Post-Sampling Leak Rate	l/min	0.00	0.00
Allowable Leak Rate	l/min	0.02	0.02
Leak Test Acceptable	-	Yes	Yes

Adsorption Efficiency	Units	Run 1	Run 2
[redacted]	%	100.0	100.0
[redacted]	%	98.8	98.7
[redacted]	%	100.0	100.0
[redacted]	%	100.0	100.0
Allowable Adsorption Efficiency	%	95.0	95.0
Adsorption Efficiency Acceptable	-	Yes	Yes

Temperature at Sample Tubes	Units	Run 1	Run 2
Temperature	°C	10	12
Allowable Temperature	°C	40	40
Temperature Acceptable	-	Yes	Yes

Test Conditions	Units	Run 1	Run 2
Ambient Temperature Recorded?	-	No	No

TOLUENE, IMS, AGE, EPICHLOROHYDRIN : QUALITY ASSURANCE

Blank Runs

Leak Test Results	Units	Blank 1
Expected Sampling Rate	l/min	0.5
Sampling Leak Rate	l/min	0.00
Allowable Leak Rate	l/min	0.03
Leak Test Acceptable	-	Yes

Validity of Blank vs ELV	Units	Blank 1	Allowable
Allowable for [redacted]	mg/m³	0.1	N/A
Allowable for [redacted]	mg/m³	0.2	N/A
Allowable for [redacted]	mg/m³	0.4	N/A
Allowable for [redacted]	mg/m³	0.1	N/A

Method Deviations

Nature of Deviation (x = deviation applies to the associated run)	Run Number 1	2	
There are no deviations associated with the sampling employed.	x	x	

[redacted] : MEASUREMENT UNCERTAINTY CALCULATIONS

	Value			Standard uncertainty			
Measured Quantities	**Symbol**	**Run 1**	**Run 2**	**Symbol**	**Units**	**Run 1**	**Run 2**
Sampled Volume (STP)	V_m	0.0275	0.0278	uV_m	m³	0.0006	0.0006
Leak	L	0.00	0.00	uL	%	-	-
Laboratory Result	L_r	10.00	10.00	uL_r	%	-	-

	Uncertainty as a Percentage			
Measured Quantities	**Units**	**Run 1**	**Run 2**	**Requirement of Standard**
Sampled Volume (STP)	%	2.00	2.00	≤2%
Leak	%	0.00	0.00	≤5%
Laboratory Result	%	10.00	10.00	No Requirement

	Uncertainty in Measurement Units				Sensitivity Coefficient	
Measured Quantities	**Symbol**	**Units**	**Run 1**	**Run 2**	**Run 1**	**Run 2**
Sampled Volume (STP)	V_m	m³	0.0275	0.0278	65227	68361
Leak	L	mg/m³	0.00	0.00	1.00	1.00
Laboratory Result	L_r	mg/m³	179.64	190.36	1.00	1.00

	Uncertainty in Result		
Measured Quantities	**Units**	**Run 1**	**Run 2**
Sampled Volume (STP)	mg/m³	35.929	38.072
Leak	mg/m³	0.0000	0.0000
Laboratory Result	mg/m³	179.64	190.36

	Oxygen Correction Part of MU Budget		
Measured Quantities	**Units**	**Run 1**	**Run 2**
O_2 Correction Factor	-	N/A	N/A
Stack Gas O_2 Content	% v/v	N/A	N/A
MU for O_2 Correction	-	N/A	N/A
Overall MU For O_2 Measurement	%	N/A	N/A

Parameter	**Units**	**Run 1**	**Run 2**
Combined uncertainty	mg/m³	183.20	194.13
Expanded uncertainty (95% confidence), without Oxygen Correction	mg/m³	359.07	380.50
Expanded uncertainty (95% confidence), with Oxygen Correction	mg/m³	N/A	N/A
Expanded uncertainty (95% confidence), estimated with Method Deviations	mg/m³	359.07	380.50
Reported Uncertainty	mg/m³	359.07	380.50
Expanded uncertainty (95% confidence), without Oxygen Correction	%	20.0	20.0
Expanded uncertainty (95% confidence), with Oxygen Correction	%	N/A	N/A
Expanded uncertainty (95% confidence), estimated with Method Deviations	%	20.0	20.0
Reported Uncertainty	%	20.0	20.0

NOTE: Uncertainties reported in mg/m ³ are based upon the summation of all Speciated VOCs Measured.

Version Number	Record of changes made within this version of the document
V1	The original document issued to the client

Appendix D - Natural Gas Steam Generators (A4, A5)

- Technical specification data
- Certuss monitoring data for comparable model

CERTUSS Steam Generators

CERTUSS Steam Generators

Universal 500 – 2000 TC

Also in product range

TC as in
Touch Control

Steam generators **JUNIOR SC** series		
Size	**Steam capacity kg/h**	**Method of combustion**
1	80 – 120	Oil or gas
2	150 – 200	Oil or gas
3	250 – 400	Oil or gas
4	500 – 600	Oil, gas or combination

Steam generators **UNIVERSAL SC** series		
Size	**Steam capacity kg/h**	**Method of combustion**
5	700 – 850	Oil, gas or combination
6	1000 – 1500	Oil, gas or combination
7	1500 – 2000	Oil, gas or combination

Steam generators **ELEKTRO E 6 – 72 M** series		
Size	**Steam capacity kg/h**	**Method of heating**
One size	8 – 97	Electrical 6 – 72 kW

Steam generators **ELEKTRO E 100** series		
Size	**Steam capacity kg/h**	**Method of heating**
One size	135 / 160	Electrical 100 / 120 kW

CONTAINER Steam System
Completely equipped and ready to operate

CVE
Supply unit as complete ready-to-operate boiler housing installation

In addition: Water softening equipment, measuring equipment

CERTECON
Exhaust gas heat exchangers for Junior series

In addition: Exhaust gas heat exchangers ECO SPI for Universal series

DESALINATION HEAT EXCHANGER
Heat recycling from the desalination condensate to heat feed water

Reduction of the amount of cooling water at steam systems with mixing heat exchangers when waste water cooling is required

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CERTUSS Steam Generators

Universal 500 – 2000 TC at a glance

Efficiency
+ Extremely high degree of efficiency (with exhaust gas heat exchanger up to 98%) achieved through the 3-fold air insulation with simultaneous preheating of combustion air at very low emission losses
+ Short heat-up time. Full steam output is reached after a maximum of 5 minutes
+ Immediate output adjustment to the respective stream requirements which saves energy and thus costs through electronic combustion management and pilot flame system (gas burner)
+ With gas burner equipment modulating output control between 50 and 100% steam output (at oil operation via two output stages 50 and 100%)
+ Low-maintenance, continuous speed-controlled feed water pump
+ Low-emission burner developed specially to latest European standards for all sizes

User friendliness
+ Notably simplified operation through self-explanatory touch screen menu navigation
+ Graphically supported start and shutdown instructions
+ "Thermotimat" automatic system for fully automatic operation*
+ Remote control and control via Ethernet and mobile communications*
+ Optionally: "CVE" supply unit as complete boiler housing installation of boiler feed pump, steam dryer, water conditioning and waste-water mixing heat exchanger

Operation and installation
+ Secure installation without foundation at low space requirements
+ Can be installed in work areas, no boiler housing required
+ No permit required for installation and use in Germany up to Category III
+ Standard equipping for operation without constant supervision

Safety and quality
+ Function and malfunction indications can be linked to central control system / building services control system provided by customer
+ Can be remotely programmed and read out or controlled via Ethernet, CAN bus, PROFIBUS or GSM/UMTS modem*
+ Customer service standby 24 hours a day, 365 days a year
+ Spare parts supply guaranteed for 20 years
+ Function and error messages as well as service instructions through clear text display in many languages

Advantages of our technology
+ Robust all-steel design with double-shell air cooling without insulation materials
+ Air intake from above, trapped heat in boiler house extracted, floor dust remains
+ Noise and vibration damping, elastic aggregate fastening
+ Flue-gas recycling (NO_x reduction)*
+ Vertical tension-free central mounting of the heating system with low-point clarifying filtration
+ Recognized exemplary service
+ Can optionally be equipped with burners for EL heating oil, natural gas, liquid gas or combined (natural gas/EL heating oil) tested and approved by the TÜV-Rheinland-Berlin/ Brandenburg in accordance with the latest EU regulations for burners

Universal 500 – 2000 TC in detail

The new generation of a proven series
The steam generators CERTUSS Universal 500 - 2000 TC are characterized by the immediate modulating output adjustment and the simplified operation.

Complete and safe
The new Universal 500 - 2000 TC series encompasses completely equipped, ready-to-operate, electronically controlled steam generators with all safety devices for burner technology, pressure and temperature.
An electronic combustion management with self-monitoring of the latest generation can be programmed for all types of fuel.
The Universal 500 - 2000 TC steam generators are started via non-seated flow controllers. Steam and waste gas temperatures are controlled through self-monitoring electronic thermostats with approval.

Manual, remote-controlled or automatic
The new series disposes of a self-explanatory control and operation function via a graphical user interface on a 7" touch screen.
All the operating and fault messages as well as service instruction are displayed visually in all the desired languages.
Controlling is carried out either manually or graphics-supported start and shutdown instructions or with optional "Thermotimat" automatic system in the system for fully automatic operation without operating personnel.
Controlling via a central control system / building services control system is also just as possible as the display and transfer of operating and fault messages via Ethernet, CAN bus or PROFIBUS, as well as remote programming via a GSM modem.

Automatic desliming and start dewatering
The Universal 500 - 2000 TC steam generators can be equipped additionally with an automatic desliming and start dewatering in connection with the "Thermotimat" automatic system.

Installation conditions
In accordance with the European Pressure Equipment Directive 2014/68/EU the CERTUSS steam generators are classified as Category III or IV depending on the operating pressure. They have been tested in accordance with the EC type examination. No permit is required for installation and use in Germany up to Category III Initial and repetitive tests can be carried out by the CERTUSS customer service as qualified persons on the Universal 500 - 600 series up to an operating pressure of 20 bar.

Size	Capacities			Levels	Pressures		Consumption			Dimensions (~ mm)						Weight (~ kg)	Connections								Categorization	Regulations
	Steam-capacity kg/h	Heating capacity kW	Nominal load kW		Max. operating pressure MPa (bar)	Max. permissible overpressure MPa (bar)	Heating oil (EL) kg/h	Natural gas m³/h	Liquid-gas m³/h	Height A	Width B	Depth C	Boiler Ø D	Flue gas pipe Ø E	Flue gas (center) F		Electrical connection load kVA	Oil connection DN	Natural gas DN	Liquid gas DN	Feed water DN	Steam connection DN	Safety valve DN	Start-up line DN	EPEG category	Germany BetrSichV Tests § 15 – 16
4	500 600	328 393	364 436	2	0.8-1.4-1.8-2.2-2.9 (8-14-18-22-29)	1.0-1.6-2.0-2.5-3.2 (10-16-20-25-32)	30.6 36.8	36.4 43.6	14.1 16.9	1980	930	1600	700	250	1460	950	6.32	3/8"	50	25	1 1/4"	32	40	3/4"	III	up to 20 bar CERTUSS [1] over 20-32 bar AIA [2]
5	700 850	459 557	510 619	2	0.8-1.4-2.2-2.9 (8-14-22-29)	1.0-1.6-2.5-3.2 (10-16-25-32)	42.9 52.1	50.9 61.8	19.7 24.0	2290	1160	1870	870	300	1750	1100	7.34	3/8"	65	40	1 1/4"	40	40	1"	up to 25 bar III over 25-32 bar IV	AIA [2]
6	1000 1300	656 853	728 947	2	0.8-1.4-2.2-2.9 (8-14-22-29)	1.0-1.6-2.5-3.2 (10-16-25-32)	61.3 79.8	72.7 94.6	28.2 36.7	2535	1260	2125	1000	350	1940	1500	13.02	3/8"	65	40	1 1/4"	50	40	1 1/2"	up to 16 bar III over 16-32 bar IV	AIA [2]
7	1500 1800 2000	984 1180 1320	1093 1311 1457	2	0.8-1.4-2.2-2.9 (8-14-22-29)	1.0-1.6-2.5-3.2 (10-16-25-32)	92.0 110.4 123.0	109.1 130.9 145.7	42.3 50.8 56.5	2675	1380	2310	1100	500	2025	2300	15.85	1/2"	80	50	1 1/4"	65	50	1 1/2"	up to 10 bar III over 10-32 bar IV	AIA [2]

Reference values: Natural gas 10 kW/Nm³ - 8600 kcal/Nm³, liquid gas 25,8 kW/Nm³ - 22200 kcal/Nm³.
Dimensions and weights have been rounded up or down. MPa and bar are overpressure values.
Performance values referenced to 100 °C feed-water temperature and 1 MPa (10 bar) steam overpressure.
CERTUSS burner with flue-gas recycling (NO_X reduction)*.

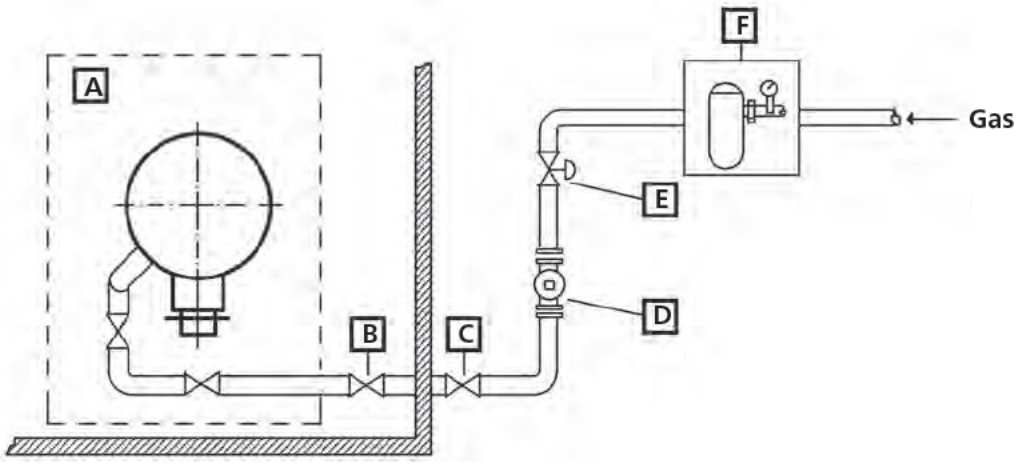
[1] Through CERTUSS customer service as "qualified persons"
[2] Through "approved inspection agency", e.g. TÜV
* Supplementary equipment
We reserve the right to make technical modifications.

21.044.02.1704.02

1 MPa (10 bar) = 145 psi
10 psi = 0.069 MPa (0.69 bar)

1 kW = 3413 BTU
1000 BTU = 0.293 kW

13.1 Gas-Anschluss



Anschluss- und Einstelldaten
Änderungen vorbehalten.

Typ CERTUSS		Universal 500	600	700	850	1000	1300	1500	2000	Type CERTUSS	
A Dampfautomat Gasanschluss										**A** Steam generator Gas connection	
Erdgas	DN	50		65				80		Natural gas	DN
Flüssiggas	DN	25		40				50		Liquid gas	DN
B Absperrventil										**B** Shut-off valve	
Erdgas	DN	50		65				80		Natural gas	DN
Flüssiggas	DN	25		40				50		Liquid gas	DN
C Not-Absperrventil *										**C** Emergency shut-off valve *	
Erdgas	DN	50		65				80		Natural gas	DN
Flüssiggas	DN	25		40				50		Liquid gas	DN
D Gasmengenzähler Q min./ max.										**D** Gas meter Q min./ max.	
Erdgas	m^3/h	1 / 65				1 / 100		1 / 160		Natural gas	m^3/h
Flüssiggas	m^3/h	0,5 / 65								Liquid gas	m^3/h
E Gasdruckregler ** Gasfließdruck Ausgang	kPa									**E** Gas pressure regulator Gas flow pressure **	kPa
Erdgas min./ max.		2 – 5 (20 – 50 mbar)		3 – 5 (30 – 50 mbar)						Natural gas min./ max.	
Flüssiggas min./ max.		5 (50 mbar)								Liquid gas min./ max.	
F Flüssiggasverdampfer *** Durchflussleistung	m^3/h	20		30		40		60		**F** Liquid gas evaporator *** Flow capacity	m^3/h

* Je nach Ländervorschrift elektrisch betätigt.
** Wenn Gasfließdruck größer 5 kPa (50 mbar).
*** Nur bei Entnahme aus der Flüssigphase.

Die Nennweite der Gaszuleitung, unter Berücksichtigung der Anschlussleistung, des Gasdruckes, der Länge sowie Anzahl der Bögen von autorisierter Fachkraft errechnen lassen.

