EMISSIONS MODELLING ASSESSMENT

Ellgia Limited

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1.0	18/10/2023	DY		Draft for client comment
1.1	19/10/2023	DY		Addition of section 1.4
1.2	29/11/2023	DY		Updated in response to EA Schedule 5 Notice to include dust, Total VOC and CO emissions modelling for biomass boiler.

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1 Introduction

1.1 Background and Context of Assessment

1.1.1 An emissions modelling assessment has been undertaken in support of an Environmental Permit variation application being submitted by Ellgia Limited for their site at Winterton Road, Scunthorpe. The assessment has been undertaken to predict the potential air quality impacts at sensitive receptor locations as a result of residual emissions from generators and a biomass boiler used on site.

1.2 Site Location

1.2.1 The site is located at Ellgia Limited, Winterton Road, Scunthorpe. Reference should be made to Appendix I for site location plan.

1.3 Proposed Activities and Environmental Context

1.3.1 Ellgia Limited are seeking to consolidate existing permits and add installation activities at their waste recycling site at Winterton Road, Scunthorpe.

1.3.2 A number of diesel generators are operated at the site for the purpose of providing electrical power required for the operations. A biomass boiler is also operated to produce heat for drying of Refuse Derived Fuel (RDF). The boiler is currently regulated by the Local Authority under a separate Part B permit. However, this assessment has considered potential in-combination impacts associated with operation of the boiler and generators.

1.3.3 There are five generators used on site. Four of these have a rated thermal input that is greater than 1MW, two of which were installed in March 2021 and two installed in September 2018. They are therefore subject to regulation under the Medium Combustion

Plant Directive (MCPD)[1]. The operator has advised that these were all manufactured during 2012 or earlier. Provided these were all commissioned (brought into operation) at other sites prior to December 2018, they will be classed as 'existing' MCPD appliances and will not therefore be subject to MCPD controls until 2029. An additional generator is used, which is less than 1MW rated thermal input and therefore not subject to MCPD controls. A Specified Generator Permit is not required as it will be operated as part of a Schedule 1 installation following variation of the permit.

1.3.4 The operation of the generators and boiler has the potential to create airborne emissions and subsequent impacts upon the surrounding environment. Potential long-term and short-term air quality impacts associated with operation of the process have been quantified within this report through prediction of resulting ground level pollutant concentrations which have been compared to the relevant Air Quality Limit Values (AQLVs), Environmental Assessment Levels (EALs) and critical levels/loads.

1.4 Scope of Assessment

1.4.1 Monitoring has been undertaken for emissions of Nitrogen Oxides (NO_x), Sulphur Dioxide (SO_2), Total Volatile Organic Compounds (VOC) and Carbon Monoxide (CO) for the generators. The monitoring reports are contained within Appendix VI.

1.4.2 A H1 screening assessment has been undertaken based on the monitoring data. With the exception of NO_x, all other emissions screened out as insignificant from the generators and they have not therefore been considered further in this assessment. Therefore, this assessment has considered NO_x emissions only for the generators, which accords with the information requested in the Schedule 5 Notice. These have been considered in-combination with the biomass boiler.

[1] 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

1.4.3 Emissions of CO, particulate matter and Total VOC have been modelled for the biomass boiler to address information requested as part of a Schedule 5 Notice. It has been agreed with the EA that SO_2 emissions do not need to be considered for the biomass boiler, given the type of wood fuel that is used.

2 Air Quality Standards

2.1 Air Quality Limit Values and Objectives

2.1.1 Table 2.1 contains the AQLVs which are relevant to this assessment. These have been obtained from the Air Quality Standards Regulations 2010 and government permitting risk assessment website.

Table 2.1 - Air Quality Limit Values

Pollutant	Measured As	Purpose	Air Quality Limit Values/Objectives
Nitrogen dioxide (NO_2)	1-hour mean	Protection of human health	200µg.m^{-3} (not to be exceeded more than 18 times per calendar year)
	Annual mean	Protection of human health	40µg.m^{-3}
Particulate matter less than 10µm in aerodynamic diameter (PM_{10})	24-hour mean	Protection of human health	50µg.m^{-3} (not to be exceeded more than 35 times per calendar year)
	Annual mean	Protection of human health	40µg.m^{-3}
Particulate matter less than 2.5µm in aerodynamic diameter ($PM_{2.5}$)	Annual mean	Protection of human health	20µg.m^{-3}
Benzene	Annual mean	Protection of human health	5µg.m^{-3}
Carbon monoxide (CO)	Running 8-hour mean in each daily period	Protection of human health	10,000µg.m^{-3}

2.2 Environmental Assessment Levels

2.2.1 A list of short and long-term EALs relevant to this assessment are presented in the table below. These have been obtained from the permitting risk assessment guidance on the government website[2].

Table 2.2 - Environmental Assessment Levels

Substance	EALs	
	24-Hour Mean Limit (µg.m^{-3})	Hourly Mean Limit (µg.m^{-3})
CO	-	30,000
Benzene	30	-

2.3 Critical Levels for Protection of Vegetation and Ecosystems

2.3.1 The table below contains critical levels for the protection of vegetation at nature conservation sites which are relevant to this assessment.

Table 2.3 - Critical Levels for the Protection of Vegetation

Pollutant	Critical Levels	
	Concentration (µg.m^{-3})	Measured As
NO_x	30	Annual mean
	75	Daily mean

2.4 Critical Loads for Protection of Vegetation and Ecosystems

2.4.1 Critical loads are assigned for nitrogen and acid deposition at sensitive ecological sites, above which it is suggested harmful effects on vegetation may occur. In accordance with the relevant guidance, potential impacts have been considered at any Special Protection Areas (SPA), Special Areas of Conservation (SAC) and ramsar sites within 10km of the site and any Sites of Special Scientific Interest (SSSI), Local Wildlife Sites (LWS), ancient

[2] https://www.gov.uk/guidance/air-emissions-risk-assessment-for-your-environmental-permit

woodland areas and Local Nature Reserves (LNRs) within 2km of the site. Reference has been made to the APIS website to determine site specific critical loads. The tables below outline the relevant sites and critical loads, which have been considered within this assessment.

2.4.2 There are a number of local nature sites within 2km of the site. However, no site specific information is available on critical loads for such sites. Therefore, the tables below contain worst case critical loads which are precautionary, being the lowest critical loads assigned for any habitat on the APIS website.

Table 2.4 – Critical Loads for Nitrogen Deposition

Site	Worst Case Critical Load for Nitrogen Deposition (Kg $N.ha^{-1}.Year^{-1}$)
Risby Warren SSSI	5
Humber Estuary SAC/Ramsar	5
Humber Estuary SPA	5
Local Nature Sites within 2km	3

Table 2.5 – Critical Loads for Acid Deposition

Site	Worst Case Critical Load for Acid Deposition ($keq.ha^{-1}.Year^{-1}$)	
	MinCLMinN	MinCLMaxN
Risby Warren SSSI	Not sensitive	Not sensitive
Humber Estuary SAC/Ramsar	0.856	4.856
Humber Estuary SPA	0.856	4.856
Local Nature Sites within 2km	0.1	0.1

3 Baseline Position

3.1 Air Quality Across North Lincolnshire

3.1.1 North Lincolnshire Council (NLC) are required to undertake a review and assessment of air quality within their area of jurisdiction under Section 82 part IV of the Environment Act (1995). Local Authorities (LAs) are obligated to prepare an Annual Status Report (ASR) each year. For areas where AQLVs are not expected to be achieved, the LA will undertake further assessment. Subsequently, if AQLVs are not predicted to be met following detailed assessment, the LA must declare an Air Quality Management Area (AQMA).

3.1.2 There is one AQMA declared across the NLC area at present. This is declared for 24-hour mean PM_{10} concentrations, as follows:

- Scunthorpe AQMA – An area incorporating part of the town of Scunthorpe and an area to the east of Scunthorpe. Including the site of the steelworks.

3.1.3 The latest ASR produced by NLC is the 2023 ASR. This reported that no exceedences of the annual mean and hourly mean AQLV for NO_2 were recorded at any monitoring location within the NLC area during the most recent year of available data (2022). No exceedences of the annual mean AQLV for PM_{10} have been reported at any monitoring location within Scunthorpe in recent years. However, there have been some breaches of the 24-hour mean AQLV for PM_{10} at the Low Santon monitoring location in recent years.

3.2 Air Quality Monitoring Data

3.2.1 Continuous Monitoring

3.2.1.1 The Automatic Urban and Rural Network (AURN) is a network of air pollution monitoring stations across the UK, managed and co-ordinated by Bureau Veritas on behalf of DEFRA. The main purpose of the network is to enable the government to assess air quality at different locations to aid with the implementation of suitable policy measures for protection of human health.

3.2.1.2 The closest AURN monitoring station to the proposed site is Scunthorpe Town, which is an urban industrial monitoring location situated approximately 1.1km to the South of the site. Given the nature of this monitoring location and the distance from the site, it is considered that it potentially provides a suitable source of data for use in this assessment. NO_x, NO_2 and PM_{10} data from this site is presented in the tables below, which has been calculated from data downloaded from the DEFRA website.

Table 3.1 - Calculated Annual Mean NO_x Concentrations at Scunthorpe Town

Site	Site Type	Site NGR	Calculated Annual Mean NO_x Concentrations ($\mu g.m^{-3}$)							
			2015	2016	2017	2018	2019	2020	2021	2022
Scunthorpe Town	Urban industrial	490338, 410836	24.95	25.25	22.30	21.74	22.36	17.98	17.38	17.21

Table 3.2 - Calculated Annual Mean NO_2 Concentrations at Scunthorpe Town

Site	Site Type	Site NGR	Calculated Annual Mean NO_2 Concentrations ($\mu g.m^{-3}$)							
			2015	2016	2017	2018	2019	2020	2021	2022
Scunthorpe Town	Urban industrial	490338, 410836	17.58	16.72	15.64	15.39	15.39	13.35	13.44	13.24

Table 3.3 - Calculated Annual Mean PM_{10} Concentrations at Scunthorpe Town

Site	Site Type	Site NGR	Calculated Annual Mean PM_{10} Concentrations ($\mu g.m^{-3}$)							
			2015	2016	2017	2018	2019	2020	2021	2022
Scunthorpe Town	Urban industrial	490338, 410836	20.4	17.23	16.06	18.27	19.72	16.62	16.69	19.41

3.2.1.3 NLC also maintain continuous monitoring sites within their area of jurisdiction. Four of these are located within the Scunthorpe area. These include Low Santon, which is an urban industrial monitoring location approximately 2.5km to the East of the site, East Common Lane, which is an urban background monitoring location approximately 2.25km to the South-South-East of the site, Amvale, which is an industrial monitoring location situated approximately 3.5km to the South-South-East of the site and High Street East, which is an industrial monitoring location approximately 650m to the South of the site. Given the nature of these monitoring locations and the distance from the site, it is considered that they potentially provide a suitable source of data for use in this assessment. Available NO_x, NO_2,

PM_{10} and $PM_{2.5}$ data from these sites is presented in the tables below, which has been calculated from data downloaded from the North Lincolnshire Council Air Quality website[3] and obtained from data contained in NLC air quality progress reports.

Table 3.4 - Calculated Annual Mean NO_x Concentrations at Low Santon

Site	Site Type	Site NGR	Calculated Annual Mean NO_x Concentrations ($\mu g.m^{-3}$)							
			2015	2016	2017	2018	2019	2020	2021	2022
Low Santon	Urban industrial	492945, 411931	28	30.62	29.49	28.81	30.63	28.2	20.68	18.76

Table 3.5 - Calculated Annual Mean NO_2 Concentrations at Low Santon

Site	Site Type	Site NGR	Calculated Annual Mean NO_2 Concentrations ($\mu g.m^{-3}$)							
			2015	2016	2017	2018	2019	2020	2021	2022
Low Santon	Urban industrial	492945, 411931	18	19.32	18.46	19.84	19.25	19.76	13.49	12.63

Table 3.6 - Reported Annual Mean PM_{10} Concentrations at Monitoring Locations within Scunthorpe

Site	Site Type	Site NGR	Reported Annual Mean PM_{10} Concentrations ($\mu g.m^{-3}$)							
			2015	2016	2017	2018	2019	2020	2021	2022
Low Santon	Urban industrial	492945, 411931	27.8	26	30	31	29	29	27	31
East Common Lane	Urban background	490663, 409789	19.3	20	18	19	22	19	22	22
Amvale	Industrial	491343, 408782	18.6	17	16	20	21	22	21	20
High Street East	Industrial	490224, 411301	19.7	21	19	22	21	18	19	22

[3] https://www.nlincsair.info/

Table 3.7 - Reported Annual Mean $PM_{2.5}$ Concentrations at Monitoring Locations within Scunthorpe

Site	Site Type	Site NGR	Reported Annual Mean $PM_{2.5}$ Concentrations ($\mu g.m^{-3}$)							
			2015	2016	2017	2018	2019	2020	2021	2022
Low Santon	Urban industrial	492945, 411931	No data	No data	No data	No data	No data	No data	No data	13
East Common Lane	Urban background	490663, 409789	No data	7	6	10	7	7	6	8

3.2.2 Nitrogen Dioxide Diffusion Tube Monitoring

3.2.2.1 NO_2 diffusion tubes are deployed at numerous locations throughout the NLC area of jurisdiction. The table below presents data from urban background and industrial monitoring locations within Scunthorpe.

Table 3.8 - Reported Annual Mean NO_2 Concentrations at Diffusion Tube Monitoring Locations

Site	Site Type	Site NGR	Reported Annual Mean NO_2 Concentrations ($\mu g.m^{-3}$)							
			2015	2016	2017	2018	2019	2020	2021	2022
Frodingham Road	Urban Background	489099, 411723	24.5	25	21	19	21	23.8	24	28.4
Britannia Corner	Urban Background	489190, 411285	25.2	25	26	24	24	21.5	24.8	24
Oswald Road	Urban Background	489209, 411118	24.2	27	24	23	24	21.5	23.3	22.7
Rowland Road AQ Station	Industrial	490316, 410837	18.2	17	16	16	15	13.7	13.4	13.9
Rowland Road AQ Station	Industrial	490316, 410837	17	17	15	16	15	13.4	13.5	13.3
Rowland Road AQ Station	Industrial	490316, 410837	16.5	17	15	15	15	13.7	14.1	13.1

3.2.3 Non-Automatic Hydrocarbon Network

3.2.3.1 The Non-Automatic Hydrocarbon Network measures ambient benzene concentrations at various sites around the United Kingdom. Benzene is monitored at the Scunthorpe Town monitoring location. Data from the most recent 8 years of monitoring is presented in the table below, obtained from Local Authority progress reports.

Table 3.9 - Reported Annual Mean Benzene Concentrations at Scunthorpe Town

Site	Site Type	Site NGR	Reported Annual Mean Benzene Concentrations (µg.m^{-3})							
			2015	2016	2017	2018	2019	2020	2021	2022
Scunthorpe Town	Urban industrial	490338, 410836	1.12	1.02	0.77	0.87	1.11	0.87	0.72	0.79

3.3 Background Pollutant Mapping

3.3.1 The DEFRA website contains background pollutant mapping data for NO_x, NO_2, PM_{10}, $PM_{2.5}$, benzene and CO on a 1km by 1km grid square basis across the UK. This data is routinely used for assessing background pollutant concentrations where no suitably representative air pollution monitoring data exists. The archive is maintained by AEA on behalf of DEFRA. NO_x, NO_2, PM_{10}, and $PM_{2.5}$ data is available for each grid square for the years 2018 to 2030. Mapped background data for CO and benzene is only available for 2001 base year. Year adjustment factors on the DEFRA website have been used to calculate CO and benzene background concentrations for 2023 base year from 2001 background data.

3.3.2 The table below contains background pollutant concentrations for the grid square containing the site.

Table 3.10 - Background Pollutant Mapping Data for Grid Square 490500, 412500

Pollutant	2023 Annual Mean Concentration (µg.m^{-3}) within Grid Square Containing Site
NO_x	13.54
NO_2	10.23
PM_{10}	13.76
$PM_{2.5}$	8.16
CO	132.14
Benzene	0.24

3.4 Summary of Background Data Used in Assessment

3.4.1 The table below summarises the background data used within this assessment. The data used is precautionary, being based on highest reported annual mean pollutant concentrations for NO_x, NO_2, PM_{10}, $PM_{2.5}$ and benzene from monitoring data outlined and discussed in Section 3.2.

Table 3.11 - Summary of Background Data Used in Assessment

Pollutant	Annual Mean Background Concentration ($\mu g.m^{-3}$)	1-Hour Mean Background Concentration ($\mu g.m^{-3}$)[(a)]	8-Hour Mean Background Concentration ($\mu g.m^{-3}$)[(c)]	24-Hour Mean Background Concentration ($\mu g.m^{-3}$)[(b)]	Source of Annual Mean Background Data
NO_x	30.63	N/A	N/A	36.14	Highest reported annual mean NO_x concentration from most recent 8 years of available data monitored at Low Santon
NO_2	28.4	56.8	N/A	N/A	Highest reported annual mean NO_2 concentration from most recent 8 years of available data monitored at urban background/industrial monitoring locations within Scunthorpe
PM_{10}	31	N/A	N/A	36.58	Highest reported annual mean PM_{10} concentration from most recent 8 years of available data from Low Santon
$PM_{2.5}$	13	N/A	N/A	N/A	Highest reported annual mean $PM_{2.5}$ concentration from most recent 8 years of available data from Low Santon
CO	132.14	264.28	185	N/A	DEFRA Mapped Background Data
Benzene	1.12	N/A	N/A	1.32	Highest reported annual mean benzene concentration from most recent 8 years of available data from Scunthorpe Town AURN

N.B (a) 1-hour mean concentration assumed to be twice annual mean background concentration in accordance with relevant guidance
(b) 24-hour mean concentration provided by multiplying 1-hour mean concentration by factor of 0.59 in accordance with relevant guidance
(c) 8-hour mean concentration provided by multiplying 1-hour mean concentration by factor of 0.7 in accordance with relevant guidance

3.5 Sensitive Receptors

3.5.1 The table below outlines discrete receptors included within the assessment. This includes human receptors representative of worst case long term exposure. In addition, relevant ecological receptors have been identified. Local Wildlife Sites were identified from local planning policy maps contained on the NLC website.

3.5.2 In order to provide a precautionary assessment of potential short term impacts at human receptor locations, the maximum point of impact surrounding the plant has been used to assess worst case short term impacts.

3.5.3 Receptor locations are graphically represented in Appendix II.

Table 3.12 - Sensitive Receptors

Receptor Identifier	Receptor Description	National Grid Reference (m)	
		X	Y
R1	Residential property on Station Road	490075.3	411225.9
R2	Residential property on Lindum Street	489950	411239.9
R3	Residential property on Cole Street	489690.9	411272
R4	Residential property on King Street	489799.4	411711.2
R5	Scunthorpe Church of England Primary School	489473.8	411633.7
R6	Residential property on Normanby Road	489505.7	411830.5
R7	Residential property on Normanby Road	489485.6	411905.5
R8	Residential property on Normanby Road	489384.7	412021.7
R9	Residential property on Normanby Road	489379.2	412106.3
R10	School	489229	412269.6
R11	Residential property on Normanby Road	489271.3	412346.1
R12	Residential property on Normanby Road	489284.6	412480.4
R13	Residential property on Normanby Road	489281.9	412561.9
R14	Residential property on St Vincent's Avenue	489358.3	412947.9

Receptor Identifier	Receptor Description	National Grid Reference (m)	
		X	Y
R15	Residential property on St Vincent's Avenue	489398.1	413047.4
R16	Residential property on St Vincent's Avenue	489483.9	413065.6
R17	Humer Estuary Ramsar/SAC	486176.6	413453.8
R18	Humer Estuary SPA	487006.5	420948.2
R19	Risby Warren SSSI	491195.4	413526.5
R20	Risby Warren SSSI	492313.8	412707.7
R21	Sawcliffe LNR	490416.6	413097.6
R22	Sawcliffe LNR	490572.9	413033.2
R23	Atkinson's Warren LNR	488560.2	412681.4
R24	Frodingham LNR	488588.8	410715
R25	Conesby Quarry LNR	489601.2	414287.1
R26	Local Wildlife Site	490221.1	412696.1
R27	Local Wildlife Site	489901.6	412592.8
R28	Local Wildlife Site	490329.8	413157.4
R29	Local Wildlife Site	490459.9	413097.7
R30	Local Wildlife Site	490596.2	413037.4
R31	Local Wildlife Site	490909.6	414301
R32	Local Wildlife Site	490013.5	414025.9
R33	Local Wildlife Site	489439.3	414083.9
R34	Local Wildlife Site	488283.4	412736.1
R35	Local Wildlife Site	488600.3	410724
R36	Pig & Whistle Pub	489888	411698.1
R37	App Frod Fishing Angling Club	Various – adjacent to site, see receptors plan	
R38	Scunthorpe AQMA	Various - see receptors plan	

4 Modelling Methodology

4.1 Model Description

4.1.1 The potential air quality impacts associated with residual emissions arising from the process have been quantified using AERMOD, which is a steady state, next generation, dispersion model. AERMOD was developed jointly by the American Meteorological Society (AMS) and the United States (US) Environmental Protection Agency (EPA) Regulatory Model Improvement Committee. AERMOD is a development from the Industrial Source Complex (ISC) 3 dispersion model and incorporates improved dispersion algorithms and pre-processors to integrate the impact of meteorology and topography within the modelling output, and is approved for use in the UK by the EA. The version of AERMOD that has been used for this current assessment is Lakes Environmental ISC-AERMOD View Version 11.2.0. The model has been run using version 22112 of the model executable file. In order to improve model run times, Lakes Environmental have produced an equivalent source code to 22112, known as AERMOD parallel which enables the model to be run over multiple processors. The model was run using Lakes Environmental AERMOD MPI 22112.

4.2 Model Inputs

4.2.1 Emission Source Process Parameters

4.2.1.1 There are five generators used to provide power to the site at present. In addition, there is a biomass boiler used on site, which is currently regulated by the Local Authority in accordance with a Part B EP.

4.2.1.2 The tables below contain expected process parameters for the generators and biomass boiler.

4.2.1.3 Exhaust parameters for the biomass boiler are based on previous monitoring undertaken as part of permit compliance requirements. In order to provide a conservative assessment of potential impacts, emission rates for the biomass boiler were based on Emission Limit Values (ELVs) contained within the permit. Exhaust data from the most recent four rounds

of monitoring was used to calculate emission rates for NO_x,, particulate matter, CO and Total VOC. The table below presents the worst case emission rates and associated process parameters.

4.2.1.4 For the five generators considered as part of this assessment, there are currently no requirements for emissions monitoring nor limits in place in the existing permit. However, emissions monitoring was recently commissioned by the operator in order to inform this assessment. Reference should be made to Appendix VI for monitoring reports. One of the generators was offline at the time the monitoring was undertaken (asset P193) and was awaiting repair. Therefore it was not possible to undertake monitoring for all appliances. Assumptions have therefore been made for this generator, based on manufacturer data sheets and emissions data for other appliances. The assumed emission rate is considered conservative based on the monitoring data for other similar sized generators. It should also be noted than Asset P194 is used as a backup to Asset P193 and it has been assumed that both will operate simultaneously for 100% of the year. As such, the assessment is considered highly precautionary. The generators will only be subject to an emission limit for NO_x.

4.2.1.5 Stack diameter and height information was provided by the site operator.

4.2.1.6 Reference should be made to Appendix IV for a graphical representation of stack locations assigned in the model.

Table 4.1 - Expected Emission Source Process Parameters – Biomass Boiler Exhaust (Emission Point A1)

Process Parameter	Value
Stack NGR assigned in model (X,Y)	490308.21, 412186.68
Exhaust flue internal diameter (m)	0.34
Flue height (m)	10.98
Expected Exhaust efflux velocity ($m.s^{-1}$)	7.26
Expected Exhaust volumetric flowrate ($m^3.s^{-1}$)	0.659
Expected Exhaust volumetric flowrate, normalised to permit reference conditions, 11%O_2, 273.1K, 101.3Kpa ($Nm^3.s^{-1}$)	0.193
Expected stack efflux temperature (K)	333
Expected oxygen content of exhaust gas (v/v, %)	10.6

Process Parameter	Value
Expected absolute stack pressure (KPa)	100.3
NOx emission rate ($g.s^{-1}$)	0.223
Particulate matter emission rate ($g.s^{-1}$)	0.033
CO emission rate ($g.s^{-1}$)	0.139
Total VOC emission rate ($g.s^{-1}$)	0.011

Table 4.2 - Expected Emission Source Process Parameters – Generators

Process Parameter	Emission Point A2 – Asset P182	Emission Point A3 – Asset P183	Emission Point A4 – Asset P179	Emission Point A5 – Asset P194	Emission Point A6 – Asset P193
Stack NGR (X,Y)	490224.81, 412331.37	490229.25, 412329.65	490289.21, 412079.01	490095.37, 411986.79	490101.23, 411984.12
Exhaust internal diameter (m)	0.2	0.2	0.085	0.198	0.196
Flue height (m)	2.26	2.26	1.9	2.28	2.26
Expected Exhaust efflux velocity ($m.s^{-1}$)	17.83	20.05	17.62	25.98	52.04
Expected Exhaust volumetric flowrate ($m^3.s^{-1}$)	0.56	0.63	0.1	0.8	1.57
Expected stack efflux temperature (K)	766	793	455	461	731
Expected exhaust gas oxygen content, dry basis (vol/vol, %)	18.5	18.4	19.2	19	No data available
Expected exhaust gas moisture content (vol/vol, %)	2.3	5	6.4	6	No data available
NO_x Emission Rate ($g.s^{-1}$)	0.048	0.059	0.007	0.081	0.1 (assumed)

4.2.2 NOx to NO_2 Conversion

4.2.2.1 Nitric oxide (NO) and NO_2 are normally measured as oxides of NO_x, but when comparing against health based standards, NO_x is usually expressed as it's individual components. NO is oxidised to NO_2 in the presence of ozone. In order to provide a conservative estimate of resulting NO_2 concentrations, it has been assumed that 35% of modelled NO_x concentrations are present as NO_2 for short-term hourly-mean concentrations and 70% present as NO_2 for long term concentrations. This provides a worst case scenario, in accordance with the relevant guidance.

4.2.3 Particulate Matter

4.2.3.1 Total particulate matter emissions were assumed to comprise 80% PM_{10} and 40% $PM_{2.5}$, in accordance with government guidance on pollution inventory reporting for appliances combusting biomass.

4.2.4 Total VOC

4.2.4.1 Total VOC emissions were assumed to comprise 100% benzene, in accordance with the relevant guidance.

4.2.5 Building Downwash

4.2.5.1 Significant buildings and structures were digitised within the model based on site layout and elevation information provided by the site operator. As the closest buildings to the emission points, these would be expected to have an influence on pollutant dispersion. Table 4.3 contains information on buildings/structures included within the model. Reference should be made to Appendix IV for plans showing building/structure locations and orientation. The integrated Building Profile Input Programme (BPIP) module within AERMOD was used to assess the potential impact of building downwash upon predicted dispersion characteristics. Building downwash occurs when turbulence, induced by nearby structures, causes pollutants emitted from an elevated source to be displaced and dispersed rapidly towards the ground, resulting in elevated ground level concentrations. All buildings and structures were input into the BPIP processor.

Table 4.3 - Building Inputs

Structure	Length and Width (m)	Max Height (m)	Diameter, Circular Structures (m)
Structure A	58 x 38.1	11.5	N/A
Structure B	26 x 8.3	11.5	N/A
Structure C	2.3 x 5.9	2.26	N/A
Structure D	2.3 x 5.9	2.26	N/A

Structure	Length and Width (m)	Max Height (m)	Diameter, Circular Structures (m)
Structure E	61.2 x 30.6	12	N/A
Structure F	4.75 x 1.65	2.28	N/A
Structure G	4.75 x 1.65	2.28	N/A
Structure H	16.3 x 10.7	8.5	N/A
Structure I	16.3 x 10.7	8.5	N/A
Structure J	14.25 x 5.8	8.5	N/A
Structure K	5.7 x 4.05	8.5	N/A
Structure L	54.5 x 10.2	11.5	N/A
Structure M	30.1 x 12.31	5	N/A
Structure N	13.8 x 9.8	5	N/A
Structure O	1.7 x 3.2	1.6	N/A
Structure P	1.7 x 3.2	1.6	N/A
Structure Q	N/A	3.35	3
Structure R	2.2 x 2.2	1.66	N/A
Structure S	2.23 x 2.23	1.66	N/A
Structure T	2.1 x 2.65	1.28	N/A
Structure U	4.75 x 1.65	1.9	N/A

4.2.6 Meteorological Data

4.2.6.1 Meteorological data used in this assessment was from Robin Hood Airport. Robin Hood Airport meteorological station is located approximately 27km to the West-South-West of the proposed site and it is considered that it provides suitable data for use in this assessment. Previous guidance outlined met stations within 30km of a site to be potentially suitable to use in assessments.

4.2.6.2 Reference should be made to Appendix III for wind roses showing wind speed and direction frequency at Robin Hood Airport between 2011 and 2015.

4.2.6.3 Five years of sequential meteorological data observed between 2011 and 2015 was used within the assessment. The AERMET processor within AERMOD was used to process the data to be site specific. US EPA guidance on processing met data for use within AERMOD states that land use up to 1km upwind from a site should be considered when determining surface roughness characteristics, whilst for Bowen ratio and albedo, land use types within a 10km by 10km area centred over the site should be considered[4]. AERMOD guidance states that albedo and Bowen ratio should be calculated as the arithmetic and geometric mean respectively of land use types over the 10km by 10km grid, not weighted by direction or distance. The Land Use Creator and AERSURFACE tool within AERMET was used to calculate the appropriate land-use characteristics, which are contained in the following table.

Table 4.4 - Parameters for Surface Roughness, Albedo and Bowen Ratio

Directional Sector (degrees)	Albedo	Bowen Ratio	Surface Roughness
0-30	0.18	0.78	0.34
30-60	0.18	0.78	0.348
60-90	0.18	0.78	0.36
90-120	0.18	0.78	0.347
120-150	0.18	0.78	0.493
150-180	0.18	0.78	0.716
180-210	0.18	0.78	0.735
210-240	0.18	0.78	0.715
240-270	0.18	0.78	0.765
270-300	0.18	0.78	0.708
300-330	0.18	0.78	0.7
330-360	0.18	0.78	0.7

[4] AERMOD Implementation Guide, USEPA, August 2015.