Mindestfließgasdrücke am Dampfautomaten dürfen nicht unterschritten werden.
Bei Erstellung der Gasversorgung die Vorschriften der Bauaufsicht und des Gasversorgers beachten.

13.1 Gas connection

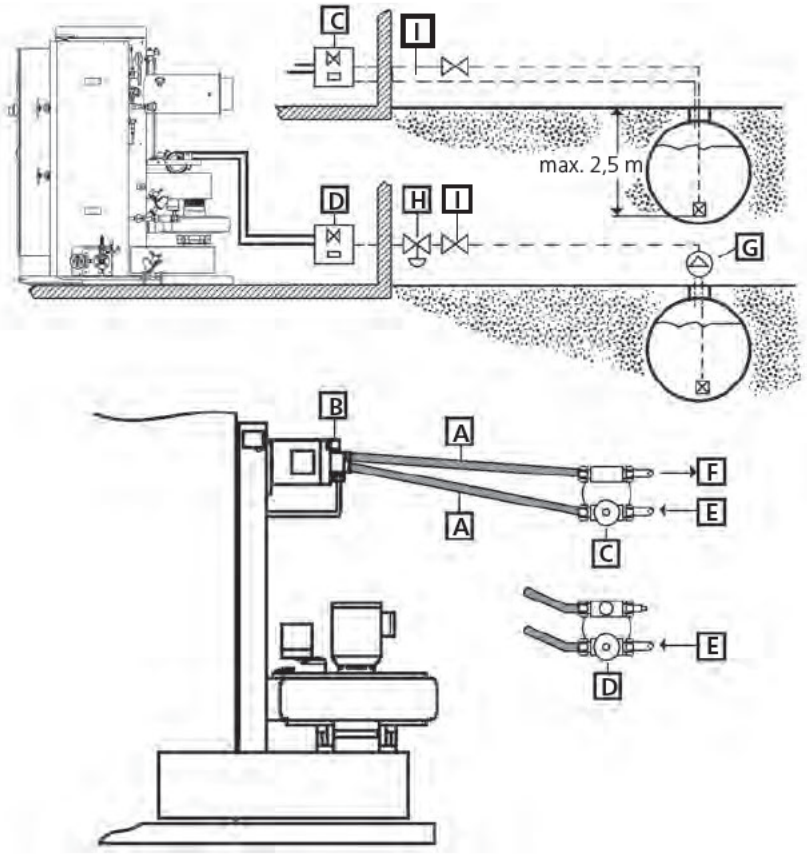
Connection and adjustment data
Technical specifications are subject to change.

* According to country´s regulation operated electrically.
** If gas flow pressure is more than 5 kPa (50 mbar).
*** Only when taken in liquid phase.

Have nominal width of the gas supply line calculated by an authorised specialist, taking into account connection capacity, gas pressure, length and amount of bends.

Do not underrun min. flow gas pressures on the steam generator.
When preparing the gas supply, adhere to prescriptions of construction supervision and gas supplier.

13.2 Öl-Anschluss



Anschluss- und Einstelldaten
Änderungen vorbehalten.

Typ CERTUSS	Universal 500 – 600	700 – 850	1000 – 1300	1500 – 2000	Type CERTUSS
A Ölschlauch	$^3/_8$"		$^1/_2$"		**A** Oil hose
B Ölmanometer-anschluss MPa	0 – 2,5 (0 – 25 bar)				**B** Oil manometer connection MPa
C Ölfilter Zweiweg *	$^3/_8$"		$^1/_2$"		**C** Oil filter, two-way *
D Ölfilter Einweg, mit Rücklaufzuführung	$^3/_8$"		$^1/_2$"		**D** Oil filter, one-way with return line
E Ölansaugleitung DN	10		13		**E** Oil intake line DN
F Ölrücklaufleitung DN	10		13		**F** Oil return line DN
G Ölförderaggregat (bei Bedarf) MPa	0,1 (1bar)				**G** Oil feed pump (if required) MPa
H Öldruckminderer eingestellt auf MPa	0,05 (0,5 bar)				**H** Oil pressure reducer adjusted to MPa
I Notabsperrventil **	$^3/_8$"		$^1/_2$"		**I** Emergency shut-off valve**

* In der Bundesrepublik Deutschland ist bei Ölversorgung nur das Einstrangsystem zugelassen.

**Je nach Ländervorschrift elektrisch betätigt.

Connection and adjustment data
Technical specifications are subject to change.

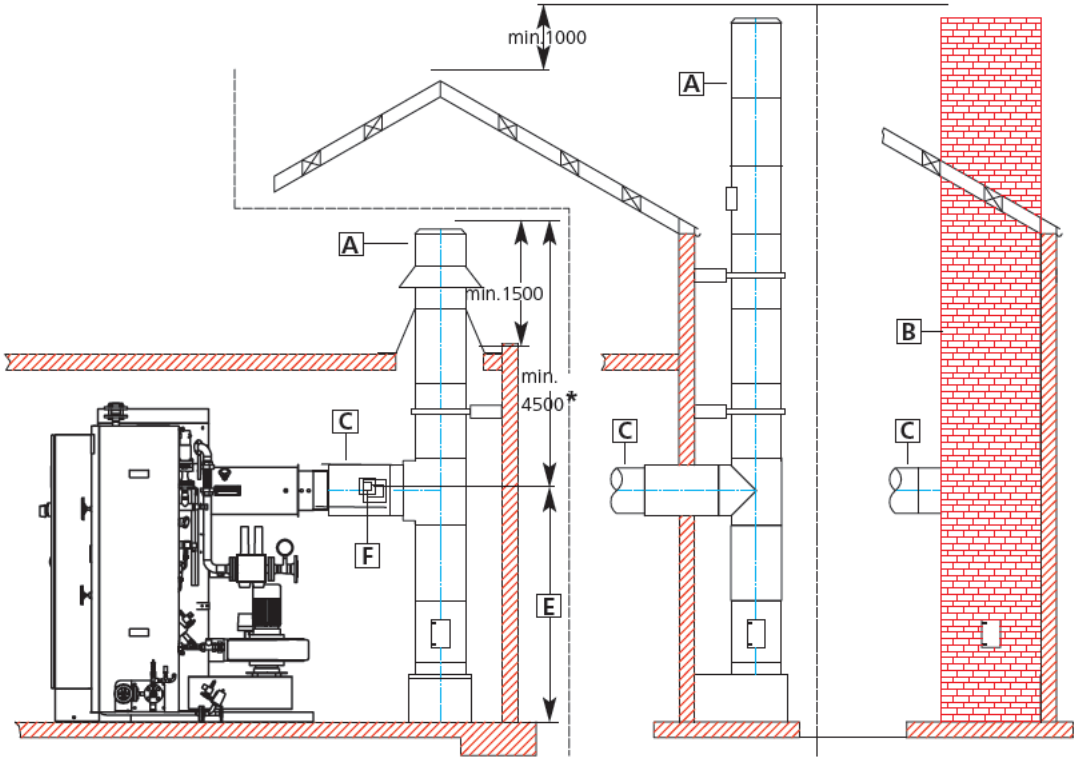
* In the Federal Republic of Germany only the one-way-system is allowed for oil supply.

** According to country´s regulation operated electrically.

Bei Erstellung der Ölversorgung bauaufsichtliche Vorschriften beachten.

When installing the oil supply, pay attention to regulations of the building inspection.

13.3 Rauchgas-Anschluss



Anschluss- und Einstelldaten
Änderungen vorbehalten

Typ CERTUSS	Universal				Typ CERTUSS
	500 – 600	**700 – 850**	**1000 – 1300**	**1500 – 2000**	
A Edelstahlkamin ** lichter Ø min. mm	250	300	350	500	**A** Stainless steel chimney,** inside Ø min. mm
B Gemauerter / Formstein-Kamin ** min▱ mm	250	300	350	500	**B** Shaped brick chimney ** min.▱ mm
C Rauchgasrohr Ø mm	250	300	350	500	**C** Flue gas tube Ø mm
E Abzug Höhe mm	1460	1750	1940	2025	**E** Vent height mm
F Zugregler *** kPa	0,005 – 0,025				**F** Draught regulator ***kPa

* Bei Feuerungsleistung > 1 MW muss die Schornsteinhöhe min. 10 Meter über Erdgleiche betragen.
** Die Eignung des Kamins muss rechnerisch nachgewiesen werden.
*** Bei Bedarf und Kamin über 8 m wirksamer Höhe.

Bei Erstellung von Kaminanlagen bauaufsichtliche Vorschriften beachten.

13.3 Flue gas connection

Connection and adjustment data
Technical specifications are subject to change.

* With firing capacity > 1 MW, the chimney height must be min. 10 mtr. above ground level.
** The suitability of the chimney has to be proven by figures.
*** When required and with chimney of more than 8 m effective height.

Observe building inspection regulations for the installation of chimneys.

14.1 Umrechnungstabelle Wasserhärte

14.1 Water-hardness calculation table

	1 mmol/l Erdalkali-Ionen earthy-base ions	10 mg CaO/l Grad, deutsch degree, German	10 mg $CaCO_3$/l Grad, französisch degree, French	1 mg $CaCO_3$/l = ppm $CaCO_3$
mmol/l	1	5,6	10	100
°dH	0,18	1	1,78	17,8
°f (TH)	0,1	0,56	1	10
ppm $CaCO_3$	0,01	0,056	0,1	1

14.2 Abgasmenge

Ausrüstung mit Gebläsebrennern, die mit dem Dampfautomaten eine Baueinheit bilden.

Dampfautomat / Steam generator Typ / type		Universal							
		500	600	700	850	1000	1300	1500	2000
Brennerstufen / Burner stages		2							
Feuerungswärmeleistung / Firing heat cap.	kW	364	436	510	619	728	947	1093	1311
Wirkungsgrad / Efficiency		0,92							
Nennwärmeleistung / Nominal heat output	kW	335	401	469	569	670	871	1006	1206
Rauchgasstutzen / Flue gas union	Ø mm	250		300		350		500	
Abgasmassenstrom / Exhaust gas flow quantity									
Erdgas / Natural gas									
CO_2	%	10							
	kg/s	0,16855	0,20189	0,23615	0,28662	0,33710	0,43850	0,50611	0,60705
Flüssiggas / Liquid gas									
CO_2	%	11							
	kg/s	0,15687	0,18778	0,21962	0,26645	0,31375	0,44346	0,49109	0,56475
Heizöl EL / Fuel oil EL									
CO_2	%	12,8							
	kg/s	0,15728	0,18827	0,22019	0,26714	0,31456	0,40893	0,47231	0,56621
Abgastemperatur / Exhaust gas temp.	ca. °C	245	255	235	250	245	265	240	260
Zug am Kaminstutzen / Draught on chimney union	kPa	0,005 – 0,025							

14.3 Anforderung an Kesselspeisewasser

Gesamthärte Total hardness	Sauerstoffgehalt Oxygen content	Kohlensäure gebunden Carbon dioxide bound	Kohlensäure frei Carbon dioxide free	PH-Wert bei 20°C PH value at 20°C	Eisen gesamt Iron content in total	Permanganat-zahl Permanganate rate	Leitfähigkeit Conductivity
°dH	mg/ltr.	mg/ltr.	mg/ltr.		mg/ltr.	mg/KM NO_4	µs/cm
< 0,1	< 0,05	< 25	0	8,5 – 9,5	< 0,02	< 5	< 1000

Sonstige Werte nach DIN EN 12952-12, Tabelle 5.3

Betriebsbedingungen für Speisewasser

1. Speisewassertemperatur 90 – 95°C spätestens 15 Minuten nach Kaltstart sicherstellen.
2. Eisen- und manganfreies Rohwasser verwenden (min. 2 bar, max. 7 bar).
3. Enthärtungsanlage mit ausreichender Kapazität einsetzen.
4. Empfohlen wird eine Dosierung des Speisewassers mit Sauerstoffbindemittel.

Temperatur im Speisewasserbehälter während des Betriebes min. 90 – 95°C, damit eine Teilentgasung erreicht wird und die Wassereintrittstemperatur in den Dampfautomaten zur Vermeidung von Taupunktunterschreitung min. 80°C beträgt.

14.2 Exhaust gas quantity

Equipment with fan burners, forming a unit with the steam generator.

14.3 Requirements for steam generator feed water

Other values in accordance with EN 12952-12, Table 5.3

Operation conditions for feed water

1. Provide for a feed water temperature of 90 – 95°C not later than 15 minutes after cold start.
2. Use iron- and manganese-free raw water (min. 2 bar, max. 7 bar).
3. Use softening installation with sufficient capacity.
4. It is recommended to dose the feed water with oxygen binder.

Temperature inside of the feed water tank min. 90 – 95°C, during operation, so that a partial degasification is achieved and a water inflow temperature to the steam generator of min. 80°C is provided in order to prevent it from falling below dew point.

CERTUSS Dampfautomaten

Abnahmeprotokoll TC GAS

Kessel-Nr.: 14820

Einstellwerte Allgemein

Sicherheitsventil Abblasedruck 10 bar

Dampftemperaturwächter max. 250 °C

Wasservordruckwächter 16+x bar

Druckbegrenzer max. 9,5 bar

Rauchgastemperaturbegrenzer 249 °C

Eingestellter Arbeitsdruck max 8,0 bar

Eingestellter Differenzdruck: 0,5 bar

Umschaltung Flammüberwachung - sec

Gemessene Werte

Vordruck Wasserpumpe 50% 10 bar bei Dampfdruck 8 bar

Vordruck Wasserpumpe 100% 16 bar bei Dampfdruck 7 bar

Teillastbrennergasdruck 20 mbar

Vorpressung, Gebläse 50% 4,2 100% 16,6 mbar

Hauptbrennergasdruck 50% 4,4 100% 18 mbar

Angezeigte Rauchgastemperatur 50% 187 100% 226 °C

Gemessene Rauchgastemperatur 50% 180,2 100% 221,3 °C

Lufttemp. vor Brenner 50% 61,5 100% 60,8 °C BURNER A.R TEMP

O_2 50% 3,6 100% 3,2 % O2 CONTENT EXHAUST

CO 50% 4 100% 29 ppm CO " "

CO_2 50% 9,8 100% 10 % CO_2 " "

NOx 50% 60 100% 57 ppm. NO_x " "

Feuerungst. Wirkungsgrad 50% 94,5 100% 92,6 EFFICIENCY

Abgasverlust 50% 5,5 100% 7,4

Ionisat. Hauptbrenner 50% 82 100% 78 µA/%

Ionisation Teillastbrenner 72 µA/%

Einstellwerte

Gasfließdruck vor Gasventil bei 100% 35 mbar

Dichtheitskontrollgerät 15 mbar

Gasdruckwächter min. 20 mbar

Gasdruckwächter max. 19 mbar

Luftdruckwächter min. 2,5 mbar

Gasdurchsatz 50% 27,25 100% 54,5 m^3 GAS CONSUMPTION

Gasdurchsatz 50% 254,5 100% 509 Kw/h kW

Luftklappenstellmarke 50% 25 100% 50 °

Zusatzgebläse Luftdruckwächter min. - mbar

Appendix E - [redacted] Abatement Plant Stack (A6)

- Drawings
- Monitoring results
- Bromination process – copy of Batch Protocol (01/04/22)
- Shift Handover Log (01/04/22)

DO NOT SCALE | IF IN DOUBT ASK | ALL DIMENSIONS IN MM UNLESS OTHERWISE STATED

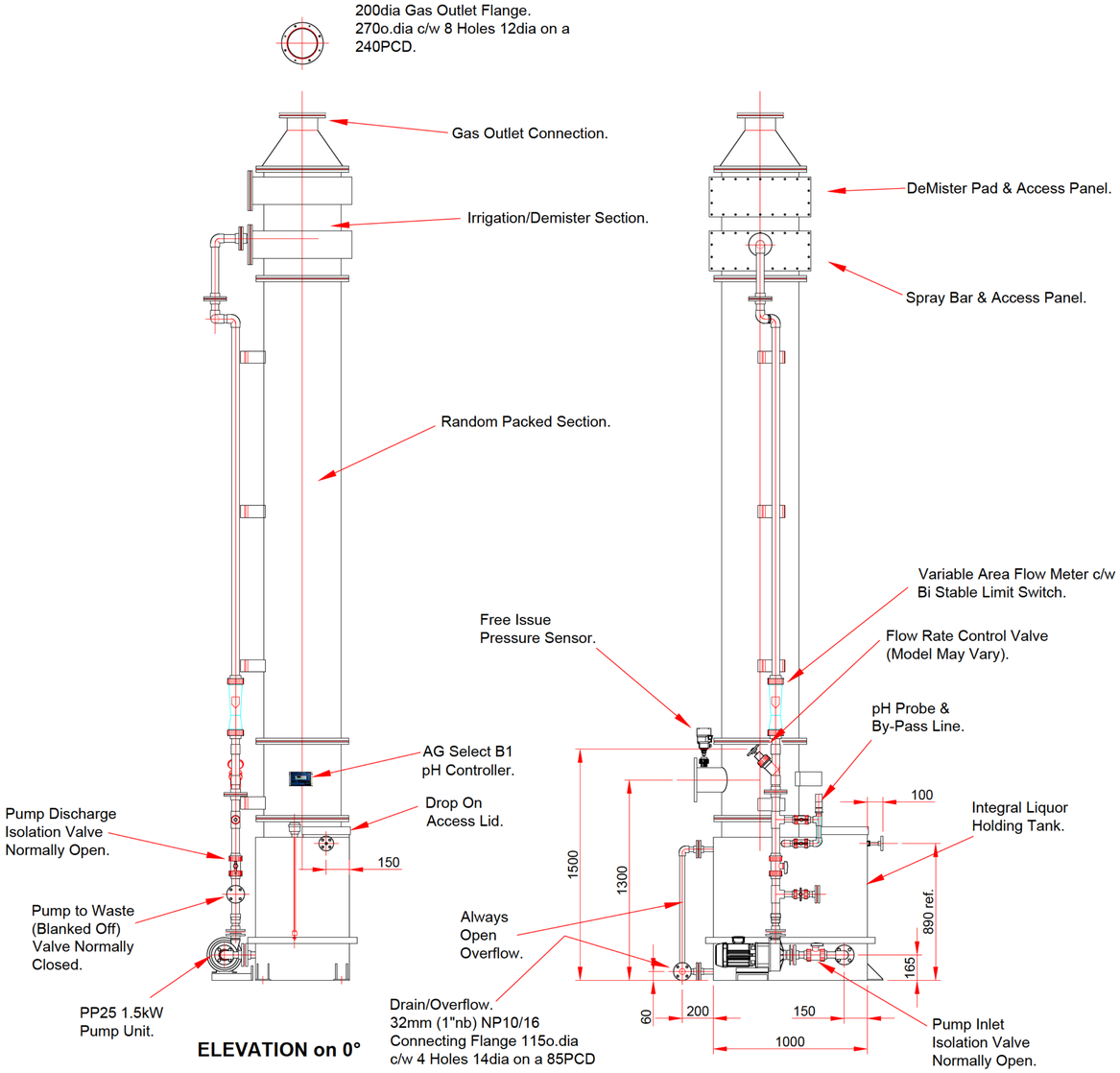
REV				
A	DRAWN	GEW	DATE 05/10/20	SIG.
	CHECKED		DATE	SIG.
	APPROVED		DATE	SIG.

DESCRIPTION

Layout amended as per customer email 02/10/20
Issued for Approval

REV			
	DRAWN	DATE	SIG.
	CHECKED	DATE	SIG.
	APPROVED	DATE	SIG.

DESCRIPTION



ELEVATION on 0°

ELEVATION on 90°

ELEVATION on 180°

PLAN VIEW.

PLAN VIEW with ORIENTATION.

NOTE :

Unit Externally Reinforced:
GRP general purpose resin

Finish Colour :
RAL 7035 Light Grey.

Roperhurst Limited
Ty Verlon Industrial Estate
Cardiff Road Barry CF63 2BE
TEL: +44(0) 1446 732 555
e-MAIL enquires@roperhurst.com

roperhurst
fume treatment systems

CLIENT	BRIGGS OF BURTON BRIGGS HOUSE DERBY STREET BURTON ON TRENT DE14 2LH
CONTRACT No.	P9192
CONTRACT TITLE	BROMINE SYSTEM PUROLITE
TITLE	GENERAL ARRANGEMENT OF BROMINE SCRUBBER
DRAWN	Glenn Williams
DATE	22/09/20
REV	A
CHECKED	
DATE	
APPROVED	
DATE	
SCALE	1:20@A1
DRAWING No.	P9192-101

A1

Purolite	PUROLITE FORM	Number	FM-8
	SHIFT HANDOVER LOG	Revision	13

Purolite Controlled Document

The handover log should be completed at the end of each day by the Team Leader, or deputy. OPM-8 should be referenced to ensure all information is inputted in sufficient detail to the handover log. See end of document for distribution instructions.

Team Leader:	Choose an item.	**Shift Date:**	**01/04/2022**

1. BATCHES IN PROGRESS

Complete details for each batch in progress. Refer to production plan for target completion date. To complete the "On Track?" box, tick green if the batch is ahead of schedule or up to 1 day behind; tick amber if the batch is between 1 and 5 days behind schedule; tick red if the batch is greater than 5 days behind schedule. Input the anticipated change in completion date as a positive or negative value. Reasons for delay should be discussed in section 2.

Lot Number	Product	Start Date	Current Stage	Target End Date	On Track?			Completion Date Change	New Comments
	Click here to enter Product Name.	Click to enter batch start date.	Choose an item.	Click to target end date.	☐	☐	☐	Click here to enter change in days.	Click here to enter comments.
	Click here to enter Product Name.	Click to enter batch start date.	Choose an item.	Click to target end date.	☐	☐	☐	Click here to enter change in days.	Click here to enter comments.

2. EQUIPMENT SUMMARY

Summarize each vessel activity, status and next steps in detail. The Lot Number should be included in the summary for each equipment where the process is being carried out. Use tick box if the pH probe is present.

Vessel	Work Done Today	Status	Work Required Tomorrow
RE01 ☐	Engineering work	Clean and empty	-
RE02	Engineering work	Clean and empty	Needs a clean master.
DV03	Settling	[redacted]	Settling
WC4A	3rd[redacted] wash carried out.	[redacted]	[redacted] wash and test Et. Cell. content (4th)
WC4B	-	Clean and empty	-
RE5A ☐	-	Clean and empty	-
RE5B ☐	Cleanmaster started.	CIP	-

WC5C	Transferred [redacted]	[redacted]	-
Backwash Column	-	Clean and Empty	-
SV6A/6B	-	Clean and empty.	-
Screens	-	Dissassembled and cleaned .	-
SV7A	-	Clean and Empty	-
SV7B	-	Clean and empty	-
PCK1	-See packaging Handover log	See packaging Handover log	-See packaging Handover log
RE08 ☐	-	Clean and Empty.	-
RE09	Brominated [redacted]	Unclean and Empty	Cleanmaster when possible.
C10A ☐	Received [redacted] from RE09. Bromination verification samples obtained from before and after reaction in RE09. ABD-790 written because we will not be waiting for allylation titration results before c. crosslink is begun.	[redacted]	C. Crosslink.
MV01	-	-unit D	-
MV02	-	-unit D	-
MV03	-	[redacted]	Take concentration sample first thing in the morning.
MV04	-	Clean and Empty	-
MV05	-	Clean and empty	-
MV06	Deacon 90 wash carried out.	Clean and Empty	-
MV07	-	[redacted] (In 20% ethanol)	-
MV08	-	[redacted]	-

IMS1/ TOL1/ AGE1/ GMC1	TOL1 delivery	-	-
ETA1/ETB1/ ETD1/ ETE1/ ETE2/ ETF1	-	-	-
Maintenance	-	-	-
Other	-Paperwork - 3rd vessel from jetting over in WC11A (full batch) -Housekeeping -Handover log by HJT.	-	-

3. UTILITIES

Process Water Storage	-	Days since last sterilization: 27.03.22	-
Purified Water	-	-	-
Chilled Water	-	-	-
Steam	-	-	-
TCU	-	-	-
Nitrogen	-	-	-
Compressed Air	-	-	-

4. PACKAGING

Comments:	Please See FM-69 "Packaging Handover Log" for packaging status.

5. RAW MATERIALS & EFFLUENT VOLUMES

Enter volumes and weights of each raw material bulk tank, IBC and effluent storage tank.

Raw Material	**Volume (L)**	**RM IBCs**	**Weight (kg)**	**Effluent**	**Volume (L)**

[redacted]	11114.3
[redacted]	39230
[redacted]	6106
[redacted]	8421

[redacted] (CS01)	237
[redacted] (CS02)	1239
[redacted]	0
[redacted]	252
[redacted]	156

ETA1	33624
ETD1	13356
ETE1	0
ETE2	16816
ETF1	15642
ETB1	11060
Crash Tank	LL
Discharge to Foul Drain	0 m3

6. COMPLETED TASKS

Check the box if the task has been completed and emailed to Abigail Pincombe

Daily Checklist	☐	Weekly Checklist	☐	Raw materials sheet	☐

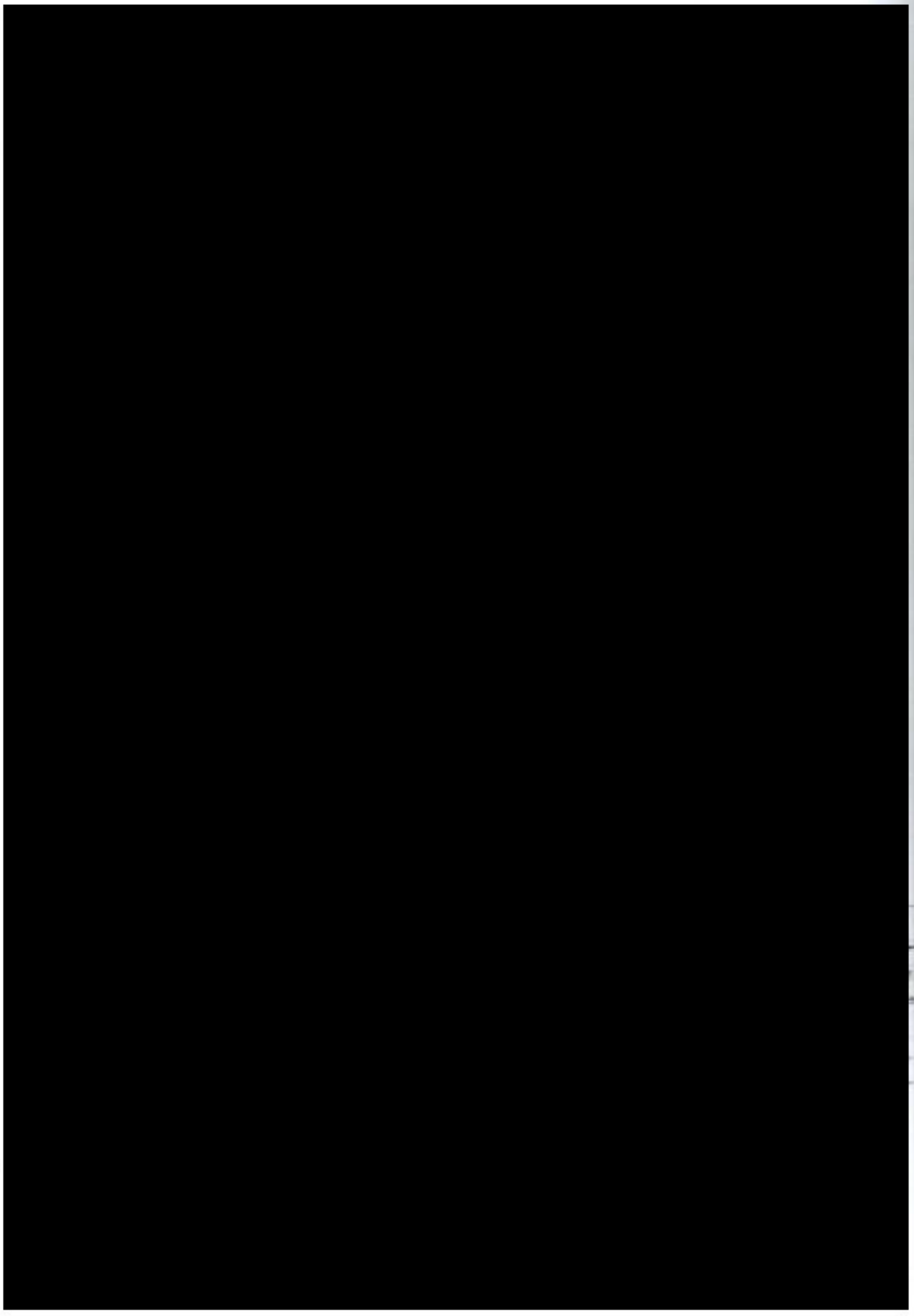
7. Batch Documentation

Documentation completed and up to date?	☒
Comments	-

Distribution

When completed, the handover log should be saved as .pdf file in the locations: G:\Agarose\19. Plant - Operator Docs\SOP, Templates, Checklists, Handover\Handover logs

The file should also be distributed to the mailing list: HandoverLogAMF@purolite.com



Element, Unit C6, Emery Court, The Embankment Business Park, Heaton Mersey, Stockport, SK4 3GL
Your Element Contact: Paul Martin (07827 332 630)
E: paul.martin@element.com

Stack Emissions Testing Report Commissioned by
Purolite Ltd

Installation Name & Address
Purolite Ltd
Unit C
Llantrisant Business Park
Llantrisant
CF72 8LF

EPR Permit: AB3894ZF

Stack Reference
[redacted] Stack

Dates of the Monitoring Campaign
1st April 2022

Job Reference Number
EMT02936

Report Written by
Martin Futter Assistant Operations Manager MCERTS Level 2 MM 03 216 TE1 TE2 TE3 TE4

Report Approved by
Martin Futter Assistant Operations Manager MCERTS Level 2 MM 03 216 TE1 TE2 TE3 TE4

Report Date
20th April 2022

Version
Version 1

Signature of Report Approver


CONTENTS

MONITORING OBJECTIVES

Purolite Ltd, Llantrisant
Bromine Stack
1st April 2022

Overall Aim of the Monitoring Campaign

Element were commissioned by Purolite Ltd to carry out stack emissions testing on the Bromine Stack at Llantrisant.

The aim of the monitoring campaign was to perform testing of an investigative nature under trial operation.

Special Requirements

There were no special requirements.

Target Parameters

[redacted]

Executive Summary

MONITORING RESULTS

Purolite Ltd, Llantrisant

[redacted] Stack

1st April 2022

where MU = Measurement Uncertainty associated with the Result

					Concentration				Mass Emission			
Parameter					**Units**	**Result**	**MU +/-**	**Limit**	**Units**	**Result**	**MU +/-**	**Limit**
[redacted]				[1]	mg/m³	< 0.03	0.003	-	g/hr	< 0.006	0.0013	-
Carbon Dioxide	% v/v	**Wet**	0.07		% v/v	**Dry** 0.07	0.13					
Water Vapour					% v/v	1.2	0.1					
Stack Gas Temperature					°C	19.5						
Stack Gas Velocity					m/s	2.6	0.5					
Volumetric Flow Rate (ACTUAL)					m³/hr	256	48					
Volumetric Flow Rate (REF)				[1]	m³/hr	240	45					

NOTE: VOLUMETRIC FLOW RATE & VELOCITY DATA TAKEN FROM THE PRELIMINARY VELOCITY TRAVERSE.

[1] Reference Conditions (REF) are: 273K, 101.3kPa, without correction for water vapour content.

Executive Summary

MONITORING DATE(S) & TIMES

Purolite Ltd, Llantrisant
Bromine Stack
1st April 2022

Parameter		Units	Concentration	Units	Mass Emission	Sampling Date(s)	Sampling Times	Duration mins
[redacted]	R1	mg/m³	< 0.022	g/hr	< 0.005	01/04/2022	12:08 - 13:38	90
[redacted]	R2	mg/m³	< 0.028	g/hr	< 0.007	01/04/2022	13:43 - 15:13	90
Carbon Dioxide	R1	% v/v	0.05			01/04/2022	12:08 - 13:38	90
Carbon Dioxide	R2	% v/v	0.10			01/04/2022	13:43 - 15:13	90
Velocity Traverse	R1					01/04/2022	15:15 - 15:17	

All results are expressed at the respective reference conditions.