4.2.7 Assessment Area

4.2.7.1 Two uniform cartesian receptors grids were used to define the modelling domain, the first extended over a 3,000m by 3,000m area with a spacing of 20m in X and Y direction, centred over the emission source locations, the second extended over a 20,000m by 20,000m area with spacing of 200m in X an Y direction. This ensured the maximum point of impact could be captured, to enable precautionary assessment of potential short term impacts. In addition, receptors R1 to R36, were included within the model as discrete cartesian receptors. Receptor R37 is an angling club, located adjacent to the boundary of the site. Given the proximity to the site and potential extent of this receptor, the maximum point of impact surrounding the plant was used as a basis for assessing potential impacts at this receptor, providing a precautionary assessment. For Receptor R38, which is an AQMA, discrete receptors were placed at a minimum spacing of 10m intervals along the boundary of the AQMA closest to the site, to ensure the maximum point of impact was captured. The receptor locations assigned for the AQMA are defined in the model input files which have been provided to the EA separately.

4.2.7.2 All human receptor heights were set to 1.5m above ground level, representative of typical breathing height. Receptor R4 is a multi storey apartment block 4 storeys high and there are also other high rise residential tower blocks adjacent to this receptor which are approximately 20 storeys high. Therefore, as a model sensitivity check, additional model runs were undertaken for receptor R4 based on receptor heights set at 3m, 5m, 10m, 20m, 30m, 40m, 50m and 60m at this location.

4.2.7.3 All ecological receptor heights were set to ground level (0.0m).

4.2.8 Terrain Data

4.2.8.1 The site and surrounding area is relatively flat. Assessment on Google Earth indicates that the gradient of the land between the site and receptors is generally less than 10%. As such, terrain data was not included in the model, in accordance with the relevant guidance[5].

4.2.9 Model Scenarios

4.2.9.1 The scenarios modelled are contained within Table 4.5.

4.2.9.2 A worst case assumption was made that the generators will operate 24 hours per day, 365 days per year. This will not be the case in reality. Data from the operator indicates that these are all operational for significantly less than 50% of the year. As such, potential long term impacts are likely to have been considerably overestimated in this assessment.

4.2.9.3 The short term AQLVs for NO_2 and PM_{10} permit a number of exceedances per year. As such, the model was used to calculate equivalent percentiles for short term concentrations for each assessment year, as described in the table.

Table 4.5 – Model Scenarios

Pollutant	Modelled Scenarios
NO_x	Annual mean, maximum 24-hour mean across five years of met data
NO_2	Annual mean, 99.8th percentile of 1-hour mean concentrations, each individual met data year
PM_{10}	Annual mean, 90.4th percentile of 24-hour mean concentrations, each individual met data year
$PM_{2.5}$	Annual mean
CO	1-hour mean, maximum rolling 8-hour mean, each individual met data year
Total VOC (as benzene)	Annual mean, maximum 24-hour mean across five years of met data

5 LAQM.TG(22), DEFRA, 2022.

4.3 Assessment of Potential Impacts

4.3.1 Methodology for Assessment of Potential Impacts at Human Receptors and European Ecological Sites

4.3.1.1 Assessment of potential impacts at human receptors and relevant European Ecological sites has been undertaken in accordance with permitting air emissions risk assessment guidance on the government website.[6]

4.3.1.2 The government guidance indicates that potential impacts from a process can be considered insignificant if the following screening criteria are met:

- The long term process contribution (PC) is <1% of the long term environmental standard; and/or,
- The short term PC is <10% of the short term environmental standard.

4.3.1.3 The guidance also indicates that more detailed assessment of emissions (modelling) for a process may be required if the following criteria are exceeded:

- The long term PC + background concentration is >70% of the long term environmental standard; and/or
- The short term process contribution is >20% (Short term environmental standard minus twice annual mean background concentration).

4.3.1.4 If any of the criteria above are met for both short and long term modelled concentrations, it can be concluded that potential impacts will be acceptable and there is no requirement for further assessment, in accordance with the relevant guidance. If the above criteria are exceeded, the Predicted Environmental Concentration (PEC), inclusive of background

[6] https://www.gov.uk/guidance/air-emissions-risk-assessment-for-your-environmental-permit.

concentrations, is then compared to the relevant environmental standard. If the modelling shows that the relevant standard will be met at receptor locations, confidence will be high that a breach of the standard will be unlikely, especially given the conservative assumptions which have been used in the assessment.

4.3.2 Methodology for Assessment of Potential Impacts at Local Nature Sites

4.3.2.1 In accordance with government permitting risk assessment guidance, potential impacts on any relevant local nature sites can be screened out as insignificant if the PC is <100% of the critical level/load for relevant pollutants.

4.3.3 Detailed Methodology for Assessment of Potential Impacts on Critical Loads for Acid Deposition at Ecological Receptors

4.3.3.1 The APIS website provides specific guidance for assessing potential impacts on critical loads for acid deposition as follows, which has been used for assessing potential impacts on critical loads for acid deposition associated with the proposed development:

"The potential impacts of additional sulphur and/or nitrogen deposition from a source are partly determined by PEC, because only if PEC of nitrogen deposition is greater than CLminN will the additional nitrogen deposition from the source contribute to acidity. Consequently, if PEC is less that CLminN only the acidifying affects of sulphur from the process need to be considered.

Where PEC N Deposition < CLminN

*PC as % CL function = (PC S deposition/CLmaxS)*100*

Where PEC is greater than CLminN (the majority of cases), the combined inputs of sulphur and nitrogen need to be considered. In such cases, the total acidity input should be calculated as a proportion of the CLmaxN.

Where PEC N Deposition > CLminN

*PC as %CL function = ((PC of S+N deposition)/CLmaxN)*100"*

4.3.3.2 Where the PC is <1% of the critical load function for acid deposition at relevant European and nationally designated sites (SSSIs), the impact can be concluded to be insignificant. Where the PC is <100% of the critical load function at any relevant local nature sites, the impact can be concluded to be insignificant.

4.4 Model Verification and Uncertainty

4.4.1 There can be a significant degree in uncertainty in predications made by any atmospheric dispersion model, which needs to be considered when assessing results. Such uncertainty can arise as a result of model limitations, uncertainty in input data, including emissions estimates, meteorological data used and background pollutant concentrations used in the assessment.

4.4.2 AERMOD is a commonly used model produced by the US EPA and is approved for use in the UK. The model is well validated and the US EPA present the results of the model validation exercises undertaken on their website. These verify the output of the model in comparison to observed data for a number of scenarios, to ensure predictions are as accurate as possible. The model input code is periodically updated by the US EPA to resolve bugs and errors and to improve the output to take account of latest knowledge.

4.4.3 In addition to the choice of model, the following methods have been used in the assessment to ensure that confidence can be high that potential impacts have not been underestimated:

- Worst case modelled concentrations across 5 years of meteorological data used in assessment;
- Where possible, estimation of existing background pollutant concentrations have been conservative;
- Worst case assumption made for NO_x to NO_2 conversion;
- Worst case assumption that Total VOC concentrations comprise 100% benzene; and,
- Worst case assumption that processes will operate 24 hours per day, 365 days per year with no shut downs.

5 Model Results

5.1 Modelled Pollutant Concentrations

5.1.1 The tables below contain the maximum modelled pollutant concentrations within the modelling domain and at sensitive receptor concentrations, with comparison to the relevant AQLVs and critical levels for and scenario. Maximum modelled concentrations from the five years of sequential data have been used to undertake assessment of potential impacts.

5.1.2 Reference should be made to Appendix V for pollutant contour profiles for NO_x, NO_2, PM_{10} and $PM_{2.5}$, based on worst case met year for each pollutant and scenario.

Table 5.1 – Modelled Annual Mean NO_2 Concentrations at Receptor Locations

Receptor	Modelled PC to Annual Mean NO_2 Concentrations ($\mu g.m^{-3}$)					Maximum PC to AQLV (%)	Maximum Predicted Environmental Concentration (PEC) ($\mu g.m^{-3}$)	Contribution of PEC to AQLV (%)
	2011	2012	2013	2014	2015			
R1	0.23702	0.30960	0.36207	0.38398	0.31726	0.96	28.78	71.96
R2	0.23261	0.28437	0.31710	0.34773	0.27384	0.87	28.75	71.87
R3	0.16759	0.20475	0.23724	0.29249	0.16565	0.73	28.69	71.73
R4	0.55008	0.53971	0.84808	0.79410	0.53796	2.12	29.25	73.12
R5	0.27311	0.19174	0.32087	0.29116	0.22713	0.80	28.72	71.80
R6	0.34744	0.24765	0.40940	0.39693	0.27308	1.02	28.81	72.02
R7	0.33275	0.26806	0.38541	0.37895	0.29527	0.96	28.79	71.96
R8	0.31175	0.26246	0.29599	0.34289	0.28032	0.86	28.74	71.86
R9	0.32883	0.26909	0.26755	0.29187	0.25388	0.82	28.73	71.82
R10	0.21597	0.21445	0.20087	0.19461	0.19172	0.54	28.62	71.54
R11	0.23492	0.24042	0.22954	0.19929	0.19058	0.60	28.64	71.60
R12	0.21675	0.22730	0.21168	0.18894	0.20325	0.57	28.63	71.57
R13	0.24514	0.23226	0.21519	0.18752	0.19719	0.61	28.65	71.61
R14	0.26720	0.27684	0.22678	0.22061	0.22001	0.69	28.68	71.69
R15	0.27164	0.27372	0.21044	0.24372	0.21776	0.68	28.67	71.68
R16	0.29284	0.28512	0.22776	0.25507	0.23411	0.73	28.69	71.73
R36	0.58909	0.69332	0.95100	0.99630	0.55520	2.49	29.40	73.49

Table 5.2 – Modelled 99.8th Percentile of 1-Hour Mean NO_2 Concentrations at Receptor Locations

Receptor	Modelled PC to 99.8th Percentile of 1-Hour Mean NO_2 Concentrations (µg.m^{-3})					Maximum PC to AQLV (%)	Maximum PEC (µg.m^{-3})	Contribution of PEC to AQLV (%)
	2011	2012	2013	2014	2015			
R1	11.56374	13.31378	17.28546	16.80081	16.58324	8.64	74.09	37.04
R2	11.14276	12.54614	14.02571	15.77134	15.72619	7.89	72.57	36.29
R3	5.91102	8.56567	8.38554	15.71549	5.38341	7.86	72.52	36.26
R4	23.59056	22.47967	24.06103	27.71888	26.93308	13.86	84.52	42.26
R5	14.45522	8.53980	12.42018	11.29745	12.04151	7.23	71.26	35.63
R6	15.21596	11.72662	10.68334	15.84683	13.32036	7.92	72.65	36.32
R7	13.39517	11.90543	9.11564	14.35569	14.72014	7.36	71.52	35.76
R8	12.73826	12.75509	10.62129	14.88111	13.51959	7.44	71.68	35.84
R9	14.98345	13.34611	8.40631	11.53916	11.48224	7.49	71.78	35.89
R10	7.60389	7.79308	6.56020	6.89074	6.65159	3.90	64.59	32.30
R11	7.41128	8.76758	8.21757	6.86127	7.17774	4.38	65.57	32.78
R12	5.93539	7.45303	6.48912	6.63149	7.37139	3.73	64.25	32.13
R13	6.92806	7.70709	6.49962	6.19055	6.46978	3.85	64.51	32.25
R14	6.92711	7.25613	7.05066	6.75468	7.00198	3.63	64.06	32.03
R15	6.92072	7.20307	6.11435	7.76787	6.31191	3.88	64.57	32.28
R16	7.02691	7.50240	7.12192	7.28230	7.17903	3.75	64.30	32.15
R36	26.50979	25.94979	31.58621	30.14885	27.46006	15.79	88.39	44.19
Maximum Point of Impact	84.01144	88.33432	83.04571	91.01097	88.62599	45.51	147.81	73.91

Table 5.3 – Modelled Annual Mean NO_x Concentrations at Receptor Locations

Receptor	Modelled PC to Annual Mean NO_x Concentrations ($\mu g.m^{-3}$)					Maximum PC to Critical Level (%)	Maximum PEC ($\mu g.m^{-3}$)	Contribution of PEC to Critical Level (%)
	2011	2012	2013	2014	2015			
R17	0.04945	0.04756	0.04219	0.03775	0.03574	0.16	30.68	102.26
R18	0.01837	0.01685	0.01546	0.01934	0.0184	0.06	30.65	102.16
R19	0.14911	0.15374	0.13998	0.17516	0.14687	0.58	30.81	102.68
R20	0.07818	0.09511	0.08168	0.10861	0.08923	0.36	30.74	102.46
R21	0.52086	0.68551	0.63692	0.5949	0.59362	2.29	31.32	104.39
R22	0.52611	0.54914	0.49708	0.61832	0.54694	2.06	31.25	104.16
R23	0.1482	0.13588	0.12877	0.11801	0.11088	0.49	30.78	102.59
R24	0.0889	0.0676	0.10158	0.1083	0.08926	0.36	30.74	102.46
R25	0.16416	0.16888	0.13315	0.15113	0.15388	0.56	30.80	102.66
R26	2.71215	3.12498	2.67299	2.5405	2.69943	10.42	33.75	112.52
R27	1.83587	1.67143	1.4397	1.5466	1.56304	6.12	32.47	108.22
R28	0.50967	0.6957	0.61699	0.55483	0.59233	2.32	31.33	104.42
R29	0.48767	0.63992	0.59716	0.57708	0.54931	2.13	31.27	104.23
R30	0.50443	0.51355	0.46905	0.59193	0.5261	1.97	31.22	104.07
R31	0.11157	0.13714	0.12523	0.1331	0.12212	0.46	30.77	102.56
R32	0.21244	0.2607	0.19216	0.17868	0.20378	0.87	30.89	102.97
R33	0.16781	0.16631	0.13911	0.15785	0.156	0.56	30.80	102.66
R34	0.12423	0.1116	0.10362	0.09725	0.09125	0.41	30.75	102.51
R35	0.08983	0.06832	0.10265	0.10949	0.09025	0.36	30.74	102.46

Table 5.4 – Maximum Modelled 24-Hour Mean NO_x Concentrations at Receptor Locations

Receptor	Maximum Modelled PC to 24-Hour Mean NO_x Concentrations ($\mu g.m^{-3}$)	Maximum PC to Critical Level (%)	Maximum PEC ($\mu g.m^{-3}$)	Contribution of PEC to Critical Level (%)
R17	1.91347	2.55	38.05	50.74
R18	0.38665	0.52	36.53	48.70
R19	2.72136	3.63	38.86	51.82
R20	2.0956	2.79	38.24	50.98
R21	14.72921	19.64	50.87	67.83
R22	10.76471	14.35	46.90	62.54
R23	3.97038	5.29	40.11	53.48
R24	2.47935	3.31	38.62	51.49
R25	2.66181	3.55	38.80	51.74
R26	35.8263	47.77	71.97	95.96
R27	17.90094	23.87	54.04	72.05
R28	14.69897	19.60	50.84	67.79
R29	13.97299	18.63	50.11	66.82
R30	10.05005	13.40	46.19	61.59
R31	3.09211	4.12	39.23	52.31
R32	3.22651	4.30	39.37	52.49
R33	2.91279	3.88	39.05	52.07
R34	3.48358	4.64	39.62	52.83
R35	2.50568	3.34	38.65	51.53

Table 5.5 – Model Sensitivity Analysis – Variable Receptor Heights at Receptor R4

R4 Receptor Height	Modelled PC to Annual Mean NO_2 Concentrations ($\mu g.m^{-3}$)					Maximum PC to AQLV (%)	Maximum PEC ($\mu g.m^{-3}$)	Contribution of PEC to AQLV (%)
	2011	2012	2013	2014	2015			
1.5m	0.55008	0.53971	0.84808	0.79410	0.53796	2.12	29.25	73.12
3m	0.53574	0.52570	0.83250	0.77853	0.52450	2.08	29.23	73.08
5m	0.52464	0.51478	0.81906	0.76680	0.51548	2.05	29.22	73.05
10m	0.49865	0.48555	0.78273	0.74226	0.49254	1.96	29.18	72.96
20m	0.47397	0.47541	0.72827	0.72195	0.50118	1.82	29.13	72.82
30m	0.33644	0.37604	0.55468	0.53371	0.35504	1.39	28.95	72.39
40m	0.23770	0.25569	0.39632	0.38022	0.25351	0.99	28.80	71.99
50m	0.16440	0.17852	0.27262	0.26752	0.18017	0.68	28.67	71.68
60m	0.10872	0.12176	0.17996	0.18135	0.12288	0.45	28.58	71.45

Table 5.6 – Modelled Annual Mean PM_{10} Concentrations at Receptor Locations

Receptor	Modelled PC to Annual Mean PM_{10} Concentrations ($\mu g.m^{-3}$)					Maximum PC to AQLV (%)	Maximum PEC ($\mu g.m^{-3}$)	Contribution of PEC to AQLV (%)
	2011	2012	2013	2014	2015			
R1	0.01132	0.01298	0.01495	0.01582	0.01193	0.04	31.02	77.54
R2	0.00991	0.01114	0.01349	0.01523	0.00991	0.04	31.02	77.54
R3	0.00817	0.00921	0.01213	0.01410	0.00718	0.04	31.01	77.54
R4	0.01584	0.01422	0.02363	0.02216	0.01355	0.06	31.02	77.56
R5	0.01138	0.00798	0.01510	0.01191	0.00826	0.04	31.02	77.54
R6	0.01219	0.00903	0.01646	0.01546	0.00848	0.04	31.02	77.54
R7	0.01271	0.00929	0.01638	0.01624	0.00919	0.04	31.02	77.54
R8	0.01238	0.00984	0.01446	0.01362	0.01004	0.04	31.01	77.54
R9	0.01248	0.01095	0.01474	0.01329	0.01129	0.04	31.01	77.54
R10	0.01219	0.01059	0.01057	0.01078	0.01015	0.03	31.01	77.53
R11	0.01326	0.01111	0.01044	0.01070	0.00989	0.03	31.01	77.53
R12	0.01439	0.01154	0.01205	0.01088	0.00985	0.04	31.01	77.54
R13	0.01501	0.01237	0.01298	0.01090	0.01018	0.04	31.02	77.54
R14	0.01839	0.01806	0.01515	0.01414	0.01554	0.05	31.02	77.55
R15	0.01978	0.01877	0.01518	0.01526	0.01551	0.05	31.02	77.55
R16	0.02154	0.02038	0.01622	0.01740	0.01608	0.05	31.02	77.55
R36	0.01624	0.01687	0.02502	0.02562	0.01411	0.06	31.03	77.56

Table 5.7 – Modelled 90.4th Percentile of 24-Hour Mean PM_{10} Concentrations at Receptor Locations

Receptor	Modelled PC to 99.8th Percentile of 1-Hour Mean NO_2 Concentrations (µg.m^{-3})					Maximum PC to AQLV (%)	Maximum PEC (µg.m^{-3})	Contribution of PEC to AQLV (%)
	2011	2012	2013	2014	2015			
R1	0.03087	0.03214	0.04692	0.04729	0.03432	0.09	36.63	73.25
R2	0.02896	0.03094	0.03970	0.04791	0.02680	0.10	36.63	73.26
R3	0.02408	0.02440	0.03093	0.04794	0.01707	0.10	36.63	73.26
R4	0.04716	0.03955	0.08626	0.06374	0.02980	0.17	36.67	73.33
R5	0.02361	0.01666	0.05733	0.03270	0.01921	0.11	36.64	73.27
R6	0.02383	0.02053	0.06071	0.04574	0.01441	0.12	36.64	73.28
R7	0.03036	0.02158	0.05390	0.03878	0.01929	0.11	36.63	73.27
R8	0.02610	0.02846	0.04910	0.03894	0.02111	0.10	36.63	73.26
R9	0.02618	0.03354	0.05151	0.04178	0.02728	0.10	36.63	73.26
R10	0.03615	0.02836	0.03132	0.03534	0.02833	0.07	36.62	73.23
R11	0.04328	0.02920	0.03202	0.03151	0.02969	0.09	36.62	73.25
R12	0.05067	0.02950	0.04044	0.02766	0.02866	0.10	36.63	73.26
R13	0.04502	0.03786	0.03890	0.02719	0.02890	0.09	36.63	73.25
R14	0.06961	0.06267	0.04589	0.03936	0.04964	0.14	36.65	73.30
R15	0.07192	0.06342	0.04786	0.03998	0.04964	0.14	36.65	73.30
R16	0.07791	0.07058	0.05187	0.04892	0.05157	0.16	36.66	73.32
R36	0.05151	0.03996	0.08135	0.07819	0.02811	0.16	36.66	73.32
R38	0.07204	0.07806	0.08232	0.09328	0.09711	0.19	36.68	73.35
Maximum Point of Impact	6.60160	7.07554	7.21273	6.99538	6.06164	14.43	43.79	87.59

Table 5.8 – Modelled Annual Mean $PM_{2.5}$ Concentrations at Receptor Locations

Receptor	Modelled PC to Annual Mean $PM_{2.5}$ Concentrations ($\mu g.m^{-3}$)					Maximum PC to AQLV (%)	Maximum PEC ($\mu g.m^{-3}$)	Contribution of PEC to AQLV (%)
	2011	2012	2013	2014	2015			
R1	0.00566	0.00649	0.00748	0.00791	0.00596	0.04	13.01	65.04
R2	0.00496	0.00557	0.00674	0.00762	0.00496	0.04	13.01	65.04
R3	0.00408	0.00460	0.00606	0.00705	0.00359	0.04	13.01	65.04
R4	0.00792	0.00711	0.01182	0.01108	0.00678	0.06	13.01	65.06
R5	0.00569	0.00399	0.00755	0.00596	0.00413	0.04	13.01	65.04
R6	0.00610	0.00452	0.00823	0.00773	0.00424	0.04	13.01	65.04
R7	0.00636	0.00464	0.00819	0.00812	0.00460	0.04	13.01	65.04
R8	0.00619	0.00492	0.00723	0.00681	0.00502	0.04	13.01	65.04
R9	0.00624	0.00548	0.00737	0.00664	0.00564	0.04	13.01	65.04
R10	0.00610	0.00530	0.00528	0.00539	0.00508	0.03	13.01	65.03
R11	0.00663	0.00556	0.00522	0.00535	0.00494	0.03	13.01	65.03
R12	0.00720	0.00577	0.00602	0.00544	0.00492	0.04	13.01	65.04
R13	0.00750	0.00618	0.00649	0.00545	0.00509	0.04	13.01	65.04
R14	0.00920	0.00903	0.00758	0.00707	0.00777	0.05	13.01	65.05
R15	0.00989	0.00938	0.00759	0.00763	0.00776	0.05	13.01	65.05
R16	0.01077	0.01019	0.00811	0.00870	0.00804	0.05	13.01	65.05
R36	0.00812	0.00844	0.01251	0.01281	0.00706	0.06	13.01	65.06

Table 5.9 – Modelled 8-Hour Rolling Maximum CO Concentrations at Receptor Locations

Receptor	Modelled PC to Rolling 8-Hour Mean Concentrations (µg.m^{-3})					Maximum PC to AQLV (%)	Maximum PEC (µg.m^{-3})	Contribution of PEC to AQLV (%)
	2011	2012	2013	2014	2015			
R1	4.11262	3.63735	3.67546	3.65171	4.67638	0.05	189.68	1.90
R2	2.38573	2.36762	2.67667	3.25049	2.41623	0.03	188.25	1.88
R3	2.55385	5.76018	2.88534	2.85321	2.89439	0.06	190.76	1.91
R4	3.11659	3.97043	3.82068	7.17486	3.36174	0.07	192.17	1.92
R5	4.27188	2.85268	3.6813	2.60271	2.27647	0.04	189.27	1.89
R6	3.79696	3.0545	5.82103	4.23829	5.09652	0.06	190.82	1.91
R7	4.47868	2.52139	7.32733	4.42305	5.45538	0.07	192.33	1.92
R8	4.6357	2.32778	4.58984	3.29227	3.49733	0.05	189.64	1.90
R9	4.00176	3.71513	4.54698	3.39408	3.35588	0.05	189.55	1.90
R10	3.2245	2.42698	3.06576	4.57219	3.80609	0.05	189.57	1.90
R11	3.24621	3.61919	2.55999	2.95729	3.24791	0.04	188.62	1.89
R12	3.76163	2.89982	2.82799	3.26475	2.97351	0.04	188.76	1.89
R13	4.12203	4.2095	3.03232	3.22805	2.45128	0.04	189.21	1.89
R14	3.5838	4.83503	3.91257	4.97301	2.71258	0.05	189.97	1.90
R15	3.33337	4.46273	3.66106	6.00222	2.9104	0.06	191.00	1.91
R16	4.19781	5.00997	3.33711	6.39988	2.97448	0.06	191.40	1.91
R36	3.55867	6.61543	3.82059	6.16666	4.15754	0.07	191.62	1.92
Maximum Point of Impact	87.46114	91.59007	81.08739	97.67700	81.18768	0.98	283.68	2.84

Table 5.10 – Maximum Modelled 1-Hour Mean CO Concentrations at Receptor Locations

Receptor	Maximum Modelled PC to 1-Hour Mean CO Concentrations (µg.m^{-3})	Maximum PC to AQLV (%)	Maximum PEC (µg.m^{-3})	Contribution of PEC to AQLV (%)
R1	11.58565	0.04	275.87	0.92
R2	11.13793	0.04	275.42	0.92
R3	11.04892	0.04	275.33	0.92
R4	12.27904	0.04	276.56	0.92
R5	12.1482	0.04	276.43	0.92
R6	12.52316	0.04	276.80	0.92
R7	12.38585	0.04	276.67	0.92
R8	11.64622	0.04	275.93	0.92
R9	11.82461	0.04	276.10	0.92
R10	11.06605	0.04	275.35	0.92
R11	11.69976	0.04	275.98	0.92
R12	11.35229	0.04	275.63	0.92
R13	11.29182	0.04	275.57	0.92
R14	11.11188	0.04	275.39	0.92
R15	10.55483	0.04	274.83	0.92
R16	10.66678	0.04	274.95	0.92
R36	12.61167	0.04	276.89	0.92
Maximum Point of Impact	136.50029	0.46	400.78	1.34

Table 5.11 – Modelled Annual Mean Benzene Concentrations at Receptor Locations

Receptor	Modelled PC to Annual Mean Benzene Concentrations (µg.m^{-3})					Maximum PC to AQLV (%)	Maximum PEC (µg.m^{-3})	Contribution of PEC to AQLV (%)
	2011	2012	2013	2014	2015			
R1	0.00472	0.00541	0.00623	0.00659	0.00497	0.13	1.13	22.53
R2	0.00413	0.00464	0.00562	0.00635	0.00413	0.13	1.13	22.53
R3	0.0034	0.00384	0.00505	0.00588	0.00299	0.12	1.13	22.52
R4	0.0066	0.00593	0.00985	0.00923	0.00565	0.20	1.13	22.60
R5	0.00474	0.00332	0.00629	0.00496	0.00344	0.13	1.13	22.53
R6	0.00508	0.00376	0.00686	0.00644	0.00353	0.14	1.13	22.54
R7	0.0053	0.00387	0.00683	0.00677	0.00383	0.14	1.13	22.54
R8	0.00516	0.0041	0.00602	0.00567	0.00418	0.12	1.13	22.52
R9	0.0052	0.00456	0.00614	0.00554	0.0047	0.12	1.13	22.52
R10	0.00508	0.00441	0.0044	0.00449	0.00423	0.10	1.13	22.50
R11	0.00552	0.00463	0.00435	0.00446	0.00412	0.11	1.13	22.51
R12	0.006	0.00481	0.00502	0.00453	0.0041	0.12	1.13	22.52
R13	0.00625	0.00515	0.00541	0.00454	0.00424	0.13	1.13	22.53
R14	0.00766	0.00753	0.00631	0.00589	0.00647	0.15	1.13	22.55
R15	0.00824	0.00782	0.00632	0.00636	0.00646	0.16	1.13	22.56
R16	0.00898	0.00849	0.00676	0.00725	0.0067	0.18	1.13	22.58
R36	0.00677	0.00703	0.01043	0.01067	0.00588	0.21	1.13	22.61

Table 5.12 – Maximum Modelled 24-Hour Mean Benzene Concentrations at Receptor Locations

Receptor	Maximum Modelled PC to 24-Hour Mean Benzene Concentrations (µg.m^{-3})	Maximum PC to AQLV (%)	Maximum PEC (µg.m^{-3})	Contribution of PEC to AQLV (%)
R1	0.17715	0.59	1.50	4.99
R2	0.10937	0.36	1.43	4.76
R3	0.10233	0.34	1.42	4.74
R4	0.23572	0.79	1.56	5.19
R5	0.16374	0.55	1.48	4.95
R6	0.14823	0.49	1.47	4.89
R7	0.14643	0.49	1.47	4.89
R8	0.12307	0.41	1.44	4.81
R9	0.10652	0.36	1.43	4.76
R10	0.12342	0.41	1.44	4.81
R11	0.1102	0.37	1.43	4.77
R12	0.12005	0.40	1.44	4.80
R13	0.17444	0.58	1.49	4.98
R14	0.15131	0.50	1.47	4.90
R15	0.17446	0.58	1.49	4.98
R16	0.17845	0.59	1.50	4.99
R36	0.24429	0.81	1.56	5.21
Maximum Point of Impact	5.57810	18.59	6.90	22.99

5.2 Assessment of Potential Impacts at Relevant Human Receptor Locations

5.2.1 Nitrogen Dioxide

5.2.1.1 No exceedence of the annual mean AQLV for NO_2 is predicted at any relevant location surrounding the site (receptors R1 to R16 and R36), the PEC being significantly below the AQLV at these locations. As such, long term impacts are predicted to be insignificant at relevant receptor locations. This is likely to be a considerable overestimation of potential impacts since the results have not been factored to take account of the reduced operating hours of the generators each year.

5.2.1.2 No exceedence of the short term AQLV for NO_2 is predicted at any location surrounding the plant, the PEC being 73.91% of the AQLV at the maximum point of impact. As such, no significant impacts are predicted, including at the adjacent angling club (R37).

5.2.1.3 As is shown by the sensitivity analysis in Table 5.5 for receptor R4, a receptor height of 1.5m results in a more conservative assessment of potential impacts compared to more elevated heights considered. It is therefore demonstrated that the assessment of impacts is suitably precautionary for more elevated receptor locations at, and adjacent to receptor R4, including the high rise residential apartments.