Executive Summary

(Page 4 of 7)

PROCESS DETAILS

Purolite Ltd, Llantrisant

[redacted] Stack

1st April 2022

Standard Operating Conditions

Parameter	Value
Process Status	Operational
Capacity (of 100%) and Tonnes / Hour	[redacted] Vessel
Continuous or Batch Process	Batch
Feedstock (if applicable)	[redacted]
Abatement System	None
Abatement System Running Status	N/A
Fuel	N/A
Plume Appearance	None

MONITORING & ANALYTICAL METHODS

Purolite Ltd, Llantrisant
[redacted] Stack
1st April 2022

	Monitoring				Analysis					
Parameter	**Standard**	**Technical Procedure**	**Sampling Status**	**Testing Lab**	**Analytical Procedure**	**Analytical Technique**	**Analysis Status**	**Analysis Lab**	**Overall Status**	**LOD (Average)**
[redacted]	US EPA M26	CAT-TP-13	MCERTS	EET	C27	IC	17025	RPS	17025	0.025 mg/m³
Water Vapour	EN 14790	CAT-TP-05	MCERTS	EET	CAT-TP-05	Gravimetric	MCERTS	EET	MCERTS	0.10 % v/v
Carbon Dioxide	CEN/TS 17405	CAT-TP-39	MCERTS	EET	NDIR by Horiba PG-350E				MCERTS	0.1 %
Velocity & Vol. Flow Rate	EN 16911-1 (MID)	CAT-TP-41	MCERTS	EET	Pitot Tube and Thermocouple				MCERTS	1.2 m/s

ANALYSIS LABORATORIES

(with short name reference as appears in the table above)

RPS Laboratories Ltd (RPS)	ISO 17025 Accreditation Number: 0605
Element (Stockport Lab - EET)	ISO 17025 Accreditation Number: 4279

SUMMARY OF SAMPLING DEVIATIONS

Parameter	Run	Deviation
All	All	There are no deviations associated with the sampling employed.

SUITABILITY OF SAMPLING LOCATION

Duct Characteristics

Parameter	Units	Value
Type	-	Circular
Depth	m	0.185
Width	m	-
Area	m^2	0.03
Port Depth	cm	6.5
Orientation of Duct	-	Vertical
Number of Ports	-	1
Sample Port Size	-	4" Flange

Location of Sampling Platform

General Platform Information	Value
Permanent / Temporary Platform	Permanent
Inside / Outside	Outside

Platform Details

EA Technical Guidance Note M1 / EN 15259 Platform Requirements	Value
Sufficient working area to manipulate probe and operate the measuring instruments	Yes
Platform has 2 levels of handrails (approx. 0.5m & 1.0m high)	Yes
Platform has vertical base boards (approx. 0.25m high)	Yes
Platform has chains / self closing gates at top of ladders	Yes
There are no obstructions present which hamper insertion of sampling equipment	No
Safe Access Available	Yes
Easy Access Available	No

Sampling Location / Platform Improvement Recommendations

All platforms should be designed in accordance with the requirements in the Environment Agency's Technical Guidance Note M1 and EN 15259.

EN 15259 Homogeneity Test Requirements

There is no requirement to perform a EN 15259 Homogeneity Test on this Stack.

Sampling Plane Validation Criteria (from EN 15259)

Criteria in EN 15259	Units	Traverse 1		Required	Compliant
Lowest Differential Pressure	Pa	6.0		> 5 Pa	Yes
Mean Velocity	m/s	2.65		-	-
Lowest Gas Velocity	m/s	2.65		-	-
Highest Gas Velocity	m/s	2.65		-	-
Ratio of Above	: 1	1.00		< 3 : 1	Yes
Maximum Angle of Swirl	°	5.00		< 15°	Yes
No Local Negative Flow	-	Yes		-	Yes

Executive Summary

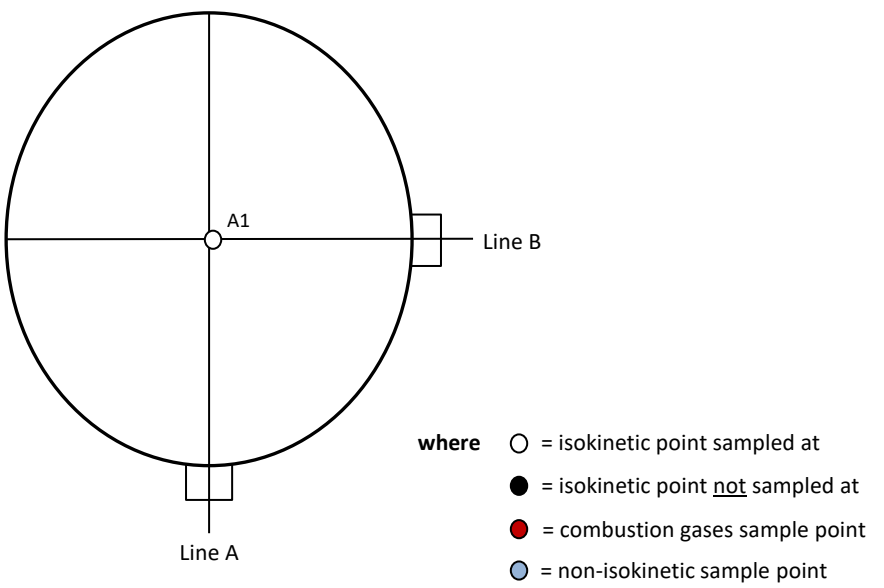
PLANT PHOTOS

Photo 1

Photo 2

Photo 3

SAMPLE POINTS



APPENDIX CONTENTS

STACK EMISSIONS MONITORING PERSONNEL

Position	Name	MCERTS Accreditation	MCERTS Number	Technical Endorsements
Team Leader	Martin Futter	MCERTS Level 2	MM 03 216	TE1 TE2 TE3 TE4
Team Leader	Lewis Doughty	MCERTS Level 2	MM 19 1534	TE1 TE2 TE3 TE4

LIST OF EQUIPMENT

Extractive Sampling	
Equipment Type	**Equipment I.D.**
Control Box DGM (1)	-
Control Box DGM (2)	-
Box Thermocouples (1)	-
Box Thermocouples (2)	-
Umbilical (1)	-
Umbilical (2)	-
Oven Box (1)	-
Oven Box (2)	-
Heated Probe (1)	-
Heated Probe (2)	-
Heated Probe (3)	-
S-Pitot (1)	-
S-Pitot (2)	-
L-Pitot	-
Site Balance	-
500g / 1Kg Check Weights	-
Last Impinger Arm	-
Callipers	-
Tubes Kit Thermocouple	CAT 4.00029

Instrumental Analysers	
Equipment Type	**Equipment I.D.**
Horiba PG-350E	CAT 39.21
Horiba PG-250 SRM	-
Servomex 5200 MP	-
Eco Physics CLD 822Mh	-
ABB AO2020-URAS26	-
Testo 350 XL	-
JCT JCC P1 Cooler	CAT 29.24
Gasmet DX4000	-
Gasmet Sampling System	-
Sick 3006	-
M&C PSS	-
Mass Flow Controller (1)	CAT 6.34
Mass Flow Controller (2)	CAT 6.35
Mass View (1)	CAT 25.82
Mass View (2)	-
Easylogger EN-EL-12 Bit	-
Easylogger EN-EL-12 Bit	-
Bioaerosols Temperature Logger	-
Electronic Refrigerator	-

Miscellaneous Items	
Equipment Type	**Equipment I.D.**
Digital Manometer (1)	CAT 3.56
Digital Manometer (2)	-
Digital Temperature Meter	CAT 3.56
Stopwatch	-
Barometer	-
Stack Thermocouple (1)	CAT 4.0092
Stack Thermocouple (2)	-
Stack Thermocouple (3)	-
1m Heated Line (1)	-
1m Heated Line (2)	-
1m Heated Line (3)	-
5m Heated Line (1)	-
15m Heated Line (1)	-
20m Heated Line (1)	-
20m Heated Line (2)	-
Dual Channel Heater Controller	-
Single Channel Heater Controller	-
Laboratory Balance	
Tape Measure	-

METHODS & TECHNICAL PROCEDURES USED

Parameter	Standard	Technical Procedure
[redacted]	US EPA M26	CAT-TP-13
Water Vapour	EN 14790	CAT-TP-05
Carbon Dioxide	CEN/TS 17405	CAT-TP-39
Velocity & Vol. Flow Rate	EN 16911-1 (MID)	CAT-TP-41

PRELIMINARY STACK SURVEY: CALCULATIONS

General Stack Details

Stack Details (from Traverse)	Units	Value
Stack Diameter / Depth, D	m	0.19
Stack Width, W	m	-
Stack Area, A	m^2	0.03
Average Stack Gas Temperature, T_a	°C	19.5
Average Stack Gas Pressure	Pa	6.0
Average Stack Static Pressure, P_{static}	kPa	0.005
Average Barometric Pressure, P_b	kPa	101.8
Average Pitot Tube Calibration Coefficient, C_p	-	0.84

Stack Gas Composition & Molecular Weights

Component	Conc ppm	Conc Dry % v/v	Conc Wet % v/v	Volume Fraction r	Molar Mass M	Density kg/m^3 p	Conc kg/m^3 p_i
CO_2 (Estimated)	-	0.06	0.06	0.0006	44.01	1.9635	0.00118
O_2 (Estimated)	-	20.80	20.56	0.2080	32.00	1.4277	0.29696
N_2	-	79.14	78.23	0.7914	28.01	1.2498	0.98913
Moisture (H_2O)	-	-	1.15	0.0115	18.02	0.8037	0.00926

Where: $p = M / 22.41$

$p_i = r \times p$

Calculation of Stack Gas Densities

Determinand	Units	Result
Dry Density (STP), P_{STD}	kg/m^3	1.287
Wet Density (STP), P_{STW}	kg/m^3	1.282
Dry Density (Actual), P_{Actual}	kg/m^3	1.207
Average Wet Density (Actual), $P_{ActualW}$	kg/m^3	1.202

Where: P_{STD} = sum of component concentrations, kg/m^3 (not including water vapour)

P_{STW} = sum of all wet concentrations / 100 x density, kg/m^3 (including water vapour)

$P_{Actual} = P_{STD} \times (T_{STP} / (P_{STP})) \times ((P_{static} + P_b) / T_a)$

$P_{ActualW}$ (at each sampling point) $= P_{STW} \times (T_s / P_s) \times (P_a / T_a)$

Calculation of Stack Gas Volumetric Flowrate, Q

Duct gas flow conditions	Units	Actual	REF [1]
Temperature	°C	19.5	0.0
Total Pressure	kPa	101.8	101.3
Moisture	%	1.15	1.15

Gas Volumetric Flowrate (from Traverse)	Units	Result
Gas Volumetric Flowrate (Actual)	m^3/hr	256
Gas Volumetric Flowrate (STP, Wet)	m^3/hr	240
Gas Volumetric Flowrate (STP, Dry)	m^3/hr	238
Gas Volumetric Flowrate REF [1]	m^3/hr	240

PRELIMINARY STACK SURVEY: VELOCITY TRAVERSE TO EN 16911-1 (MID)

(1 of 1)

Parameter	Units	Value
Date of Survey	-	01/04/2022
Time of Survey	-	15:15 - 15:17
Atmospheric Pressure	kPa	101.8
Average Stack Static Pressure	Pa	5
Result of Pitot Stagnation Test	-	Pass
Are Water Droplets Present?	-	No
Device Used	S-Type Pitot with KIMO MP 200 (500Pa)	

Parameter	Units	Value
Initial Pitot Leak Check	-	Pass
Final Pitot Leak Check	-	Pass
Orientation of Duct	-	Vertical
Pitot Tube, C_p	-	0.84
Number of Lines Available	-	1
Number of Lines Used	-	1

Sampling Line A

Traverse Point	Depth m	ΔP Pa	Temp °C	Wet Density kg/m³	Velocity m/s	Swirl °
STATIC (Units: Pa)		*5.0*				
Mean		**6.0**	**19.5**	**1.202**	**2.65**	
1	0.09	6.0	19.5	1.202	2.65	5.0

PRELIMINARY STACK SURVEY: VELOCITY TRAVERSE TO EN 16911-1 (MID) - MEASUREMENT UNCERTAINTY

(1 of 1)

Performance characteristics (Uncertainty Components)	Uncertainty	Value	Units
Standard Uncertainty on the coefficient of the Pitot Tube	u(k)	0.005	-
Standard Uncertainty associated with the mean local dynamic pressures	u(Δpi)	1.059	Pa
- Resolution	u(res)	0.00087	
- Calibration	u(cal)	0.004	
- Drift	u(drift)	0.083	
- Lack of Fit	u(fit)	0.035	
- Overall corrections to dynamic measurements	u(Cf)	0.122	
Standard uncertainty associated with the molar mass of the gas	u(M)	0.00003	-
- $\varphi O_2,w$	-	20.560	
- $\varphi CO_2,w$	-	0.059	
- Oxygen, dry	u(ϕO_2,d)	0.637	
- Carbon Dioxide, dry	u(ϕCO_2,d)	0.002	
- Water Vapour	u(ϕH_2O)	0.059	
- Oxygen, wet	u(ϕO_2,w)	0.630	
- Carbon Dioxide, wet	u(ϕCO_2,w)	0.002	
Standard uncertainty associated with the stack temperature	u(Tc)	1.492	K
Standard uncertainty associated with the absolute pressure in the duct	u(pc)	175.695	Pa
- Atmospheric Pressure	u(patm)	175.692	
- Static Pressure	u(pstat)	1.059	
Standard uncertainty associated with the density in the duct	u(ρ)	0.00648	-
Standard uncertainty associated with the local velocities	u(vi)	0.245	Pa
Standard uncertainty associated with the mean velocity	u(v)	0.245	m/s
Standard uncertainty associated with the mean velocity (95% Confidence)	Uc(v)	0.480	m/s
Standard uncertainty associated with the mean velocity (95% Confidence), relative	Uc,rel(v)	18.14	%
Standard uncertainty associated with the volume flow rate (95% Confidence)	Uc(qV,w)	47.9	m^3/hr
- $u^2(a)/a^2$	-	0.00053	
- $u^2(qV,w)/q^2V,w$	-	0.00910	
- $u^2(qV,w)$	-	598	
- $u(qV,w)$	-	24.4	
Standard uncertainty associated with the volume flow rate (95% Confidence), relative	Uc,rel(qV,w)	18.69	%

APPENDIX 2

BROMINE: RESULTS SUMMARY

Purolite Ltd, Llantrisant

Bromine Stack

Sample Runs

Parameter	Units	Run 1	Run 2		Mean
Concentration	mg/m³	< 0.0218	< 0.0284		< 0.0251
Uncertainty	±mg/m³	0.0023	0.0030		0.0026
Mass Emission	g/hr	< 0.0052	< 0.0068		< 0.0060
Uncertainty	±g/hr	0.0011	0.0015		0.0013

Parameter	Units	Run 1	Run 2		Mean
Water Vapour	% v/v	1.23	1.07		1.15
Uncertainty	±% v/v	0.06	0.06		0.06

Blank Runs

Parameter	Units	Blank 1		Maximum
Concentration	mg/m³	< 0.02		< 0.02

General Sampling Information

Parameter	Value	
Standard	US EPA M26	
Technical Procedure	CAT-TP-13	
Name of Analytical Laboratory	RPS	
Analytical Laboratory's Procedure	C27	
ISO 17025 Accredited Analysis?	17025	
Date of Sample Analysis	19/04/2022	
Probe Material	Titanium	
Filter Housing Material	Quartz Glass	
Impinger Material	Polyethylene	
Absorption Solution	0.1 mol/l Sodium Hydroxide	
Positioning of Filter	Out Stack	
Filter Size and Material	90mm Quartz Fibre	
Number of Sampling Lines Used	1 / 1	FORMAT: Number Used / Number Required
Number of Sampling Points Used	1 / 1	FORMAT: Number Used / Number Required
Sample Point I.D.'s	A1	

Reference Conditions

Reference Conditions are: 273K, 101.3kPa, without correction for water vapour content.