5.2.2 Particulate Matter

5.2.2.1 No significant impacts on the annual mean AQLVs for PM_{10} and $PM_{2.5}$ are predicted at receptors R1 to R16 and R36, the PC modelled to be less than 1% of the AQLV in each case. Furthermore, no exceedence of the annual mean AQLV is predicted for either PM_{10} or $PM_{2.5}$. As such, no significant impacts are predicted at these locations.

5.2.2.2 The modelled PC is less than 10% of the 24-hour mean AQLV at receptors R1 to R16, R36 and R38 and no exceedence of the short term AQLV is predicted at these locations. Although the modelled PC exceeds 10% of the 24-hour mean AQLV for PM_{10} at the maximum point of impact, no exceedence of the AQLV is predicted. As such, no significant impact is predicted

at any short term receptor location, including the adjacent angling club (R37) and the AQMA (R38).

5.2.3 Total Volatile Organic Compounds (As Benzene)

5.2.3.1 The modelled PC is less than 1% of the annual mean AQLV for benzene at all relevant receptor locations (R1 to R16 and R36) and no exceedence of the AQLV is predicted at these locations. Although the modelled PC exceeds 10% of the 24-hour mean EAL for benzene at the maximum point of impact, the PEC is significantly below the EAL at all locations surrounding the plant. As such, no significant impacts are predicted on the 24-hour mean EAL for benzene at any relevant receptor location, including the adjacent angling club (R37).

5.2.4 Carbon Monoxide

5.2.4.1 The modelled PC is less than 10% of the 1-hour mean EAL and 8-hour mean AQLV for CO at all locations surrounding the plant and no exceedence of the EAL/AQLV is predicted. As such, no significant impacts are predicted.

5.3 Assessment of Potential Impacts at Sensitive Ecological Receptors

5.3.1 Critical Levels

5.3.1.1 The modelled PC is substantially less than 100% of the critical level for annual mean and 24-hour mean NO_x concentrations at receptors R21 to R35. As such, potential impacts on local nature sites are predicted to be insignificant, in accordance with the relevant guidance.

5.3.1.2 At receptors R17 to R20, the modelled PC to annual mean NO_x concentrations is less than 1% of the critical level and the modelled PC to 24-hour mean NO_x concentrations is less than 10% of the critical level. As such, impacts are not predicted to be significant at Risley Warren SSSI or Humber Estuary SAC/SPA/Ramsar, in accordance with the relevant guidance.

5.3.2 Nitrogen Deposition

5.3.2.1 The maximum PC to nitrogen deposition has been calculated from the predicted annual mean NO_x concentrations, in accordance with the relevant guidance. Nitrogen deposition arising as a result of resulting annual mean NO_x concentrations has been calculated using the following formula:

$$F = \left(\frac{Vd \times C \times 10000}{1000000000}\right) \times 0.3 \times 31536000$$

Where: F = deposition flux (Kg N $ha^{-1}Year^{-1}$)

V_d = nitrogen dry deposition velocity, assumed to be 0.003m.s^{-1} (worst case assuming all vegetation is tall vegetation, such as woodland).

C = predicted annual mean NO_x concentration (µg.m^{-3})

10000 = conversion from m^2 to hectares (ha)

1000000000 = conversion from µg to Kg

0.30 = proportion of NO_2 that is nitrogen

31536000 = conversion from seconds to year

5.3.2.2 Calculated annual nitrogen deposition at relevant receptors is presented in the table below. As the PC is predicted to be <100% of the worst case critical load at local nature sites (R21 to R35) and <1% of worst case critical load at relevant statutory ecological receptors (R17 to R20), impacts are predicted to be insignificant at all relevant ecological receptors.

Table 5.13 - Calculated Annual Nitrogen Deposition at Ecological Receptors

Receptor	Maximum Modelled Annual Mean NO_x Concentration (µg.m^{-3})	Calculated PC to Annual Nitrogen Deposition (Kg N.ha^{-1}.$Year^{-1}$) Based on Modelled Annual Mean NO_x Concentration	Percentage Contribution to Worst Case Critical Load for Annual Nitrogen Deposition (%)
R17	0.04945	0.01404	0.28
R18	0.01934	0.00549	0.11
R19	0.17516	0.04971	0.99
R20	0.10861	0.03083	0.62

Receptor	Maximum Modelled Annual Mean NO_x Concentration ($\mu g.m^{-3}$)	Calculated PC to Annual Nitrogen Deposition (Kg $N.ha^{-1}.Year^{-1}$) Based on Modelled Annual Mean NO_x Concentration	Percentage Contribution to Worst Case Critical Load for Annual Nitrogen Deposition (%)
R21	0.68551	0.19456	6.49
R22	0.61832	0.17549	5.85
R23	0.1482	0.04206	1.40
R24	0.1083	0.03074	1.02
R25	0.16888	0.04793	1.60
R26	3.12498	0.88694	29.56
R27	1.83587	0.52106	17.37
R28	0.6957	0.19746	6.58
R29	0.63992	0.18162	6.05
R30	0.59193	0.16800	5.60
R31	0.13714	0.03892	1.30
R32	0.2607	0.07399	2.47
R33	0.16781	0.04763	1.59
R34	0.12423	0.03526	1.18
R35	0.10949	0.03108	1.04

5.3.3 Acid Deposition

5.3.3.1 The potential PC to acid deposition across relevant ecological sites can be calculated by converting nitrogen deposition predictions to kiloequivalents ($keq.ha^{-1}.Year^{-1}$) using the following assumption, obtained from the APIS website:

- 1 keq N $ha^{-1}.Year^{-1}$ is equal to 14kg N $ha^{-1}.Year^{-1}$.

5.3.3.2 Based upon the above, the following table summarises annual nitrogen deposition and calculated acid deposition due to nitrogen. As is shown, the PC to acid deposition is predicted to be less than 100% of the worst case critical loads at all local nature sites (R21 to R35) and less than 1% of the worst case critical load at relevant statutory ecological

receptors (R17 and R18). As such, potential impacts are predicted to be insignificant, in accordance with the relevant guidance.

Table 5.14 - Calculated Acid Deposition at Ecological Receptors

Receptor	Calculated PC to Annual Acid Deposition (Keq $N.ha^{-1}.Year^{-1}$)	Percentage Contribution to CLMaxN (%)
R17	0.001002507	0.02
R18	0.000392083	0.01
R21	0.013897442	13.90
R22	0.01253529	12.54
R23	0.00300448	3.00
R24	0.002195581	2.20
R25	0.003423728	3.42
R26	0.063353166	63.35
R27	0.037218855	37.22
R28	0.014104025	14.10
R29	0.01297319	12.97
R30	0.012000281	12.00
R31	0.002780259	2.78
R32	0.005285208	5.29
R33	0.003402036	3.40
R34	0.002518533	2.52
R35	0.002219706	2.22

6 Conclusions

6.1 An assessment of potential air quality impacts has been undertaken in support of an application to vary the existing EP at Ellgia Limited, Winterton Road, Scunthorpe. Assessment has been undertaken using AERMOD to quantify potential resulting long and short-term pollutant concentrations at surrounding receptor locations as a result of operation of the generators and biomass boiler that are operated at the site. A series of conservative assumptions have been used within the assessment, resulting in a precautionary assessment.

6.2 Modelling of potential NO_x, NO_2, PM_{10}, $PM_{2.5}$, Total VOC and CO emissions was undertaken and results compared with the relevant AQLVs, EALs, critical levels and loads and an assessment undertaken in accordance with permitting risk assessment guidance.

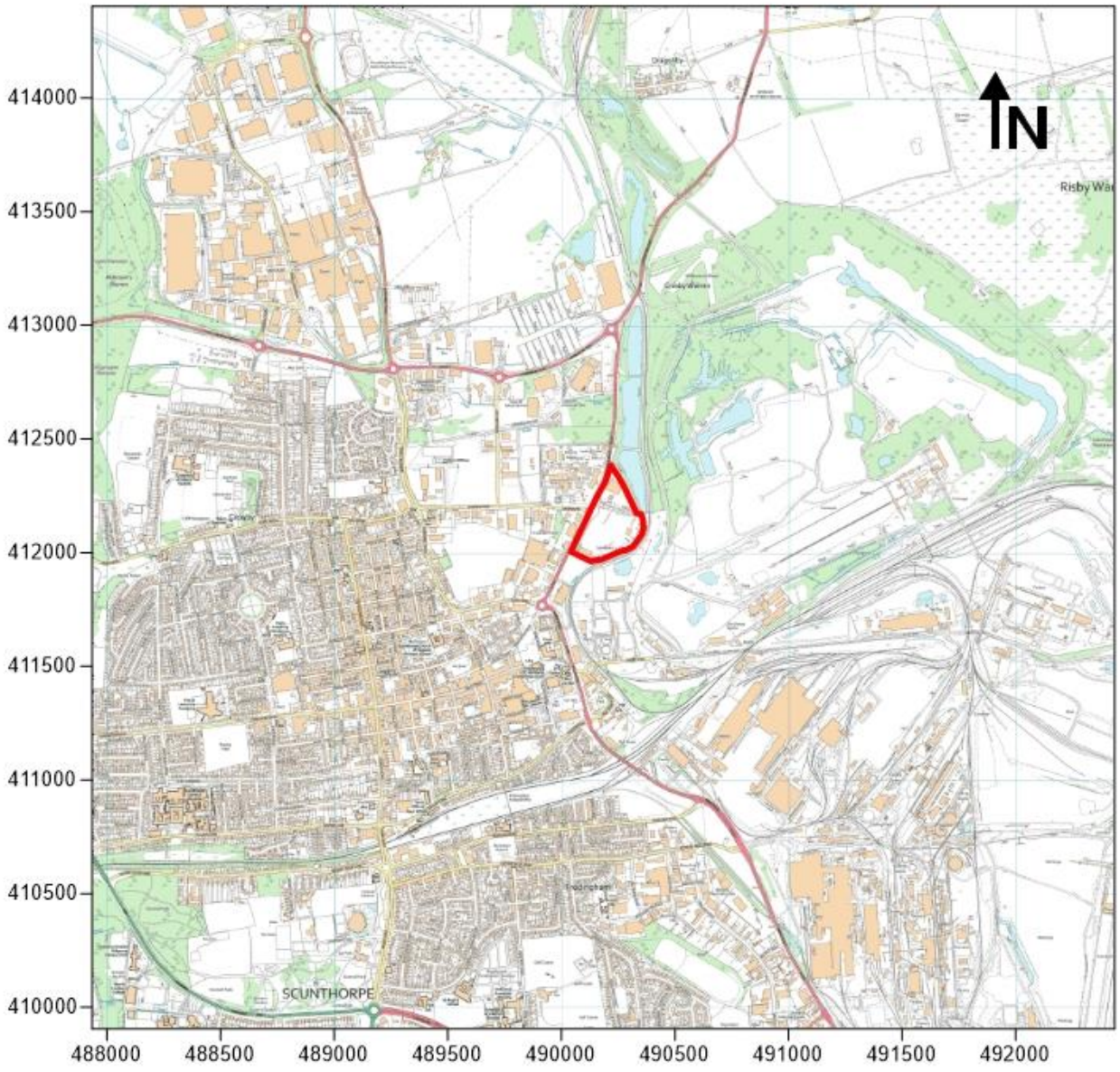
6.3 Potential impacts at human receptor locations have been assessed as 'not significant' with no exceedence of AQLVS or EALs predicted at any relevant receptor locations.

6.4 Potential impacts at ecological receptor locations have also been assessed as not significant in accordance with the relevant guidance, since the predicted PC to critical levels and loads for annual nitrogen and acid deposition has been modelled to be less than 1% at national and European designated sites and less than 100% at relevant local nature sites.

6.5 Confidence in these predictions is high, given the conservative assumptions made within the assessment.

Appendix I

Site Location Plan



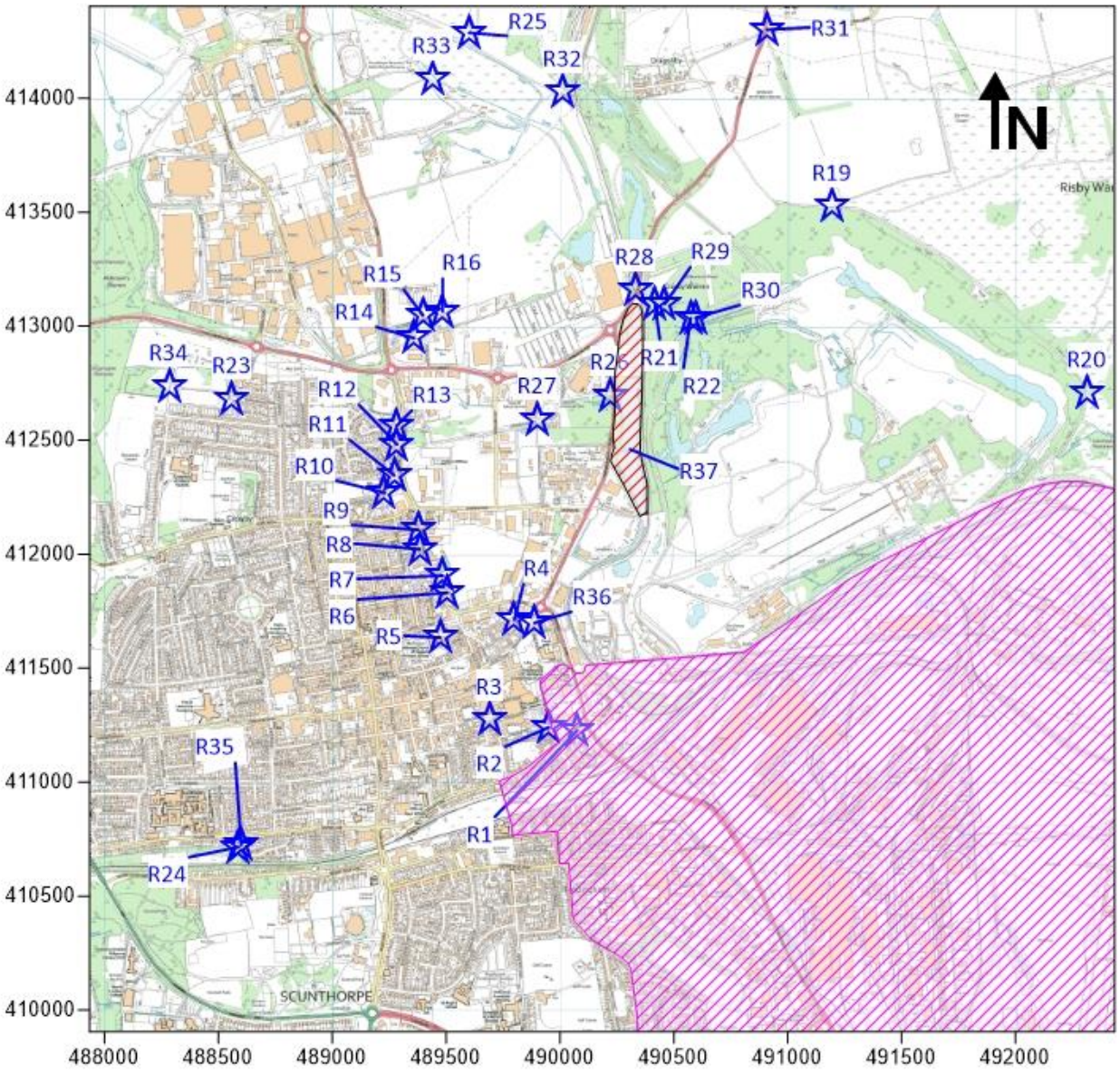
Appendix I Figure 1 - Site Location

Site Location

Oaktree Environmental Ltd
Lime House
2 Road Two
Winsford
Cheshire
CW7 3QZ

Appendix II

Sensitive Receptor Locations



Appendix II Figure 1 - Sensitive Receptors

Receptor Location

R1 Receptor Identifier

Scunthorpe AQMA

Oaktree Environmental Ltd
Lime House
2 Road Two
Winsford
Cheshire
CW7 3QZ

Appendix III

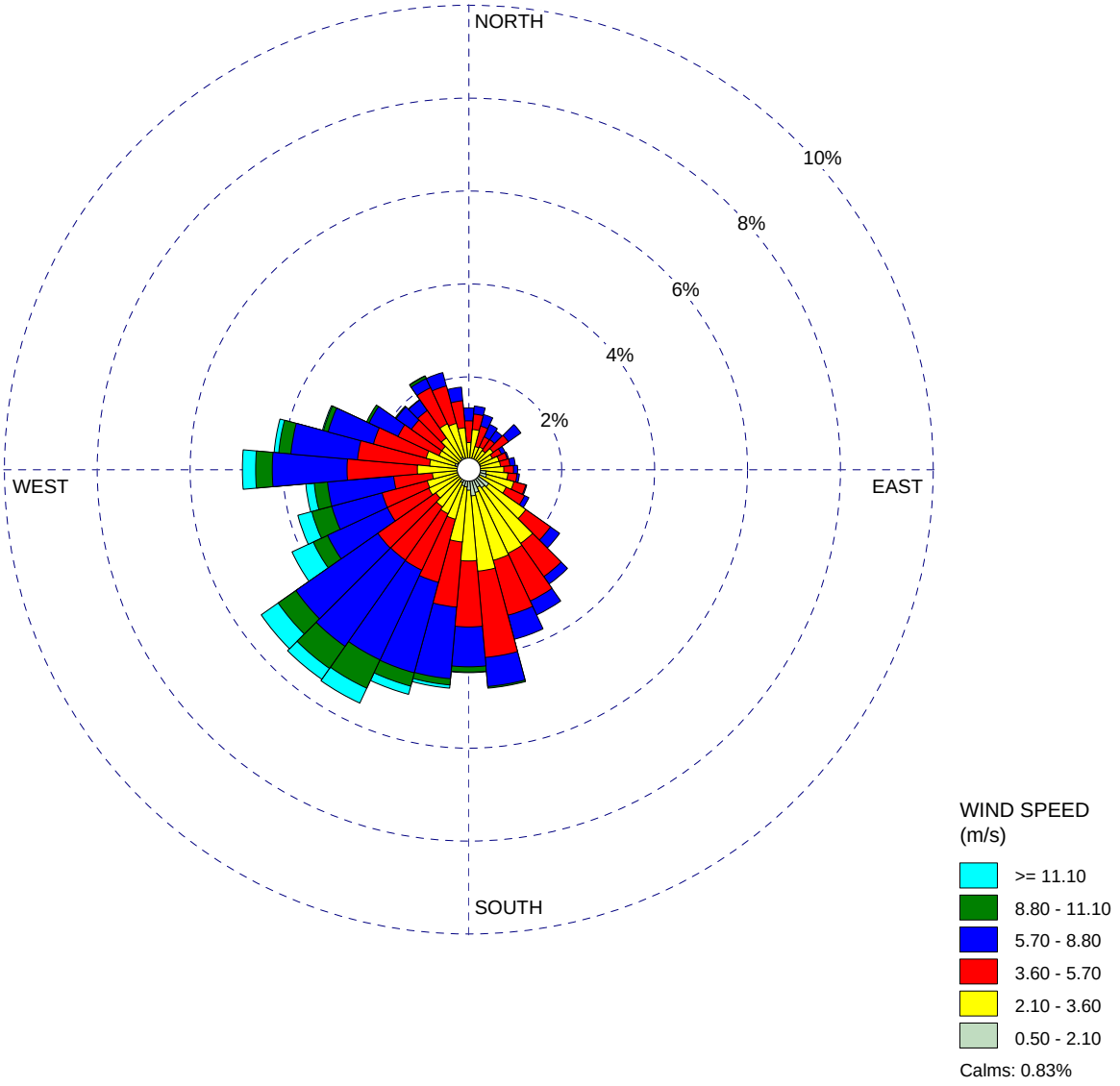
Wind Roses for Robin Hood Airport

WIND ROSE PLOT:

Robin Hood Airport - Wind Speed and Direction Frequency

DISPLAY:

Wind Speed
Direction (blowing from)



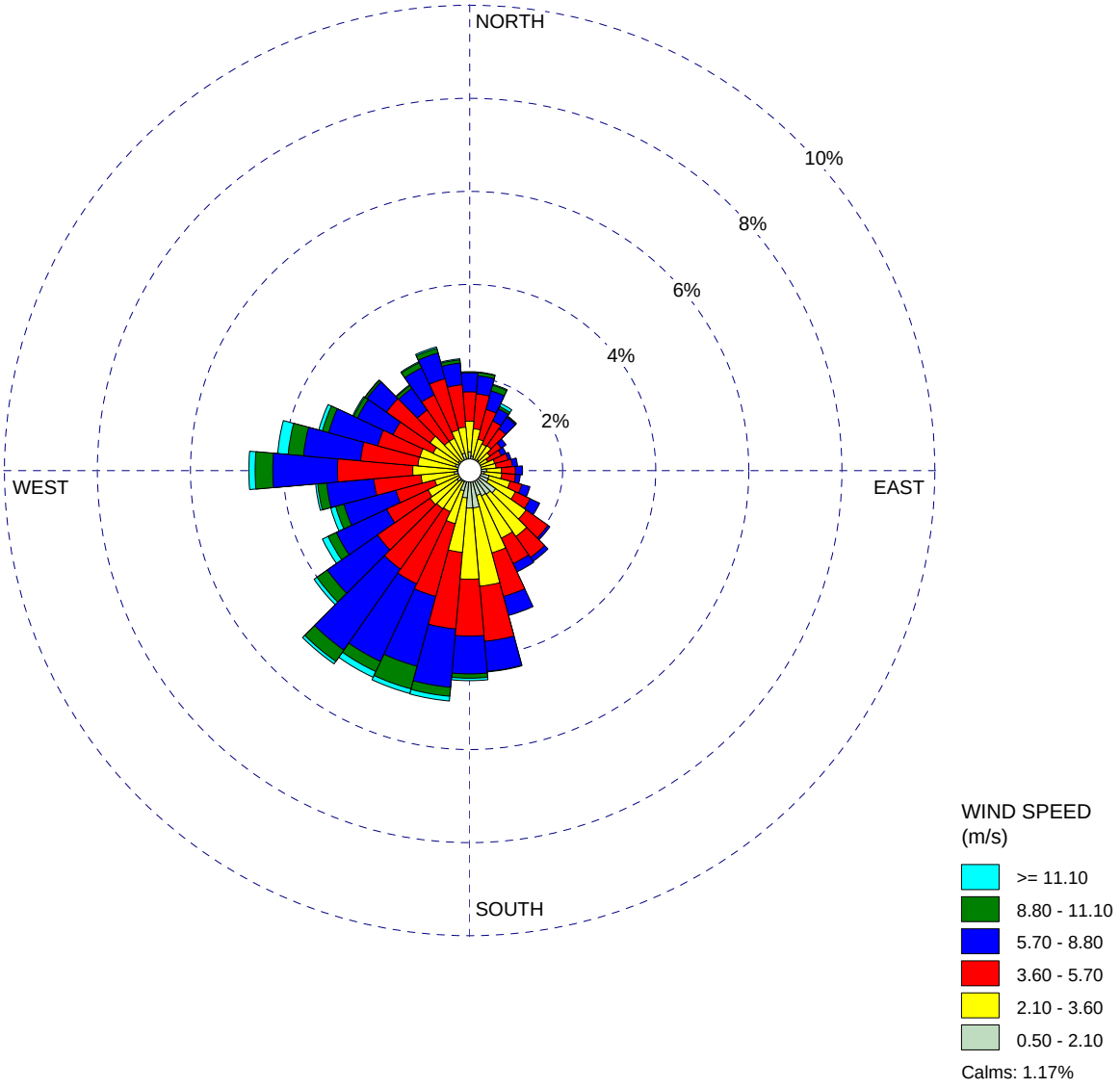
COMMENTS:	DATA PERIOD: **Start Date: 01/01/2011 - 00:00** **End Date: 31/12/2011 - 23:00**	COMPANY NAME:	
		MODELER:	
	CALM WINDS: **0.83%**	TOTAL COUNT: **8751 hrs.**	
	AVG. WIND SPEED: **4.66 m/s**	DATE: **01/02/2017**	PROJECT NO.: **3590**

WIND ROSE PLOT:

Robin Hood Airport - Wind Speed and Direction Frequency

DISPLAY:

Wind Speed
Direction (blowing from)



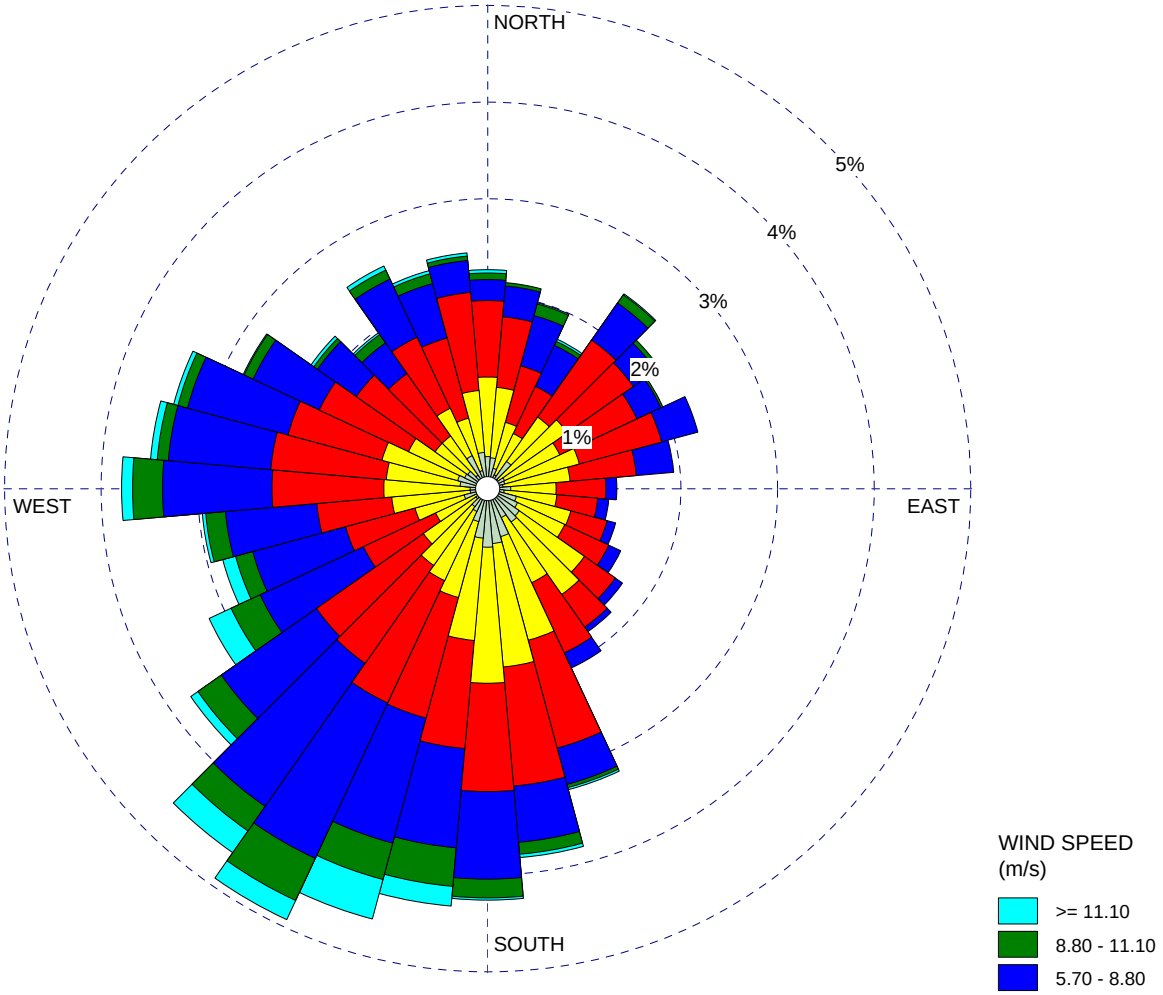
COMMENTS:	DATA PERIOD: **Start Date: 01/01/2012 - 00:00** **End Date: 31/12/2012 - 23:00**	COMPANY NAME:	
		MODELER:	
	CALM WINDS: **1.17%**	TOTAL COUNT: **8768 hrs.**	
	AVG. WIND SPEED: **4.39 m/s**	DATE: **01/02/2017**	PROJECT NO.: **3590**

WIND ROSE PLOT:

Robin Hood Airport - Wind Speed and Direction Frequency

DISPLAY:

Wind Speed
Direction (blowing from)



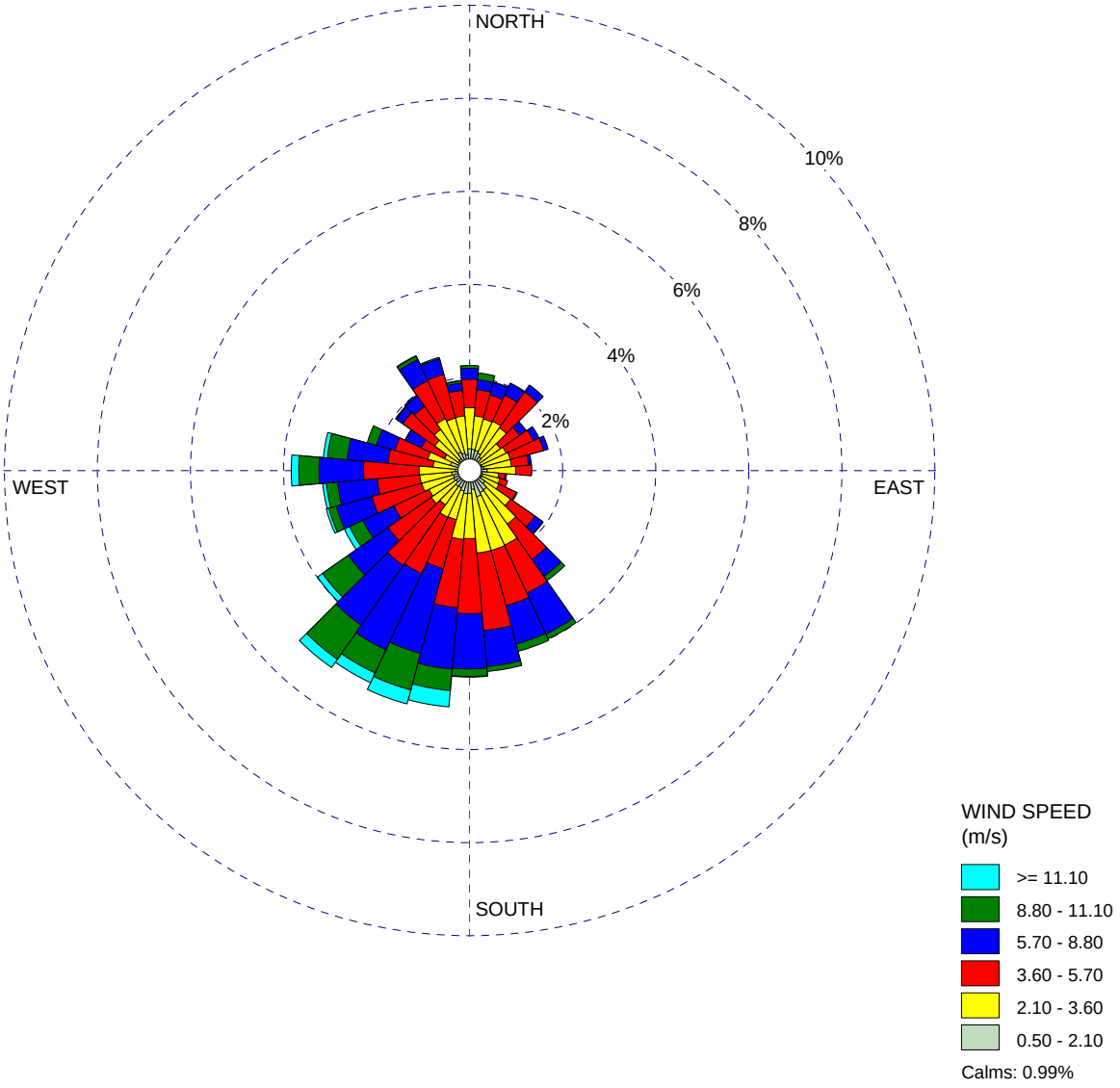
COMMENTS:	DATA PERIOD: **Start Date: 01/01/2013 - 00:00** **End Date: 31/12/2013 - 23:00**	COMPANY NAME:	
		MODELER:	
	CALM WINDS: **1.05%**	TOTAL COUNT: **8610 hrs.**	
	AVG. WIND SPEED: **4.52 m/s**	DATE: **01/02/2017**	PROJECT NO.: **3590**