BROMINE: SAMPLING DETAILS

Sample Runs

Parameter	Units	Run 1	Run 2
Sampling Times	-	12:08 - 13:38	13:43 - 15:13
Sampling Dates	-	01/04/2022	01/04/2022
Sampling Device	-	MFC / MV	MFC / MV
Duration	mins	90	90
Volume Sampled (STP, Dry)	m^3	0.5880	0.5756
Volume Sampled (STP, Wet)	m^3	0.5954	0.5819
Volume Sampled (REF)	m^3	0.5954	0.5819
Sample Flow Rate	l/min	6.53	6.39
Laboratory Result for Front Impingers	µg/ml	< 0.05	< 0.05
Laboratory Result for Back Impinger	µg/ml	< 0.05	
Volume in Front Impingers	ml	125.1	330.0
Volume in Back Impinger	ml	134.8	
Mass in Front Impingers	µg	< 6.3	< 16.5
Mass in Back Impinger	µg	< 6.7	
Total Mass Collected	µg	< 13.0	< 16.5
Calculated Concentration	mg/m^3	< 0.02	< 0.03
Liquid Trap Start Mass	g	1924.2	1916.6
Liquid Trap End Mass	g	1926.6	1918.1
Silica Trap Start Mass	g	1353.3	1356.8
Silica Trap End Mass	g	1356.8	1360.3
Total Mass Of Water Vapour	g	5.9	5.0
Calculated Water Vapour	% v/v	1.23	1.07

Where: MFC stands for Mass Flow Controller, MV stands for Mass View Flowmeter

Blank Runs

Parameter	Units	Blank 1
Blank Dates	-	01/04/2022
Average Volume Sampled (REF)	m^3	0.5886
Laboratory Result for Impingers	µg/ml	< 0.05
Volume in Impingers	ml	238.7
Total Mass Collected	µg	< 11.9
Calculated Concentration	mg/m^3	< 0.02

BROMINE: QUALITY ASSURANCE

Sample Runs

Leak Test Results	Units	Run 1	Run 2
Mean Sampling Rate	l/min	6.5	6.4
Pre-Sampling Leak Rate	l/min	0.00	0.00
Post-Sampling Leak Rate	l/min	0.00	0.00
Allowable Leak Rate	l/min	0.13	0.13
Leak Test Acceptable	-	Yes	Yes

Absorption Efficiency	Units	Run 1
Absorption Efficiency	%	100.0
Allowable Absorption Efficiency	%	N/A
Absorption Efficiency Acceptable	-	N/A

Water Droplets	Units	Run 1	Run 2
Are Water Droplets Present	-	No	No

MU (Concurrent Water Vapour)	Units	Run 1	Run 2
Measurement Uncertainty (MU)	%	5.2	5.6
Allowable MU	%	20.0	20.0
MU Acceptable	%	Yes	Yes

Silica Gel (Concurrent Water Vapour)	Units	Run 1	Run 2
Less than 50% Faded	%	Yes	Yes

Test Conditions	Units	Run 1	Run 2
Ambient Temperature Recorded?	-	No	No

Blank Runs

Leak Test Results	Units	Blank 1
Expected Sampling Rate	l/min	10.0
Pre-Sampling Leak Rate	l/min	0.15
Post-Sampling Leak Rate	l/min	0.14
Allowable Leak Rate	l/min	0.20
Leak Test Acceptable	-	Yes

Validity of Blank vs ELV	Units	Blank 1
Allowable Blank	mg/m^3	N/A
Blank Acceptable	-	N/A

Method Deviations

Nature of Deviation (x = deviation applies to the associated run, wx = deviation also applies to the concurrent water vapour run)	Run Number 1	2
There are no deviations associated with the sampling employed.	wx	wx

BROMINE: MEASUREMENT UNCERTAINTY CALCULATIONS

	Value				Standard uncertainty			
Measured Quantities	**Symbol**	**Run 1**	**Run 2**		**Symbol**	**Units**	**Run 1**	**Run 2**
Sampled Volume (STP)	V_m	0.5880	0.5756		uV_m	m^3	0.0118	0.0115
Leak	L	0.00	0.00		uL	%	-	-
Laboratory Result	L_r	5.00	5.00		uL_r	%	-	-

	Uncertainty as a Percentage			
Measured Quantities	**Units**	**Run 1**	**Run 2**	**Requirement of Standard**
Sampled Volume (STP)	%	2.00	2.00	≤2%
Leak	%	0.00	0.00	≤2%
Laboratory Result	%	5.00	5.00	No Requirement

	Uncertainty in Measurement Units				Sensitivity Coefficient	
Measured Quantities	**Symbol**	**Units**	**Run 1**	**Run 2**	**Run 1**	**Run 2**
Sampled Volume (STP)	V_m	m^3	0.5880	0.5756	0.04	0.05
Leak	L	mg/m^3	0.000	0.000	1.00	1.00
Laboratory Result	L_r	mg/m^3	0.001	0.001	1.00	1.00

	Uncertainty in Result		
Measured Quantities	**Units**	**Run 1**	**Run 2**
Sampled Volume (STP)	mg/m^3	0.000	0.001
Leak	mg/m^3	0.0000	0.0000
Laboratory Result	mg/m^3	0.0011	0.0014

	Oxygen Correction Part of MU Budget		
Measured Quantities	**Units**	**Run 1**	**Run 2**
O_2 Correction Factor	-	N/A	N/A
Stack Gas O_2 Content	% v/v	N/A	N/A
MU for O_2 Correction	-	N/A	N/A
Overall MU For O_2 Measurement	%	N/A	N/A

Parameter	**Units**	**Run 1**	**Run 2**
Combined uncertainty	mg/m^3	0.00	0.00
Expanded uncertainty (95% confidence), without Oxygen Correction	mg/m^3	0.00	0.00
Expanded uncertainty (95% confidence), with Oxygen Correction	mg/m^3	N/A	N/A
Expanded uncertainty (95% confidence), estimated with Method Deviations	mg/m^3	0.00	0.00
Reported Uncertainty	mg/m^3	0.00	0.00
Expanded uncertainty (95% confidence), without Oxygen Correction	%	10.6	10.6
Expanded uncertainty (95% confidence), with Oxygen Correction	%	N/A	N/A
Expanded uncertainty (95% confidence), estimated with Method Deviations	%	10.6	10.6
Reported Uncertainty	%	10.6	10.6

APPENDIX 2

CARBON DIOXIDE: RESULTS SUMMARY

Purolite Ltd, Llantrisant

[redacted] Stack

Sample Runs

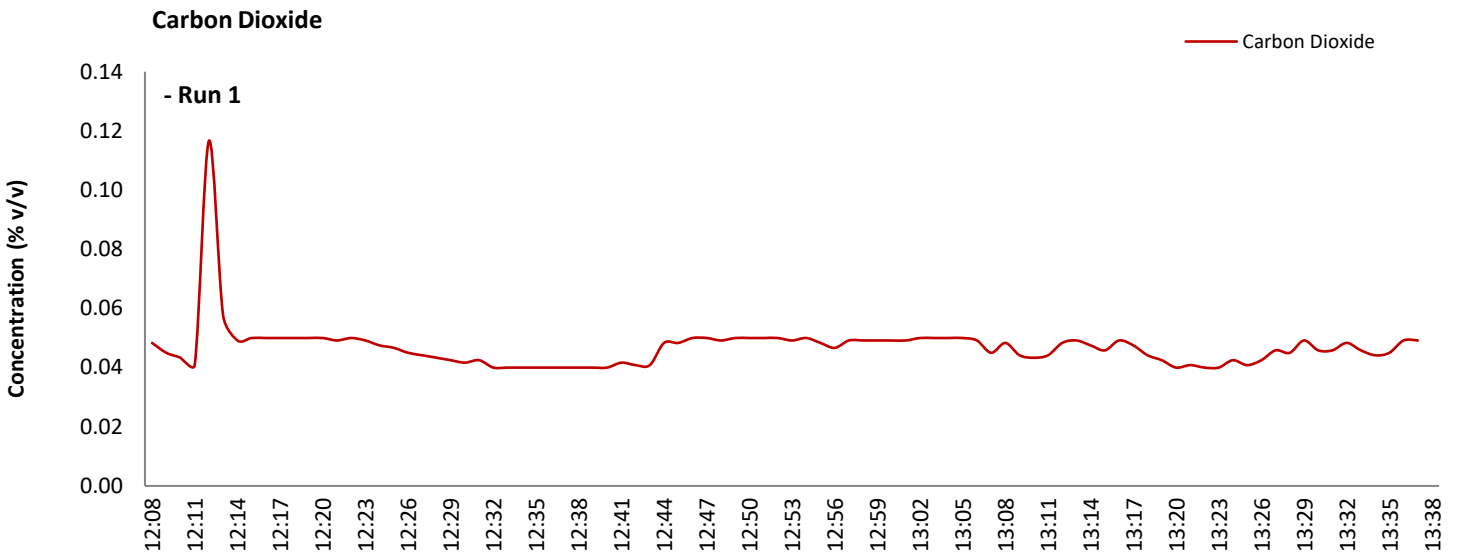
Parameter	Units	Run 1	Run 2		Mean
Concentration	% v/v	0.05	0.10		0.07
Uncertainty	±% v/v	0.12	0.12		0.12

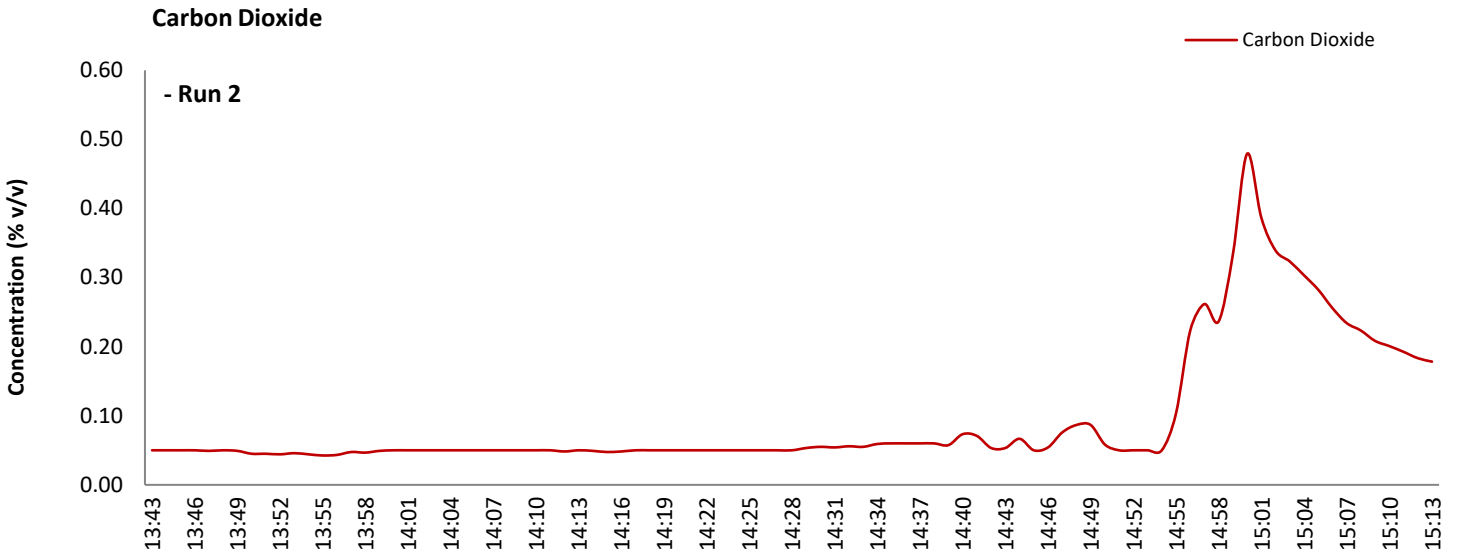
General Sampling Information

Parameter	Value	
Standard	CEN/TS 17405	
Technical Procedure	CAT-TP-39	
Probe Material	Stainless Steel	
Filtration Type / Size	0.1µm Glass Fibre	
Heated Head Filter Used	Yes	
Heated Line Temperature	180°C	
Span Gas Type	Carbon Dioxide	
Span Gas Reference Number	CYL 6.00621	
Span Gas Expiry Date	27/11/2025	
Span Gas Start Pressure (bar)	65	
Gas Cylinder Concentration (% v/v)	16.09	
Span Gas Uncertainty (%)	2.00	
Zero Gas Type	Nitrogen (5 Grade)	
Number of Sampling Lines Used	1 / 1	FORMAT: Number Used / Number Required
Number of Sampling Points Used	1 / 1	FORMAT: Number Used / Number Required
Sample Point I.D.'s	A1	

CARBON DIOXIDE: DATA TREND

Graphical Trend of Data





CARBON DIOXIDE: SAMPLING DETAILS & QUALITY ASSURANCE

Sampling Details

Parameter	Units	Run 1	Run 2
Sampling Times	-	12:08 - 13:38	13:43 - 15:13
Sampling Dates	-	01/04/2022	01/04/2022
Instrument Range	% v/v	20	20
Span Gas Value	% v/v	16.1	16.1

Quality Assurance

Conditioning Unit Temperature	Units	Run 1	Run 2
Average Temperature	°C	2.4	2.4
Allowable Temperature	< °C	4.0	4.0
Temperature Acceptable	-	Yes	Yes

	Zero Drift	Units	Run 1	Run 2
CAL 1	Zero Down Sampling Line (Pre)	% v/v	0.03	0.03
	Zero Down Sampling Line (Post)	% v/v	0.00	0.00
	Zero Drift	% v/v	-0.03	-0.03
	Zero Drift	%	0.19	0.19
	Drift Correction Applied	2-5%	No	No
CAL 2	Zero Down Sampling Line (Pre)	% v/v		
	Zero Down Sampling Line (Post)	% v/v		
	Zero Drift	% v/v		
	Zero Drift	%		
	Drift Correction Applied	2-5%		
CAL 3	Zero Down Sampling Line (Pre)	% v/v		
	Zero Down Sampling Line (Post)	% v/v		
	Zero Drift	% v/v		
	Zero Drift	%		
	Drift Correction Applied	2-5%		
	Allowable Zero Drift	± %	5.00	5.00
	Zero Drift Acceptable	-	Yes	Yes

	Span Drift	Units	Run 1	Run 2
CAL 1	Span Down Sampling Line (Pre)	% v/v	16.05	16.05
	Span Down Sampling Line (Post)	% v/v	16.05	16.05
	Span Drift	% v/v	0.00	0.00
	Zero Adj. Span Drift	%	0.19	0.19
	Drift Correction Applied	2-5%	No	No
CAL 2	Span Down Sampling Line (Pre)	% v/v		
	Span Down Sampling Line (Post)	% v/v		
	Span Drift	% v/v		
	Zero Adj. Span Drift	%		
	Drift Correction Applied	2-5%		
CAL 3	Span Down Sampling Line (Pre)	% v/v		
	Span Down Sampling Line (Post)	% v/v		
	Span Drift	% v/v		
	Zero Adj. Span Drift	%		
	Drift Correction Applied	2-5%		
	Allowable Span Drift	± %	5.00	5.00
	Span Drift Acceptable	-	Yes	Yes

Test Conditions	Units	Run 1	Run 2
Run Ambient Temperature Range	°C	12	12

Method Deviations

Nature of Deviation (x = deviation applies to the associated run)	Run Number 1	2	
There are no deviations associated with the sampling employed.	x	x	

CARBON DIOXIDE: MEASUREMENT UNCERTAINTY CALCULATIONS

Performance characteristics	RUN 1	RUN 2		Units
Limit value	N/A	N/A		%vol
Allowable MU	25.0	25.0		%
Measured concentration	0.05	0.10		%vol
Range Used	20.0	20.0		%vol
Cal gas conc.	16.1	16.1		%vol

Performance characteristics	RUN 1	RUN 2		Units
Response time	29	29		seconds
Number of readings in measurement	90	90		-
Repeatability at zero	0.00	0.00		% full scale
Repeatability at span level	0.10	0.10		% full scale
Deviation from linearity	0.10	0.10		% of value
Zero drift	-0.19	-0.19		% full scale
Span drift	0.19	0.19		% full scale
Volume or pressure flow dependence	0.10	0.10		% of full scale
Atmospheric pressure dependence	0.30	0.30		% of value/kPa
Ambient temperature dependence	-0.20	-0.20		% full scale/10K
Combined interference	0.00	0.00		% range
Dependence on voltage	0.40	0.40		% full scale/10V
Losses in the line (leak)	0.25	0.25		% of value
Uncertainty of calibration gas	2.00	2.00		% of value

Performance characteristic	RUN 1	RUN 2		Units
Standard deviation of repeatability at zero	use rep at span	use rep at span		%vol
Standard deviation of repeatability at span level	0.01	0.01		%vol
Lack of fit	0.01	0.01		%vol
Drift	0.00	0.00		%vol
Volume or pressure flow dependence	0.00	0.00		%vol
Atmospheric pressure dependence	0.02	0.02		%vol
Ambient temperature dependence	-0.03	-0.03		%vol
Combined interference (from MCERTS Certificate)	0.00	0.00		%vol
Dependence on voltage	0.05	0.05		%vol
Losses in the line (leak)	0.00	0.00		%vol
Uncertainty of calibration gas	0.00	0.00		%vol

			RUN 1	RUN 2		Units
Measurement uncertainty		**Result**	0.05	0.10		%vol
Combined uncertainty			0.06	0.06		%vol
Expanded uncertainty	k =	1.96	0.12	0.12		%vol

	RUN 1	RUN 2		Units
Expanded uncertainty (no O_2) - at 95% Confidence	247.70	120.76		% of Value

Version Number	Record of changes made within this version of the document
V1	The original document issued to the client

Appendix F H1 Screening Assessment

A screening assessment was carried out using the EA's H1 screening tool[40] (H1 tool) to identify whether detailed modelling of the emissions was required, or whether the environmental impact could be screened out as not significant. The H1 tool can assess releases to air, water or land; in this case it was only used to assess the releases to air.