WIND ROSE PLOT:

Robin Hood Airport - Wind Speed and Direction Frequency

DISPLAY:

Wind Speed
Direction (blowing from)



COMMENTS:	DATA PERIOD: **Start Date: 01/01/2014 - 00:00** **End Date: 31/12/2014 - 23:00**	COMPANY NAME:	
		MODELER:	
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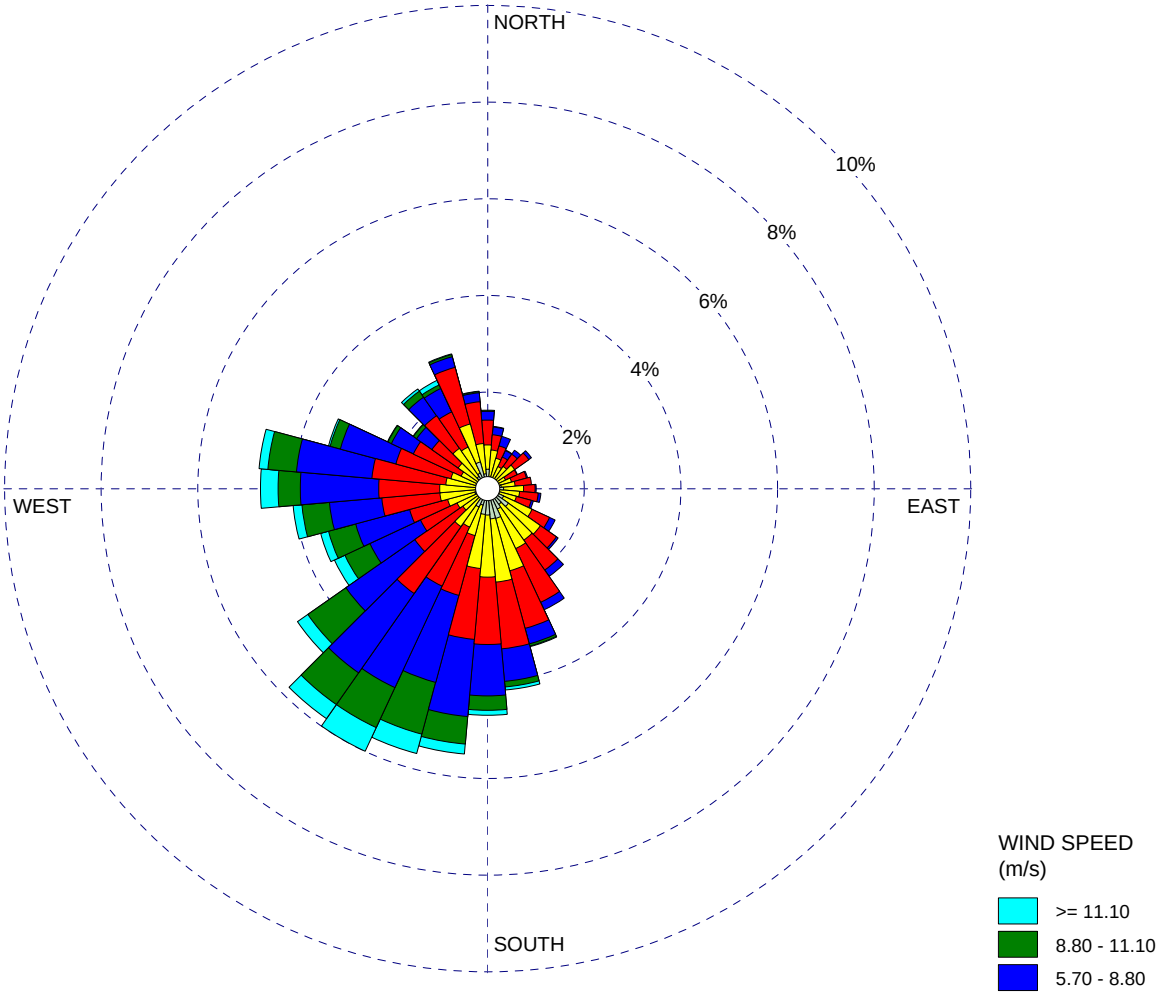
	AVG. WIND SPEED: **4.38 m/s**	DATE: **01/02/2017**	PROJECT NO.: **3590**

WIND ROSE PLOT:

Robin Hood Airport - Wind Speed and Direction Frequency

DISPLAY:

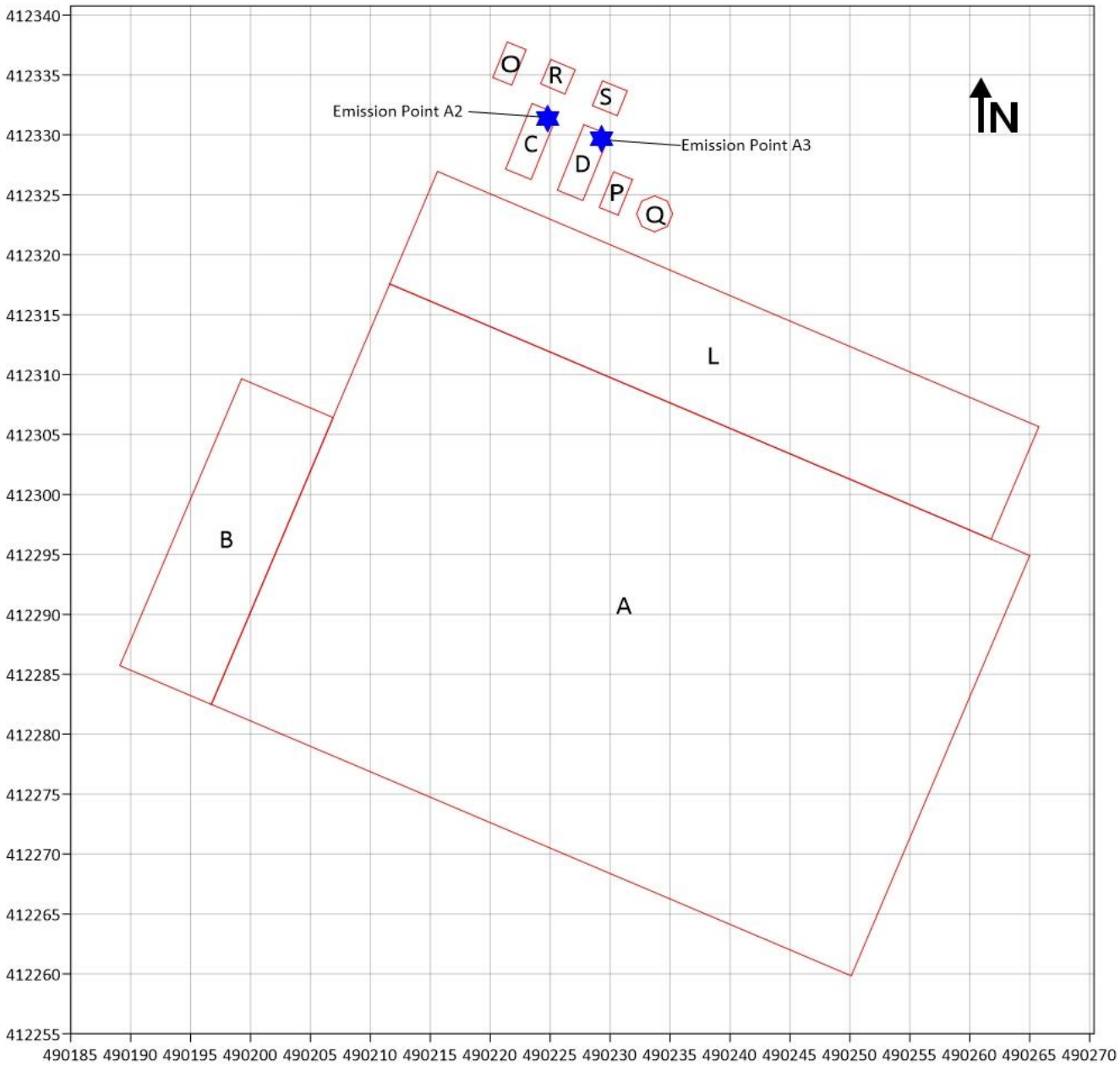
Wind Speed
Direction (blowing from)



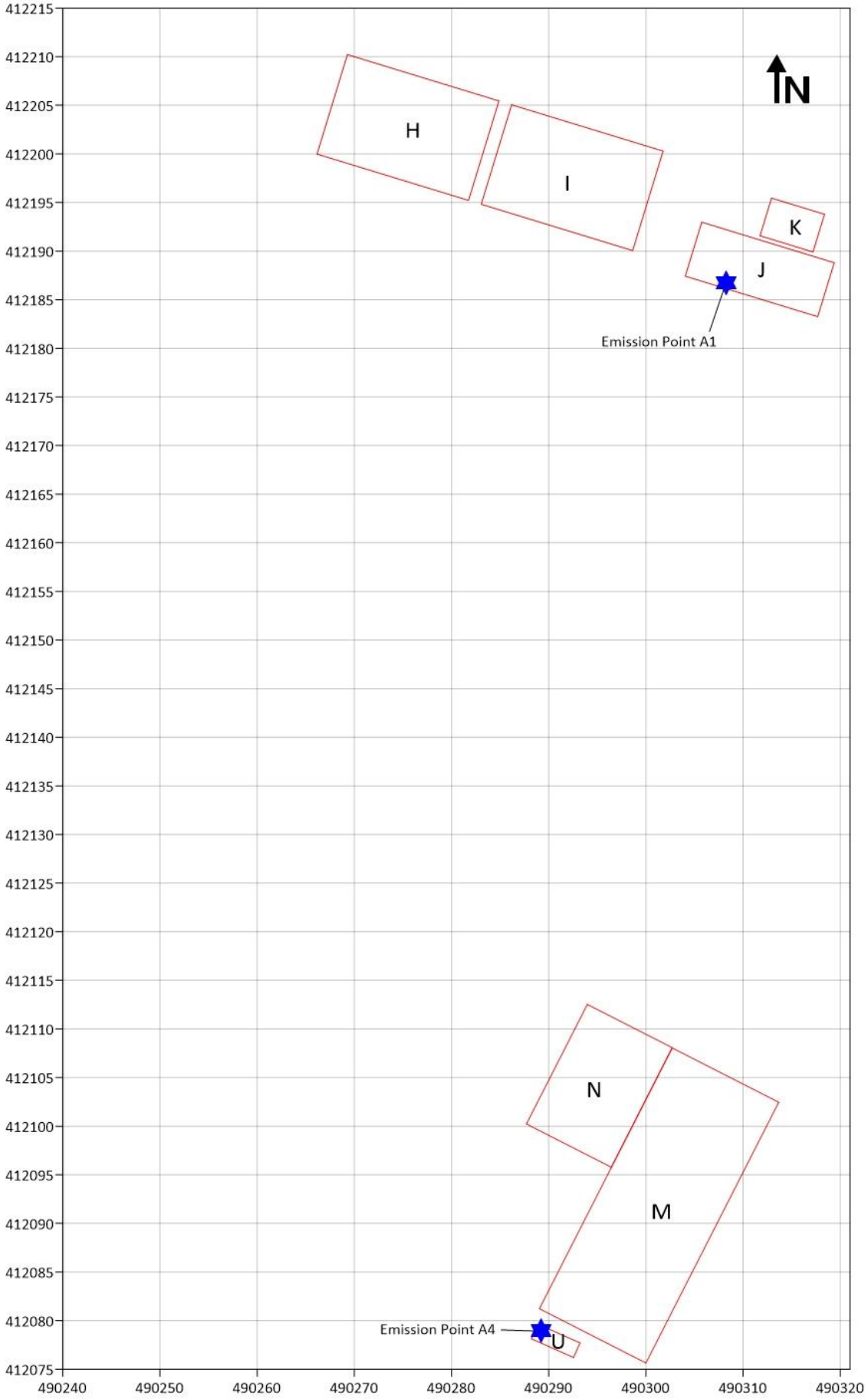
COMMENTS:	DATA PERIOD: **Start Date: 01/01/2015 - 00:00** **End Date: 31/12/2015 - 23:00**	COMPANY NAME:	
		MODELER:	
	CALM WINDS: **1.06%**	TOTAL COUNT: **8746 hrs.**	
	AVG. WIND SPEED: **4.81 m/s**	DATE: **01/02/2017**	PROJECT NO.: **3590**