The input data for H1 are those given in Table 6 of the main report. The effective stack height of 0m has been used for emission points A4 and A5 (steam generators), as the respective release heights are less than 3m above the ground or building the stack is situated on, or >3m above ground or building, but less than the height of any building within the distance 5L from the stack. An effective height of 0.498m for A6 ([redacted] abatement plant stack), was calculated based on the height of the adjacent building. As a screening tool, H1 aims to make pessimistic predictions of PC. It also calculates PEC and Headroom. The outcome of the H1 assessment was that the releases to air were not screened out as insignificant in respect of:

- NO_2 for short-term impacts on human receptors
- NOx for short and long-term impact on sensitive ecological receptors

Therefore, detailed modelling assessment has been carried out in addition to a detailed assessment of odour which is not assessed by H1. The H1 results are summarised in Table and Table 20 for long-term and short-term AQS respectively.

Table 19 H1 results, long-term AQS

AQS	BG(µg/m³)	PC (µg/m³)	PC/ AQS (%)	PEC (µg/m³)	PEC/AQS (%)	PEC/AQS >= 70% ?
Nitrogen dioxide	13.1	2.15	5.36	15.3	38.2	**No**
Nitrogen dioxide (Ecological - Daily Mean)	19.48	2.15	7.14	21.7	72.1	**Yes**

Notes: bold indicates AQS not screened out

Table 20 H1 results, short-term AQS

AQS	Background (µg/m³)	PC (µg/m³)	PC/Headroom (%)	PC/Headroom >= 20%?
Nitrogen dioxide	13.1	144	82.6	**Yes**
Nitrogen dioxide (Ecological - Daily Mean)	19.48	144	398	**Yes**

Notes: bold indicates AQS not screened out

[40] Environment Agency, H1 Software Tool User Guide, Version 2.78, January 2017

Appendix G Model and Model Set-up

G.1 Meteorology and associated parameters

Hourly meteorological data

The model uses hourly data of surface meteorology parameters that are typically measured at a synoptic station or are generated by a numerical model. In this assessment, five years' of data were obtained for the period 2016-2020 for Site location from a Numerical Weather Prediction system known as the Global Forecast System (GFS).

The GFS is a spectral model and data are archived at a horizontal resolution of 0.5 degrees longitude, or approximately 50km over the UK (latterly 0.25 degrees, or approximately 25km). The GFS resolution captures major topographical features and the broad-scale characteristics of the weather over the UK. The use of NWP data has advantages over traditional meteorological records as:

- Calm periods in traditional records may be over-represented.
- Traditional records may include local deviations from the broad-scale wind flow that would not necessarily be representative of the site being modelled
- Information on the state of the atmosphere above ground level, which would otherwise be estimated by the meteorological pre-processor, may be included explicitly.

Figure 3 shows windroses for each year of data. The prevailing wind directions are westerly. The data were used with the ADMS 5 calms option with default values. Table 21 shows the number of lines of usable data each year with and without calms option. Without the calms options the lowest percentage of usable lines was 96.0 %.

Defra's LAQM TG16[23] contains cautionary guidance on use of data with less than 85% usable data in calculating for comparison with short-term AQS. The minimum value of usable data were far above this threshold.

Table 21 Meteorological station data for calm conditions

Year of data	Number of hours modelled with calm conditions	Hours used (%)
2017	14	100
2018	10	100
2019	15	100
2020	19	100
2021	20	100

Notes: Meteorological parameters supplied are: wind speed, wind direction, near-ground air temperature, cloud cover

Meteorological parameters

The ADMS model uses various meteorological parameters to represent the area at the meteorological station or, in the case of numerical data, the data location, and the dispersion site, the Site. The key parameters that have been defined are the surface roughness and minimum Monin-Obuhkov length.

- Surface roughness: this is related to land-use and the height of obstacles on the ground which give rise to mechanically-generated turbulence; and
- Minimum Monin-Obukhov length: this is used to model the extent to which the urban heat island effect limits the most stable atmospheric conditions. Heat released from the urban area prevents the atmospheric boundary layer becoming very stable.

Table 22 shows the values of the parameters that can be selected in the model from a drop-down menu. Other, intermediate, values can be entered directly. The values selected for the meteorological data location and the Site are given Table 23 .

A surface roughness length (z0d (m)) of 0.3m, similar to agricultural area with high crops and structures, was selected as representative of the Site. Further sensitivity testing of z0d (m) has been undertaken (Appendix E). Based on advice provided by the GFS met data supplier, the meteorological data site surface roughness length was set to a value lower (i.e. 0.2m) than the Site z0d (m).

A minimum Monin-Obukhov length (Minimum Lmod (m)) of 10m was set for the Site to account for other industrial units in the vicinity, while a minimum Lmod (m) of 2m, for rural areas, was used for the meteorological data location.

Table 22 ADMS 5 meteorological parameter values

Surface roughness	
Descriptor	**Value (m)**
Large urban areas	1.5
Cities, woodland	1.0
Parkland, open suburbia	0.5
Agricultural areas (max)	0.3
Agricultural areas (min)	0.2
Root crops	0.1
Open grassland	0.02
Short grass	0.005
Sea	0.0001

Minimum Monin-Obuhkov length	
Descriptor	**Value (m)**
Large conurbations >1million	100m
Cities and large towns	30m
Mixed urban/industrial	30m
Rural areas (max) [1]	20m
Small towns < 50,000	10m
Rural areas (min)[1]	2m

Notes: [1] Not available from the ADMS drop-down menu

Table 23 Meteorological site and wide Site met parameters

Parameter	Meteorological data site	Wider Site
Surface roughness	0.2m	0.3m
Minimum Monin-Obhukov length	2m	10m

G.2 Buildings

The presence of buildings close to an emission point can affect the dispersion from a source, bringing the plume centreline down towards the ground in the lee of a building and entraining pollutant into the cavity (or, recirculation) region in the lee of a building. In the cavity, concentrations are assumed to be uniform and it may be a region of high concentrations depending on the amount of pollutant entrained. The presence of buildings may increase or decrease concentrations at a location compared with the no buildings scenario.

ADMS allows up to 25 buildings to be included as input and the model combines the relevant input buildings into one effective building; the effective building is calculated for each line of meteorological data. Buildings can only be circular or rectangular in cross-section so the buildings entered are simplified geometries. Buildings less than one third of the height of the stack will be ignored by the ADMS 5 model. Smaller Site structures, have been neglected as their effect outside the Site will be limited compared with the larger structures, such as the main manufacturing building.

Table 24 shows the (simplified) parameters of the two buildings on site used as input to the model; they are shown in Figure 4.

In ADMS, for each stack a 'main' building must be specified; the main operations building (Unit C) was specified as the main building for the both generators (A4 and A5), the bromine abatement plant stack (A6) and the Main Stack (A1) as a function of the building footprint and/or its proximity to each source.

Table 24 Modelled buildings

Building name	Building centre X	Building centre Y	Height (m)	Length/ Diameter (m)	Width (m)	Orientation (°)
Main Building (Unit C)	304133	184511	9.7	43	30	55
Tank Farm Gantry	304177	184491	10.0	9.0	14	55
Unit D	304088	184470	9.7	49	45	55

G.3 Terrain

The effect of terrain is not usually modelled when terrain gradients in the modelled domain are below the 1:10 threshold usually applied. However, when using numerical weather data it is recommended to consider the dispersion model predictions with and without terrain.

At an elevation of approximately 70m AOD the Site occupies a lower position within marked valley topography where land rises to 100m AOD 0.2km to the southeast, and to 164m AOD 0.9km south southeast, and 251m AOD 1.6km to the southwest. The terrain elevation data is shown in Figure 5.

G.4 Receptors

The impact of stack emissions at relevant human and ecological receptors has been modelled. A relevant receptor is defined in Defra's LAQM TG16[23] as:

> 'A location representative of human (or ecological) exposure to a pollutant, over a time period relevant to the objective that is being assessed against, where the Air Quality Strategy objectives are considered to apply.'

Human receptors

For long-term AQS the relevant receptors are residences (including care homes), schools and hospitals. For short-term AQS additional receptors may also need to be considered: outdoor spaces such as balconies, gardens, leisure sites and public space where human populations may spend the relevant time period. As most short-term AQS allow for a number of exceedances per annum, the human

exposure may need to be repeated in order to be relevant. Workplaces are usually excluded from consideration as air quality in workplaces is covered by Health and Safety legislation.[41]

Table 25 shows the locations and type of the receptors selected to be representative of the relevant human receptors. All the receptors have been modelled at a height of 1.5m, representative of inhalation height (nose level) at ground level. Their locations are shown in Figure 6.

Table 25 Human receptors

ID	Location	Type	NGR X	NGR Y	Distance from Site boundary (m)	Direction from Site
R1	Royal Glamorgan Hospital 1	Hospital	303682	184247	494	Southwest
R2	Royal Glamorgan Hospital 2	Hospital	303747	184150	497	Southwest
R3	Farmhouse 1	Residential	303950	184113	400	Southwest
R4	Llantrisant Primary School	School	304556	183850	735	Southeast
R5	House - Heol Las	Residential	304397	183699	805	South
R6	Llantrisant Rugby Football Club	Leisure	305058	183878	1,064	Southeast
R7	Farmhouse 2	Residential	305451	184615	1,270	East
R8	House - B4595	Residential	305651	184205	1,492	East
R9	RPC Containers	Commercial	304022	184516	73	West
R10	The Kite Brewery	Commercial	303993	184650	167	Northwest
R11	Three Saints Hotel / The Red Mint	Hotel	303985	184722	231	Northwest
R12	Balmoral Tanks	Commercial	304132	184632	85	North
R13	Euro Performance	Commercial	304346	184779	309	Northeast
R14	Universal Engineering	Commercial	304354	184937	443	Northeast
R15	The Royal Mint	Commercial/ Leisure	303813	184837	426	Northwest
R16	Ynysmaerdy Terrace	Residential	303441	184446	658	West
R17	Farmhouse 3	Residential	303027	184928	1,144	West
R18	Farmhouse 4	Residential	304041	185511	969	North
R19	Farmhouse 5	Residential	304846	185165	937	Northeast
R20	Farmhouse 6	Residential	304696	185331	960	Northeast
R21	Ysgol Gymraeg Castellau	School	305764	185188	1,725	Northeast
R22	Dan Y Graig Heights	Residential	304121	183397	1,072	South

Notes: All modelled at a height of 1.5m.

Ecological receptors

Ecological receptors were placed in the designated areas at the nearest locations to the Site. Table 26 shows conservation sites identified within the specified distance, (2km for SSSIs, AW, LWS and 10km for SPAs, SACs, Ramsar). Table 26 lists the ecological receptors modelled which are illustrated in Figure 7 (those within 2km) and Figure 8 (all the receptors, within 10km). All the ecological receptors have been modelled at a height of 1.5m.

[41] Health and Safety Executive EH40/2005 Workplace Exposure Limits (Fourth Edition 2020)

Table 26 Ecological receptors

ID	Site name	NGR X	NGR Y	Distance from boundary (km)	Direction from boundary
E1	Llantrisant Common & Pastures SSSI (1)	304134	184565	19	Northwest
E2	Llantrisant Common & Pastures SSSI (2)	304144	184550	3.0	Northeast
E3	Llantrisant Common & Pastures SSSI (3)	304157	184529	1.0	Northeast
E4	Llantrisant Common & Pastures SSSI (4)	304171	184513	3.0	Northeast
E5	Llantrisant Common & Pastures SSSI (5)	304187	184498	4.0	Northeast
E6	Llantrisant Common & Pastures SSSI (6)	304226	184563	77	Northeast
E7	Llantrisant Common & Pastures SSSI (7)	304257	184527	80	Northeast
E8	Llantrisant Common & Pastures SSSI (8)	304304	184595	155	Northeast
E9	Llantrisant Common & Pastures SSSI (9)	304324	184559	154	Northeast
E10	Llantrisant Common & Pastures SSSI (10)	304420	184616	265	Northeast
E11	Llantrisant Common & Pastures SSSI (11)	304551	184659	402	Northeast
E12	Llantrisant Common & Pastures SSSI (12)	304823	184781	700	Northeast
E13	Llantrisant Common & Pastures SSSI (13)	304839	184970	808	Northeast
E14	Llantrisant Common & Pastures SSSI (14)	304200	184476	19	Southeast
E15	Llantrisant Common & Pastures SSSI (15)	304254	184409	104	Southeast
E16	Llantrisant Common & Pastures SSSI (16)	304825	184106	745	Southeast
E17	Llantrisant Common & Pastures SSSI (17)	304825	184406	644	East
E18	Llantrisant Common & Pastures SSSI (18)	304838	183816	936	Southeast
E19	Rhos Tonyrefail SSSI (1)	303471	185076	837	Northwest
E20	Rhos Tonyrefail SSSI (2)	303328	184963	887	Northwest
E21	Rhos Tonyrefail_SSSI_AW (3)	303342	185292	1,080	Northwest
E22	Rhos Tonyrefail SSSI_AW (4)	303764	186221	1,715	North
E23	Rhos Tonyrefail SSSI (5)	303728	186369	1,868	North
E24	Rhos Tonyrefail SSSI (6)	303878	186434	1,905	North
E25	Cardiff Beech Woods SAC (1)	310945	182495	7,046	East
E26	Cardiff Beech Woods SAC (2)	312742	183006	8,683	East
E27	Cardiff Beech Woods SAC (3)	313877	183252	9,769	East
E28	Ancient Semi-Natural Woodland (1)	304212	185079	536	North
E29	Ancient Semi-Natural Woodland (2)	304254	185737	1,195	North
E30	Ancient Semi-Natural Woodland (3)	304683	185401	1,011	Northeast
E31	Ancient Semi-Natural Woodland (4)	305274	186015	1,853	Northeast
E32	Ancient Semi-Natural Woodland (5)	305603	185278	1,620	Northeast
E33	Ancient Semi-Natural Woodland (6)	304100	186188	1,641	North
E34	Ancient Semi-Natural Woodland (7)	302721	185465	1,669	Northwest
E35	ASNW Plantation on Ancient Woodland Site (8)	302649	184885	1,492	West
E36	ASNW_Plantation on Ancient Woodland Site (9)	303224	184091	970	Southwest
E37	Ancient Semi-Natural Woodland (10)	303540	183802	890	Southwest
E38	Restored Ancient Woodland Site (1)	302855	185375	1,508	Northwest
E39	Restored Ancient Woodland Site (2)	302249	185127	1,944	West
E40	Restored Ancient Woodland Site_PAWS (3)	303224	183868	1,086	Southwest
E41	Restored Ancient Woodland Site (4)	303365	183593	1,163	Southwest
E42	Restored Ancient Woodland Site (5)	303277	183041	1,664	Southwest
E43	Restored Ancient Woodland Site (6)	303129	183697	1,263	Southwest
E44	Restored Ancient Woodland Site (7)	305246	183285	1,603	Southeast
E45	Restored Ancient Woodland Site (8)	305741	183516	1,834	Southeast
E46	Restored Ancient Woodland Site (9)	305537	183500	1,674	Southeast
E47	Plantation on Ancient Woodland Site (1)	302953	183181	1,745	Southwest
E48	Plantation on Ancient Woodland Site (2)	303288	183208	1,517	Southwest
E49	Plantation on Ancient Woodland Site (3)	303090	183871	1,196	Southwest
E50	Ancient Woodland Site of Unknown Category (1)	303186	183371	1,448	Southwest
E51	Y Gweria Pasture Wildlife Trust Reserve	305294	184934	1,200	Northeast

G.5 Post-processing

Use of background data

Considering long-term AQS, it is a straightforward matter to add the annual mean contribution from the source, (annual mean PC) to the annual mean background concentration to predict the total concentration (annual mean PEC).

For comparison with short-term AQS the addition of background is not so straightforward. The ADMS model allows for the calculation of percentiles from hourly background and process concentrations but hourly background concentrations are not commonly available, and not for all pollutants. The approach used was that described in the Defra permit guidance:[18]

> 'When you calculate background concentration, you can assume that the short-term background concentration of a substance is twice its long-term concentration.'

This has been used for all for short-term AQS for averaging times.

Conversion of NOx to NO_2

The ADMS model includes a NOx chemistry model, but the conversion of primary NOx emissions to NO_2 is usually undertaken as a post-processing step for industrial permitting applications. For primary NO_2 to NO_x ratios of 10% or less, which is likely to be the case for the stack emissions, the EA and NRW[42] recommend use of the following conversion ratios:

- 35% for short term assessment
- 70% for long term assessment.

These ratios have been used in this assessment.

Deposition to ecological receptors

The ADMS model includes the ability to calculate the deposition flux rate (deposition) of pollutants, but the EA recommends deposition be calculated as a post-processing step in order to give conservative estimates of both ground level concentration and deposition, by assuming no loss of pollutant from air concentration to ground deposition.

Deposition may be 'dry' or 'wet'. Dry deposition of gases occurs due to diffusive motions and removal at surfaces, primarily the ground. It is characterised by a deposition velocity that depends on the pollutant and the nature of the surface.

Table 27 gives the deposition velocities for grassland and forest for the pollutants included in this assessment which are the values recommended by AQTAG 06.[22] The values for grassland, which are lower than those for forest, have been used to represent deposition at all receptors.

[42] https://www.gov.uk/guidance/specified-generators-dispersion-modelling-assessment#nosubxsub-to-nosub2sub-conversion-ratios-to-use

Wet deposition occurs when precipitation washes pollutants out of the air. Some pollutants have a low solubility, and in addition, wet deposition is considered to be of limited importance close to the source. Wet deposition has been neglected.

Table 27 Dry deposition velocities

Pollutant	Deposition velocity (m/s)	
	Grassland	Forest
NO_2	0.0015	0.003
SO_2	0.012	0.024
NH_3	0.020	0.030

Deposition ($\mu g/m^2/s$) is calculated by multiplying the near ground air concentration ($\mu g/m^3$) by deposition velocity. Ecological receptors are sensitive to deposition of nitrogen (nutrient nitrogen) and to deposition of acid species including nitrogen (N), sulphur (S) and HCl. To convert from deposition of a pollutant to deposition of a species, the conversion factors given in Table 28 were used.

Nutrient nitrogen deposition is calculated as the total deposition of N in kg/ha/year, due to NO_2. To convert from deposition of N or S deposited to equivalent acidification units, a measure of how acidifying the chemical species can be, (keq/ha/year), the conversion factors given in Table 29 were used. Acid deposition is calculated taking into account the acidifying nitrogen and sulphur deposition, both expressed as keq/ha/year.

Table 28 Conversion factors for deposition of species N, S

Pollutant	Species deposited	Conversion factor from deposition of pollutant ($\mu g/m^2/s$) to deposition of species (kg/ha/year)
NO_2	N	96

Table 29 Conversion factors for deposition of species deposition to acid equivalent

Species	Conversion factor from deposition of species (kg/ha/year) to deposition of equivalent acidification units (keq/ha/year)
N	0.071428
S	0.0625

Appendix H Results of sensitivity tests

The impact of buildings, terrain, meteorological data year and choice of surface roughness value (z0d (m)) at the dispersion site (the Site) have been assessed. The 30 cases modelled, A-AD, are shown in Table 30.

Two values of surface roughness have been modelled. z0d is often estimated as 10% of the height of structures. The values modelled are:

- 0.5m, similar to parkland, open suburbia; and
- 0.3m, similar to agricultural area with high crops and structures.

Results of the sensitivity tests were the maximum concentration predicted at any human receptor and any ecological receptor. For each AQS, the predicted maximum was divided by (normalised) the AQS value, or if the AQS is expressed as a number of exceedances of threshold value, by the threshold value. These normalised values have been expressed as a percentage and are shown in Table 31. The comparison is expressed this way to show the relative importance of the change in terms of exceedance of the AQS. If all the results are a very small percentage of the AQS, the variation in results is unlikely to affect the conclusions of the study.

Comparing the results, modelling buildings with terrain (tests U to Y inclusive) led to higher model short-term predictions for human receptor locations. The variation due to the addition of buildings had the most pronounced effect at both human and ecological receptor locations.

Flat terrain with the inclusion of buildings resulted in the maximum predicted long and short-term concentrations at ecological receptor locations.

Comparing the change in surface roughness (z0d) makes little difference in the results and there is no worst-case value across all the statistics. Results at the receptors were calculated as the maximum value at each receptor from these 30 model runs and are therefore worst-case values across all five years, the three model options scenarios and the two values of surface roughness.

Table 30 Sensitivity tests

Sensitivity test	Flat/Buildings/Terrain model options	Meteorological data year	z0d (m)	Minimum Lmod (m)
A	Flat	2016	0.3	10
B	Flat	2017	0.3	10
C	Flat	2018	0.3	10
D	Flat	2019	0.3	10
E	Flat	2020	0.3	10
F	Flat	2016	0.5	10
G	Flat	2017	0.5	10
H	Flat	2018	0.5	10
I	Flat	2019	0.5	10
J	Flat	2020	0.5	10
K	Flat & buildings	2016	0.3	10
L	Flat & buildings	2017	0.3	10
M	Flat & buildings	2018	0.3	10
N	Flat & buildings	2019	0.3	10
O	Flat & buildings	2020	0.3	10
P	Flat & buildings	2016	0.5	10
Q	Flat & buildings	2017	0.5	10
R	Flat & buildings	2018	0.5	10
S	Flat & buildings	2019	0.5	10
T	Flat & buildings	2020	0.5	10
U	Terrain & buildings	2016	0.3	10
V	Terrain & buildings	2017	0.3	10
W	Terrain & buildings	2018	0.3	10
X	Terrain & buildings	2019	0.3	10
Y	Terrain & buildings	2020	0.3	10
Z	Terrain & buildings	2016	0.5	10
AA	Terrain & buildings	2017	0.5	10
AB	Terrain & buildings	2018	0.5	10
AC	Terrain & buildings	2019	0.5	10
AD	Terrain & buildings	2020	0.5	10

Table 31 Results as a percentage of the EAL or threshold

Pollutant	Long-term (LT) or Short-term (ST)	Value, EAL or threshold ($\mu g/m^3$)	A - E	F - J	K - O	P - T	U - Y	Z - AD	Max
Human receptors									
NO_2	ST	200	6%	5%	11%	11%	12%	12%	12%
Ecological receptors									
NOx	LT	30	4.8%	6.4%	53%	48%	27%	26%	53%
NOx	ST	75	11%	12%	129%	130%	112%	90%	130%
NOx	ST	200	4.0%	4.5%	49%	49%	42%	34%	49%

Appendix I Human receptor results

Table 32 Short-term results NO_2

ID	Receptors	Comparison with 99.79th percentile 1-hour threshold 200µg/m³			
		PC (µg/m³)	PC/AQS (%)	Headroom (µg/m³)	PC/Headroom (%)
R1	Royal Glamorgan Hospital 1	1.12	1%	174	0.6%
R2	Royal Glamorgan Hospital 2	0.86	0%	174	0.5%
R3	Farmhouse 1	0.86	0%	174	0.5%
R4	Llantrisant Primary School	0.67	0%	178	0.4%
R5	House - Heol Las	0.57	0%	178	0.3%
R6	Llantrisant Rugby Football Club	0.45	0%	180	0.2%
R7	Farmhouse 2	0.32	0%	182	0.2%
R8	House - B4595	0.27	0%	182	0.2%
R9	RPC Containers	4.68	2%	178	2.6%
R10	The Kite Brewery	2.87	1%	174	1.6%
R11	Three Saints Hotel / The Red Mint	1.53	1%	174	0.9%
R12	Balmoral Tanks	3.44	2%	178	1.9%
R13	Euro Performance	1.08	1%	178	0.6%
R14	Universal Engineering	0.78	0%	178	0.4%
R15	The Royal Mint	1.05	1%	174	0.6%
R16	Ynysmaerdy Terrace	0.87	0%	174	0.5%
R17	Farmhouse 3	0.38	0%	174	0.2%
R18	Farmhouse 4	0.43	0%	184	0.2%
R19	Farmhouse 5	0.47	0%	184	0.3%
R20	Farmhouse 6	0.35	0%	184	0.2%
R21	Ysgol Gymraeg Castellau	0.19	0%	183	0.1%
R22	Dan Y Graig Heights	0.39	0%	178	0.2%

Appendix J Ecological receptor results

Table 33 Results at ecological receptors, long-term AQS for NOx

ID	Receptors	Comparison with annual mean AQS: 30µg/m³			
		PC (µg/m³)	PC/AQS (%)	PEC (µg/m³)	PEC/AQS (%)
E1	Llantrisant Common & Pastures SSSI (1)	1.005	3%	16.7	56%
E2	Llantrisant Common & Pastures SSSI (2)	3.069	10%	18.8	63%
E3	Llantrisant Common & Pastures SSSI (3)	4.985	17%	20.7	69%
E4	Llantrisant Common & Pastures SSSI (4)	12.54	42%	28.2	94%
E5	Llantrisant Common & Pastures SSSI (5)	7.639	25%	23.3	78%
E6	Llantrisant Common & Pastures SSSI (6)	0.961	3%	16.7	56%
E7	Llantrisant Common & Pastures SSSI (7)	1.339	4%	17.0	57%
E8	Llantrisant Common & Pastures SSSI (8)	0.456	2%	16.1	54%
E9	Llantrisant Common & Pastures SSSI (9)	0.616	2%	16.3	54%
E10	Llantrisant Common & Pastures SSSI (10)	0.258	1%	15.9	53%
E11	Llantrisant Common & Pastures SSSI (11)	0.137	0%	15.8	53%
E12	Llantrisant Common & Pastures SSSI (12)	0.052	0%	15.7	52%
E13	Llantrisant Common & Pastures SSSI (13)	0.031	0%	15.7	52%
E14	Llantrisant Common & Pastures SSSI (14)	2.874	10%	18.6	62%
E15	Llantrisant Common & Pastures SSSI (15)	0.406	1%	16.1	54%
E16	Llantrisant Common & Pastures SSSI (16)	0.036	0%	15.7	52%
E17	Llantrisant Common & Pastures SSSI (17)	0.057	0%	15.7	52%
E18	Llantrisant Common & Pastures SSSI (18)	0.023	0%	15.7	52%
E19	Rhos Tonyrefail SSSI (1)	0.017	0%	10.8	36%
E20	Rhos Tonyrefail SSSI (2)	0.019	0%	10.8	36%
E21	Rhos Tonyrefail_SSSI_AW (3)	0.011	0%	10.8	36%
E22	Rhos Tonyrefail SSSI_AW (4)	0.005	0%	9.42	31%
E23	Rhos Tonyrefail SSSI (5)	0.005	0%	9.41	31%
E24	Rhos Tonyrefail SSSI (6)	0.004	0%	9.41	31%
E25	Cardiff Beech Woods SAC (1)	0.002	0%	13.1	44%
E26	Cardiff Beech Woods SAC (2)	0.001	0%	19.5	65%
E27	Cardiff Beech Woods SAC (3)	0.001	0%	13.7	46%

ID	Receptors	Comparison with annual mean AQS: 30µg/m³			
		PC (µg/m³)	PC/AQS (%)	PEC (µg/m³)	PEC/AQS (%)
E28	Ancient Semi-Natural Woodland (1)	0.028	0%	11.4	38%
E29	Ancient Semi-Natural Woodland (2)	0.009	0%	11.4	38%
E30	Ancient Semi-Natural Woodland (3)	0.014	0%	11.4	38%
E31	Ancient Semi-Natural Woodland (4)	0.006	0%	10.2	34%
E32	Ancient Semi-Natural Woodland (5)	0.011	0%	11.7	39%
E33	Ancient Semi-Natural Woodland (6)	0.005	0%	9.75	32%
E34	Ancient Semi-Natural Woodland (7)	0.007	0%	10.9	36%
E35	ASNW_Plantation on Ancient Woodland Site (8)	0.010	0%	10.9	36%
E36	ASNW_Plantation on Ancient Woodland Site (9)	0.025	0%	18.9	63%
E37	Ancient Semi-Natural Woodland (10)	0.025	0%	14.3	48%
E38	Restored Ancient Woodland Site (1)	0.008	0%	10.9	36%
E39	Restored Ancient Woodland Site (2)	0.007	0%	10.9	36%
E40	Restored Ancient Woodland Site_PAWS (3)	0.022	0%	14.3	48%
E41	Restored Ancient Woodland Site (4)	0.016	0%	14.2	47%
E42	Restored Ancient Woodland Site (5)	0.009	0%	14.2	47%
E43	Restored Ancient Woodland Site (6)	0.017	0%	14.2	47%
E44	Restored Ancient Woodland Site (7)	0.011	0%	13.9	46%
E45	Restored Ancient Woodland Site (8)	0.010	0%	13.9	46%
E46	Restored Ancient Woodland Site (9)	0.011	0%	13.9	46%
E47	Plantation on Ancient Woodland Site (1)	0.008	0%	11.3	38%
E48	Plantation on Ancient Woodland Site (2)	0.011	0%	14.2	47%
E49	Plantation on Ancient Woodland Site (3)	0.020	0%	14.2	47%
E50	Ancient Woodland Site of Unknown Category (1)	0.011	0%	14.2	47%
E51	Y Gweria Pasture Wildlife Trust Reserve	0.022	0%	13.0	0%

Table 34 Results at ecological receptors, short-term AQS for NOx

ID	Receptors	Comparison with maximum daily AQS: 75µg/m³				Comparison with maximum daily AQS: 200µg/m³			
		PC (µg/m³)	PC/AQS (%)	Headroom (µg/m³)	PC/ Headroom (%)	PC (µg/m³)	PC/AQS (%)	Headroom (µg/m³)	PC/ Headroom (%)
E1	Llantrisant Common & Pastures SSSI (1)	7.94	11%	43.6	18%	7.94	4%	169	5%
E2	Llantrisant Common & Pastures SSSI (2)	52.3	70%	43.6	120%	52.3	26%	169	31%
E3	Llantrisant Common & Pastures SSSI (3)	54.8	73%	43.6	126%	54.8	27%	169	32%
E4	Llantrisant Common & Pastures SSSI (4)	56.6	75%	43.6	130%	56.6	28%	169	34%
E5	Llantrisant Common & Pastures SSSI (5)	56.7	76%	43.6	130%	56.7	28%	169	34%
E6	Llantrisant Common & Pastures SSSI (6)	5.22	7%	43.6	12%	5.22	3%	169	3%
E7	Llantrisant Common & Pastures SSSI (7)	3.89	5%	43.6	9%	3.89	2%	169	2%
E8	Llantrisant Common & Pastures SSSI (8)	2.46	3%	43.6	6%	2.46	1%	169	1%
E9	Llantrisant Common & Pastures SSSI (9)	2.05	3%	43.6	5%	2.05	1%	169	1%
E10	Llantrisant Common & Pastures SSSI (10)	1.13	2%	43.6	3%	1.13	1%	169	1%
E11	Llantrisant Common & Pastures SSSI (11)	0.65	1%	43.6	1%	0.65	0%	169	0%
E12	Llantrisant Common & Pastures SSSI (12)	0.29	0%	43.6	1%	0.29	0%	169	0%
E13	Llantrisant Common & Pastures SSSI (13)	0.33	0%	43.6	1%	0.33	0%	169	0%
E14	Llantrisant Common & Pastures SSSI (14)	41.8	56%	43.6	96%	41.8	21%	169	25%
E15	Llantrisant Common & Pastures SSSI (15)	2.73	4%	43.6	6%	2.73	1%	169	2%
E16	Llantrisant Common & Pastures SSSI (16)	0.34	0%	43.6	1%	0.34	0%	169	0%
E17	Llantrisant Common & Pastures SSSI (17)	0.59	1%	43.6	1%	0.59	0%	169	0%
E18	Llantrisant Common & Pastures SSSI (18)	0.37	0%	43.6	1%	0.37	0%	169	0%
E19	Rhos Tonyrefail SSSI (1)	0.28	0%	53.3	1%	0.28	0%	178	0%
E20	Rhos Tonyrefail SSSI (2)	0.26	0%	53.3	0%	0.26	0%	178	0%
E21	Rhos Tonyrefail_SSSI_AW (3)	0.19	0%	53.3	0%	0.19	0%	178	0%
E22	Rhos Tonyrefail SSSI_AW (4)	0.10	0%	56.2	0%	0.10	0%	181	0%
E23	Rhos Tonyrefail SSSI (5)	0.09	0%	56.2	0%	0.09	0%	181	0%
E24	Rhos Tonyrefail SSSI (6)	0.08	0%	56.2	0%	0.08	0%	181	0%
E25	Cardiff Beech Woods SAC (1)	0.02	0%	48.8	0%	0.02	0%	174	0%
E26	Cardiff Beech Woods SAC (2)	0.02	0%	36.0	0%	0.02	0%	161	0%
E27	Cardiff Beech Woods SAC (3)	0.01	0%	47.6	0%	0.01	0%	173	0%
E28	Ancient Semi-Natural Woodland (1)	0.40	0.5%	52.2	0.8%	0.40	0%	177	0%
E29	Ancient Semi-Natural Woodland (2)	0.15	0%	52.2	0%	0.15	0%	177	0%

ID	Receptors	Comparison with maximum daily AQS: 75µg/m³				Comparison with maximum daily AQS: 200µg/m³			
		PC (µg/m³)	PC/AQS (%)	Headroom (µg/m³)	PC/ Headroom (%)	PC (µg/m³)	PC/AQS (%)	Headroom (µg/m³)	PC/ Headroom (%)
E30	Ancient Semi-Natural Woodland (3)	0.30	0%	52.2	1%	0.30	0%	177	0%
E31	Ancient Semi-Natural Woodland (4)	0.12	0%	54.6	0%	0.12	0%	180	0%
E32	Ancient Semi-Natural Woodland (5)	0.11	0%	51.6	0%	0.11	0%	177	0%
E33	Ancient Semi-Natural Woodland (6)	0.08	0%	55.5	0%	0.08	0%	181	0%
E34	Ancient Semi-Natural Woodland (7)	0.11	0%	53.2	0%	0.11	0%	178	0%
E35	ASNW_Plantation on Ancient Woodland Site (8)	0.24	0%	53.2	0%	0.24	0%	178	0%
E36	ASNW_Plantation on Ancient Woodland Site (9)	0.31	0%	37.3	1%	0.31	0%	162	0%
E37	Ancient Semi-Natural Woodland (10)	0.27	0%	46.5	1%	0.27	0%	172	0%
E38	Restored Ancient Woodland Site (1)	0.13	0%	53.2	0%	0.13	0%	178	0%
E39	Restored Ancient Woodland Site (2)	0.13	0%	53.2	0%	0.13	0%	178	0%
E40	Restored Ancient Woodland Site_PAWS (3)	0.23	0%	46.5	1%	0.23	0%	172	0%
E41	Restored Ancient Woodland Site (4)	0.20	0%	46.5	0%	0.20	0%	172	0%
E42	Restored Ancient Woodland Site (5)	0.12	0%	46.5	0%	0.12	0%	172	0%
E43	Restored Ancient Woodland Site (6)	0.18	0%	46.5	0%	0.18	0%	172	0%
E44	Restored Ancient Woodland Site (7)	0.18	0%	47.1	0%	0.18	0%	172	0%
E45	Restored Ancient Woodland Site (8)	0.10	0%	47.1	0%	0.10	0%	172	0%
E46	Restored Ancient Woodland Site (9)	0.14	0%	47.1	0%	0.14	0%	172	0%
E47	Plantation on Ancient Woodland Site (1)	0.12	0%	52.3	0%	0.12	0%	177	0%
E48	Plantation on Ancient Woodland Site (2)	0.13	0%	46.5	0%	0.13	0%	172	0%
E49	Plantation on Ancient Woodland Site (3)	0.24	0%	46.5	1%	0.24	0%	172	0%
E50	Ancient Woodland Site of Unknown Category (1)	0.15	0%	46.5	0%	0.15	0%	172	0%
E51	Y Gweria Pasture Wildlife Trust Reserve	0.14	0%	49.1	0%	0.14	0%	174	0%

Table 35 Results at ecological receptors, nutrient nitrogen deposition

Receptors	Comparison with nutrient nitrogen critical loads								
	Deposition velocity type	PC (kgN/ha/yr)	CLmin (kgN/ha/yr)	CLmax (kgN/ha/yr)	PC/CLmin (%)	PC/CLmax (%)	Background (kgN/ha/yr)	PEDR/CLmin (%)	PEDR/CLmax (%)
E1	Grass	0.101	8	15	1.3%	0.7%	16.52	208%	111%
E2	Grass	0.309	8	15	3.9%	2.1%	16.52	210%	112%
E3	Grass	0.502	8	15	6.3%	3.3%	16.52	213%	113%
E4	Grass	1.264	8	15	16%	8.4%	16.52	222%	119%
E5	Grass	0.770	8	15	9.6%	5.1%	16.52	216%	115%
E6	Grass	0.097	8	15	1.2%	0.6%	16.52	208%	111%
E7	Grass	0.135	8	15	1.7%	0.9%	16.52	208%	111%
E8	Grass	0.046	8	15	0.6%	0.3%	16.52	207%	110%
E9	Grass	0.062	8	15	0.8%	0.4%	16.52	207%	111%
E10	Grass	0.026	8	15	0.3%	0.2%	16.52	207%	110%
E11	Grass	0.014	8	15	0.2%	0.1%	16.52	207%	110%
E12	Grass	0.005	8	15	0.1%	0.0%	16.52	207%	110%
E13	Grass	0.003	8	15	0.0%	0.0%	16.52	207%	110%
E14	Grass	0.290	8	15	3.6%	1.9%	16.52	210%	112%
E15	Grass	0.041	8	15	0.5%	0.3%	16.52	207%	110%
E16	Grass	0.004	8	15	0.0%	0.0%	16.52	207%	110%
E17	Grass	0.006	8	15	0.1%	0.0%	16.52	207%	110%
E18	Grass	0.002	8	15	0.0%	0.0%	16.52	207%	110%
E19	Grass	0.002	8	15	0.0%	0.0%	17.08	214%	114%
E20	Grass	0.002	8	15	0.0%	0.0%	17.08	214%	114%
E21	Forest	0.002	5	15	0.0%	0.0%	17.08	342%	114%
E22	Forest	0.001	5	15	0.0%	0.0%	17.08	342%	114%
E23	Forest	0.001	5	15	0.0%	0.0%	17.08	342%	114%
E24	Grass	0.000	8	15	0.0%	0.0%	17.08	214%	114%
E25	Forest	0.0003	10	20	0.0%	0.0%	25.76	258%	129%
E26	Forest	0.0002	10	20	0.0%	0.0%	25.76	258%	129%
E27	Forest	0.0002	10	20	0.0%	0.0%	25.76	258%	129%
E28	Forest	0.006	10	15	0.1%	0.0%	26.32	263%	176%
E29	Forest	0.002	10	15	0.0%	0.0%	26.32	263%	175%
E30	Forest	0.003	10	15	0.0%	0.0%	26.32	263%	175%

Receptors	Comparison with nutrient nitrogen critical loads								
	Deposition velocity type	PC (kgN/ha/yr)	CLmin (kgN/ha/yr)	CLmax (kgN/ha/yr)	PC/CLmin (%)	PC/CLmax (%)	Background (kgN/ha/yr)	PEDR/CLmin (%)	PEDR/CLmax (%)
E31	Forest	0.001	10	15	0.0%	0.0%	28.14	281%	188%
E32	Forest	0.002	10	15	0.0%	0.0%	28.14	281%	188%
E33	Forest	0.001	10	15	0.0%	0.0%	26.32	263%	175%
E34	Forest	0.001	10	15	0.0%	0.0%	26.32	263%	175%
E35	Forest	0.002	10	15	0.0%	0.0%	25.76	258%	172%
E36	Forest	0.005	10	15	0.1%	0.0%	25.76	258%	172%
E37	Forest	0.005	10	15	0.0%	0.0%	25.76	258%	172%
E38	Forest	0.002	10	15	0.0%	0.0%	26.32	263%	175%
E39	Forest	0.001	10	15	0.0%	0.0%	26.32	263%	175%
E40	Forest	0.004	10	15	0.0%	0.0%	25.76	258%	172%
E41	Forest	0.003	10	15	0.0%	0.0%	25.76	258%	172%
E42	Forest	0.002	10	15	0.0%	0.0%	25.76	258%	172%
E43	Forest	0.003	10	15	0.0%	0.0%	25.76	258%	172%
E44	Forest	0.002	10	15	0.0%	0.0%	26.46	265%	176%
E45	Forest	0.002	10	15	0.0%	0.0%	26.46	265%	176%
E46	Forest	0.002	10	15	0.0%	0.0%	26.46	265%	176%
E47	Forest	0.002	10	15	0.0%	0.0%	25.76	258%	172%
E48	Forest	0.002	10	15	0.0%	0.0%	25.76	258%	172%
E49	Forest	0.004	10	15	0.0%	0.0%	25.76	258%	172%
E50	Forest	0.002	10	15	0.0%	0.0%	25.76	258%	172%
E51	Grass	0.002	5	10	0.0%	0.0%	16.8	336%	168%

Table 36 Results at ecological receptors, acid deposition (comparison against minimum Clos)

Receptors	PC (keqS/ha/yr)	PC (keqN/ha/yr)	Background (keqS/ha/yr)	Background (keqN/ha/yr)	Minimum critical loads		
					PC (%)	Background (%)	PEC (%)
E1	-	0.0072	0.30	1.20	1.23%	256%	257%
E2	-	0.0221	0.30	1.20	3.77%	256%	260%
E3	-	0.0359	0.30	1.20	6.12%	256%	262%
E4	-	0.0903	0.30	1.20	15.4%	256%	271%
E5	-	0.0550	0.30	1.20	9.39%	256%	265%
E6	-	0.0069	0.30	1.20	1.18%	256%	257%
E7	-	0.0096	0.30	1.20	1.65%	256%	258%
E8	-	0.0033	0.30	1.20	0.56%	256%	257%
E9	-	0.0044	0.30	1.20	0.76%	256%	257%
E10	-	0.0019	0.30	1.20	0.32%	256%	256%
E11	-	0.0010	0.30	1.20	0.17%	256%	256%
E12	-	0.0004	0.30	1.20	0.06%	256%	256%
E13	-	0.0002	0.30	1.20	0.04%	256%	256%
E14	-	0.0207	0.30	1.20	3.53%	256%	260%
E15	-	0.0029	0.30	1.20	0.50%	256%	256%
E16	-	0.0003	0.30	1.20	0.04%	256%	256%
E17	-	0.0004	0.30	1.20	0.07%	256%	256%
E18	-	0.0002	0.30	1.20	0.03%	256%	256%
E19	-	0.00012	0.30	1.20	0.02%	227%	227%
E20	-	0.00014	0.30	1.20	0.02%	227%	227%
E21	-	0.00015	0.30	1.90	0.01%	114%	114%
E22	-	0.00007	0.30	1.90	0.01%	114%	114%
E23	-	0.00007	0.30	1.90	0.01%	114%	114%
E24	-	0.00003	0.30	1.20	0.00%	227%	227%
E25	-	0.00002	0.30	1.50	0.002%	126%	126%
E26	-	0.00002	0.30	1.50	0.001%	126%	126%
E27	-	0.00001	0.30	1.50	0.001%	126%	126%
E28	-	0.00041	0.33	1.88	0.01%	67.0%	67.0%
E29	-	0.00013	0.33	1.88	0.00%	67.0%	67.0%

Receptors	PC (keqS/ha/yr)	PC (keqN/ha/yr)	Background (keqS/ha/yr)	Background (keqN/ha/yr)	Minimum critical loads		
					PC (%)	Background (%)	PEC (%)
E30	-	0.00020	0.33	1.88	0.01%	67.0%	67.0%
E31	-	0.00008	0.33	2.01	0.00%	69.7%	69.7%
E32	-	0.00016	0.33	2.01	0.00%	70.0%	70.0%
E33	-	0.00007	0.33	1.88	0.00%	66.7%	66.7%
E34	-	0.00010	0.33	1.88	0.01%	169%	169%
E35	-	0.00015	0.31	1.84	0.01%	179%	179%
E36	-	0.00036	0.31	1.84	0.01%	67.3%	67.3%
E37	-	0.00036	0.31	1.84	0.03%	182%	182%
E38	-	0.00012	0.33	1.88	0.01%	169%	169%
E39	-	0.00010	0.33	1.88	0.01%	169%	169%
E40	-	0.00032	0.31	1.84	0.03%	182%	182%
E41	-	0.00023	0.31	1.84	0.02%	182%	182%
E42	-	0.00013	0.31	1.84	0.01%	182%	182%
E43	-	0.00024	0.31	1.84	0.02%	182%	182%
E44	-	0.00016	0.29	1.89	0.01%	180%	180%
E45	-	0.00015	0.29	1.89	0.01%	180%	180%
E46	-	0.00016	0.29	1.89	0.01%	180%	180%
E47	-	0.00012	0.31	1.84	0.01%	181%	181%
E48	-	0.00015	0.31	1.84	0.01%	182%	182%
E49	-	0.00028	0.31	1.84	0.02%	182%	182%
E50	-	0.00016	0.31	1.84	0.01%	182%	182%
E51	-	0.00016	0.25	1.20	0.01%	137%	137%

Table 37 Results at ecological receptors, acid deposition (comparison against maximum Clos)

Receptors	PC (keqS/ha/yr)	PC (keqN/ha/yr)	Background (keqS/ha/yr)	Background (keqN/ha/yr)	Maximum critical loads		
					PC (%)	Background (%)	PEC (%)
E1	-	0.0072	0.30	1.20	0.25%	52.1%	52.3%
E2	-	0.0221	0.30	1.20	0.77%	52.1%	52.9%
E3	-	0.0359	0.30	1.20	1.25%	52.1%	53.3%
E4	-	0.0903	0.30	1.20	3.14%	52.1%	55.2%
E5	-	0.0550	0.30	1.20	1.91%	52.1%	54.0%
E6	-	0.0069	0.30	1.20	0.24%	52.1%	52.3%
E7	-	0.0096	0.30	1.20	0.33%	52.1%	52.4%
E8	-	0.0033	0.30	1.20	0.11%	52.1%	52.2%
E9	-	0.0044	0.30	1.20	0.15%	52.1%	52.2%
E10	-	0.0019	0.30	1.20	0.06%	52.1%	52.1%
E11	-	0.0010	0.30	1.20	0.03%	52.1%	52.1%
E12	-	0.0004	0.30	1.20	0.01%	52.1%	52.1%
E13	-	0.0002	0.30	1.20	0.01%	52.1%	52.1%
E14	-	0.0207	0.30	1.20	0.72%	52.1%	52.8%
E15	-	0.0029	0.30	1.20	0.10%	52.1%	52.2%
E16	-	0.0003	0.30	1.20	0.01%	52.1%	52.1%
E17	-	0.0004	0.30	1.20	0.01%	52.1%	52.1%
E18	-	0.0002	0.30	1.20	0.01%	52.1%	52.1%
E19	-	0.00012	0.30	1.20	0.004%	54.0%	54.0%
E20	-	0.00014	0.30	1.20	0.005%	54.0%	54.0%
E21	-	0.00015	0.30	1.90	0.005%	45.1%	45.1%
E22	-	0.00007	0.30	1.90	0.002%	45.1%	45.1%
E23	-	0.00007	0.30	1.90	0.002%	45.1%	45.1%
E24	-	0.00003	0.30	1.20	0.001%	54.0%	54.0%
E25	-	0.00002	0.30	1.80	0.00%	15.7%	15.7%
E26	-	0.00002	0.30	1.80	0.00%	15.7%	15.7%
E27	-	0.00001	0.30	1.80	0.00%	15.7%	15.7%
E28	-	0.00041	0.33	1.88	0.01%	67.0%	67.0%
E29	-	0.00013	0.33	1.88	0.00%	67.0%	67.0%

Receptors	PC (keqS/ha/yr)	PC (keqN/ha/yr)	Background (keqS/ha/yr)	Background (keqN/ha/yr)	Maximum critical loads		
					PC (%)	Background (%)	PEC (%)
E30	-	0.00020	0.33	1.88	0.01%	67.0%	67.0%
E31	-	0.00008	0.33	2.01	0.00%	69.7%	69.7%
E32	-	0.00016	0.33	2.01	0.00%	70.0%	70.0%
E33	-	0.00007	0.33	1.88	0.00%	66.7%	66.7%
E34	-	0.00010	0.33	1.88	0.01%	169%	169%
E35	-	0.00015	0.31	1.84	0.01%	179%	179%
E36	-	0.00036	0.31	1.84	0.01%	67.3%	67.3%
E37	-	0.00036	0.31	1.84	0.03%	182%	182%
E38	-	0.00012	0.33	1.88	0.01%	169%	169%
E39	-	0.00010	0.33	1.88	0.01%	169%	169%
E40	-	0.00032	0.31	1.84	0.03%	182%	182%
E41	-	0.00023	0.31	1.84	0.02%	182%	182%
E42	-	0.00013	0.31	1.84	0.01%	182%	182%
E43	-	0.00024	0.31	1.84	0.02%	182%	182%
E44	-	0.00016	0.29	1.89	0.01%	180%	180%
E45	-	0.00015	0.29	1.89	0.01%	180%	180%
E46	-	0.00016	0.29	1.89	0.01%	180%	180%
E47	-	0.00012	0.31	1.84	0.01%	181%	181%
E48	-	0.00015	0.31	1.84	0.01%	182%	182%
E49	-	0.00028	0.31	1.84	0.02%	182%	182%
E50	-	0.00016	0.31	1.84	0.01%	182%	182%
E51	-	0.00016	0.25	1.20	0.01%	137%	137%