Appendix IV

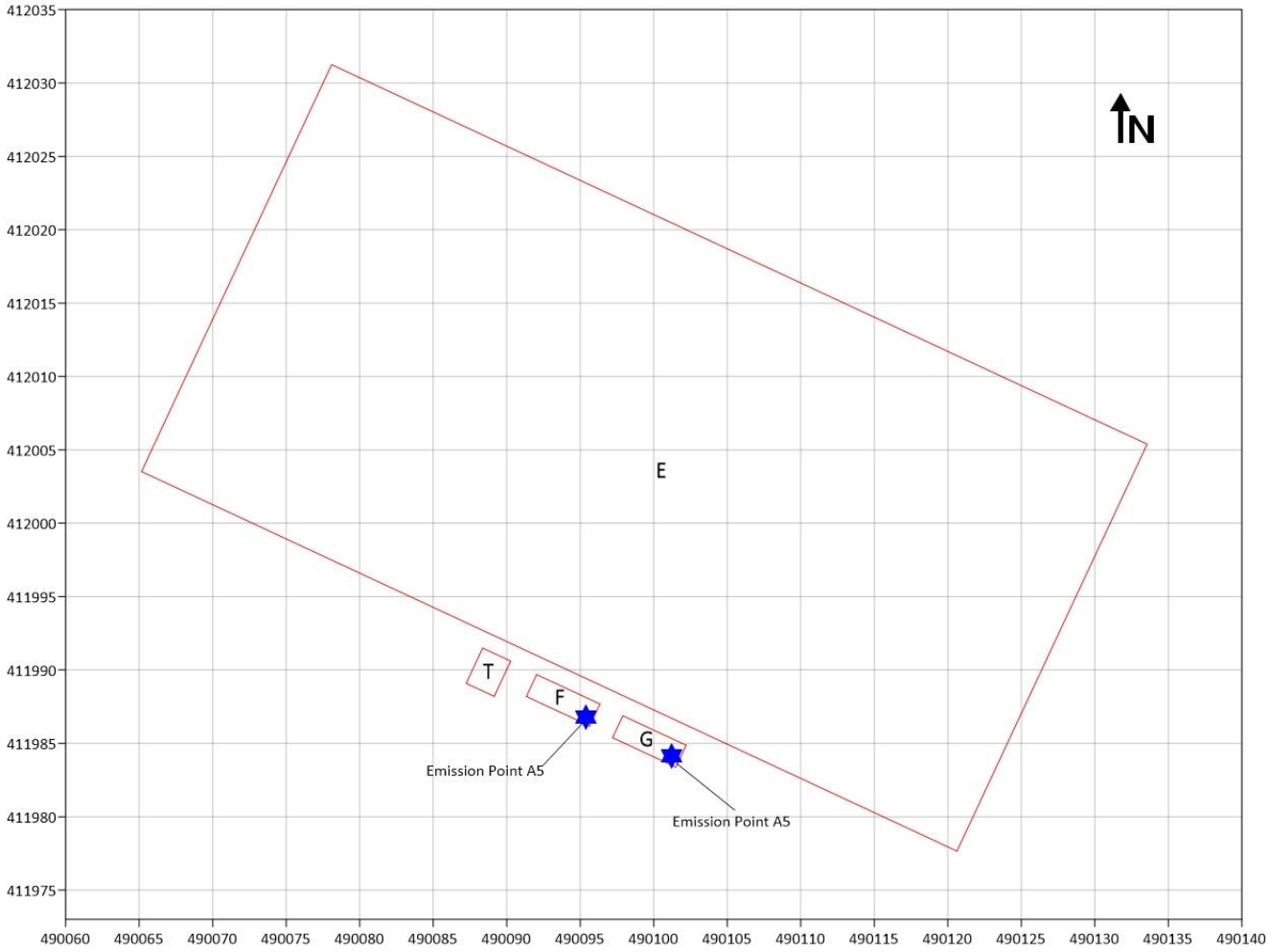
Structures and Point Sources Digitised Within Model



Appendix IV Figure 1 - Buildings and Emission Points Digitised Within Model - Northern Site Section



Appendix IV Figure 2 - Buildings and Emission Points Digitised Within Model - Central Site Section



Appendix IV Figure 3 - Buildings and Emission Points Digitised Within Model - Southern Site Section

Appendix V

Pollutant Contour Profiles

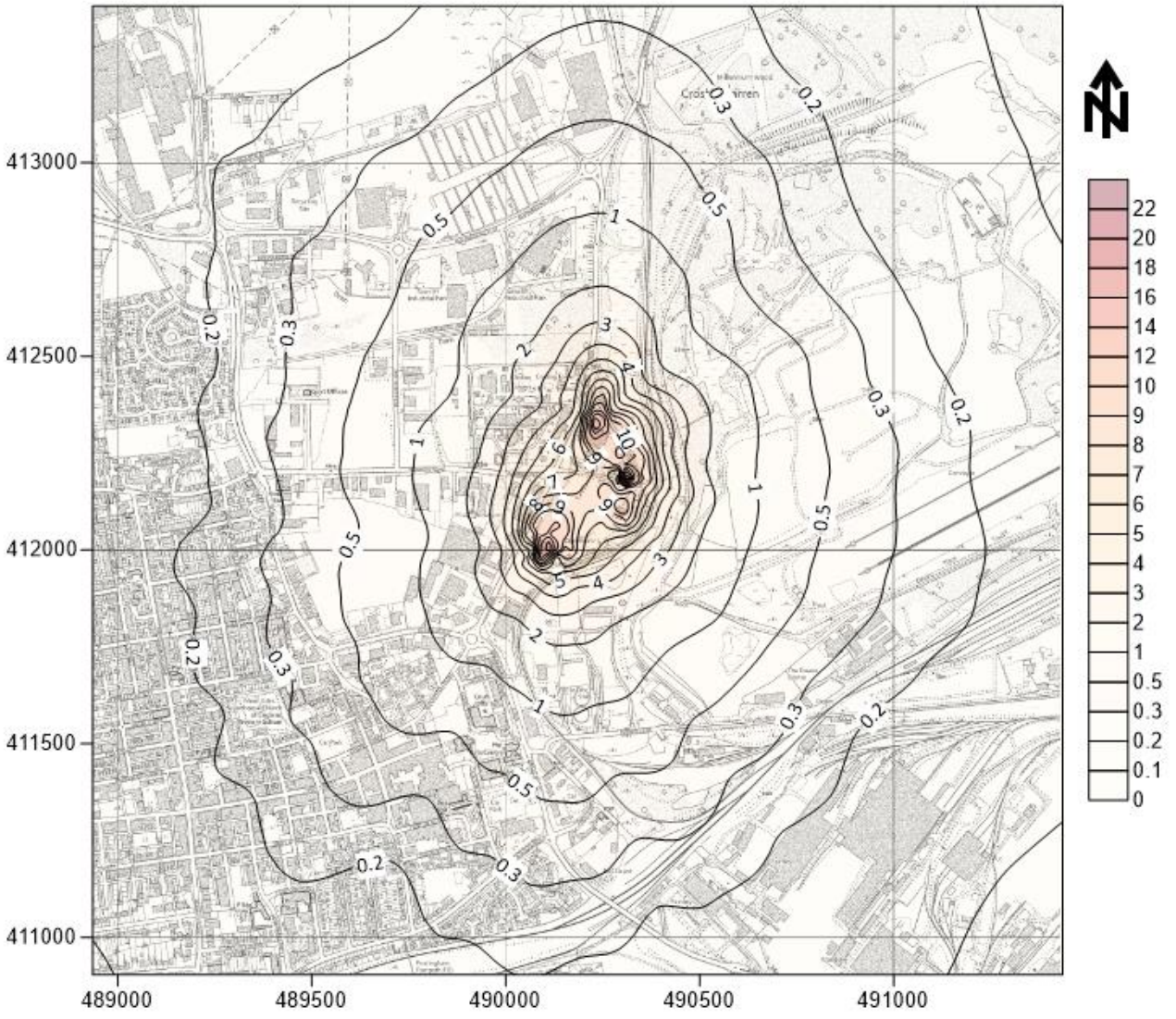


Figure V Figure 1 - Modelled annual mean nitrogen dioxide concentrations ($\mu g.m^{-3}$) based upon 2013 meteorological data (process contribution only)

Oaktree Environmental Ltd
Lime House
2 Road Two
Winsford
Cheshire
CW7 3QZ

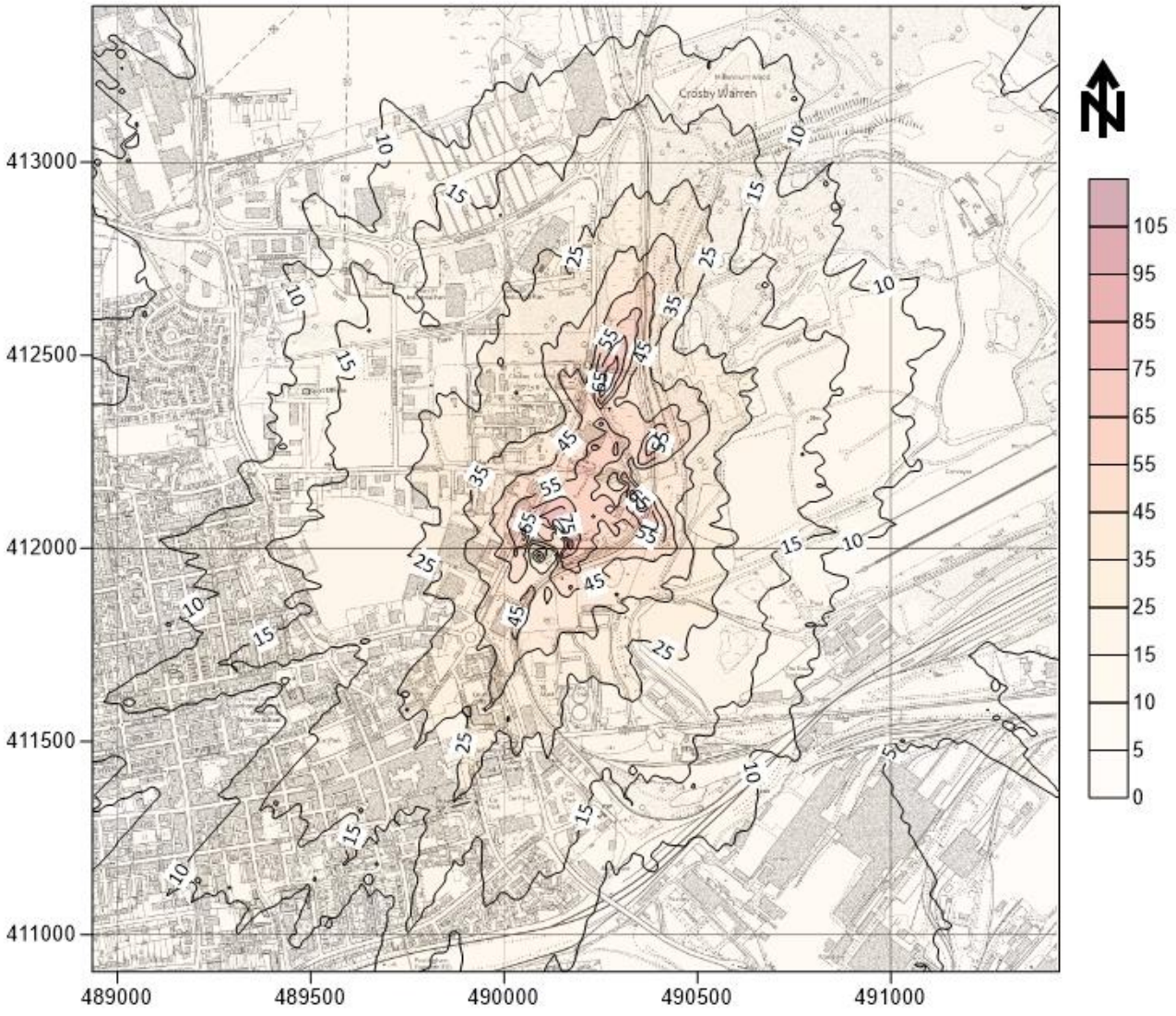


Figure V Figure 2 - modelled 99.8th percentile of 1-hour mean nitrogen dioxide concentrations ($\mu g.m^{-3}$) based upon 2014 meteorological data (process contribution only)

Oaktree Environmental Ltd
Lime House
2 Road Two
Winsford
Cheshire
CW7 3QZ

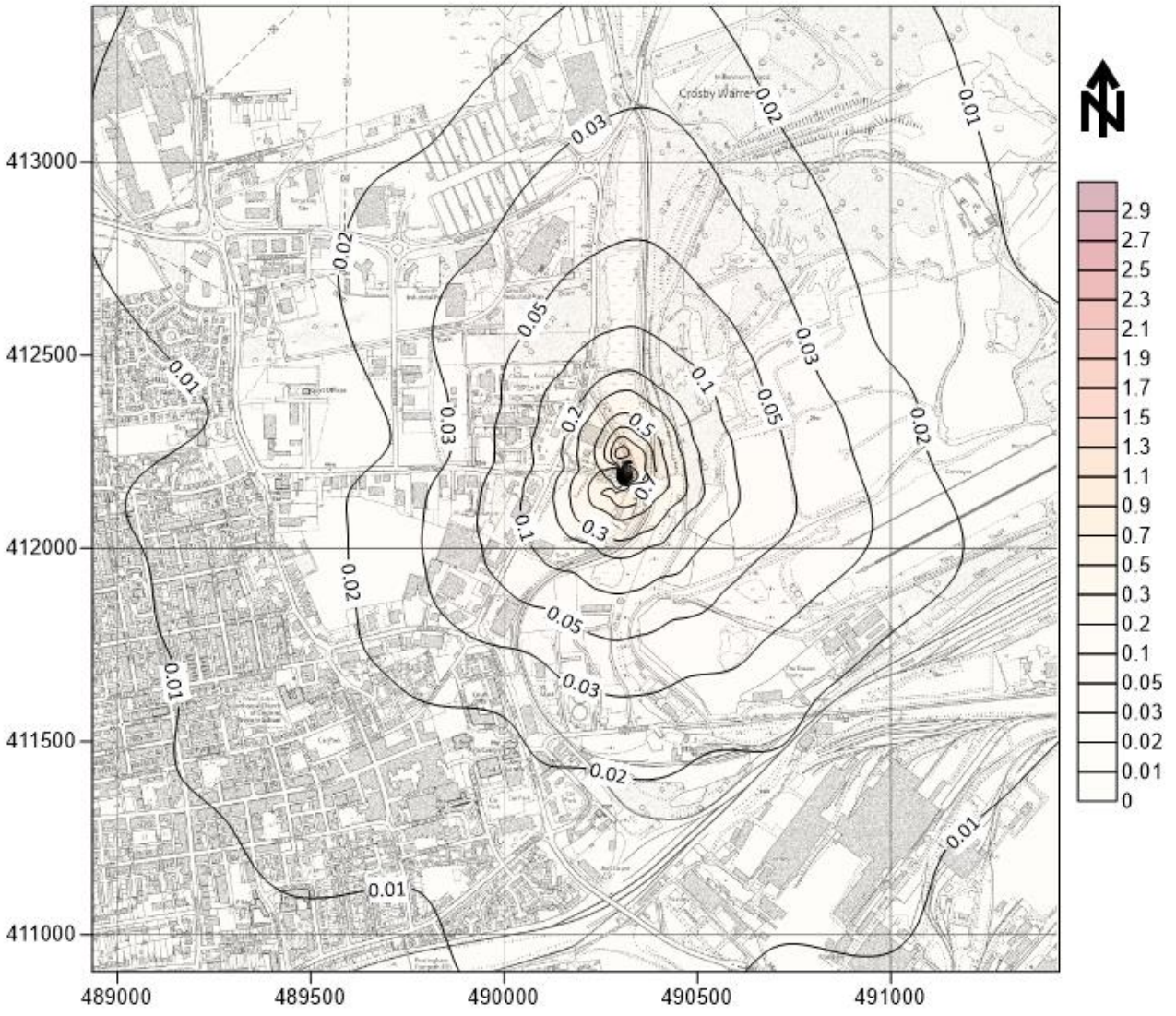


Figure V Figure 3 - Modelled annual mean PM10 concentrations (μg.m^{-3}) based upon 2013 meteorological data (process contribution only)

Oaktree Environmental Ltd
Lime House
2 Road Two
Winsford
Cheshire
CW7 3QZ

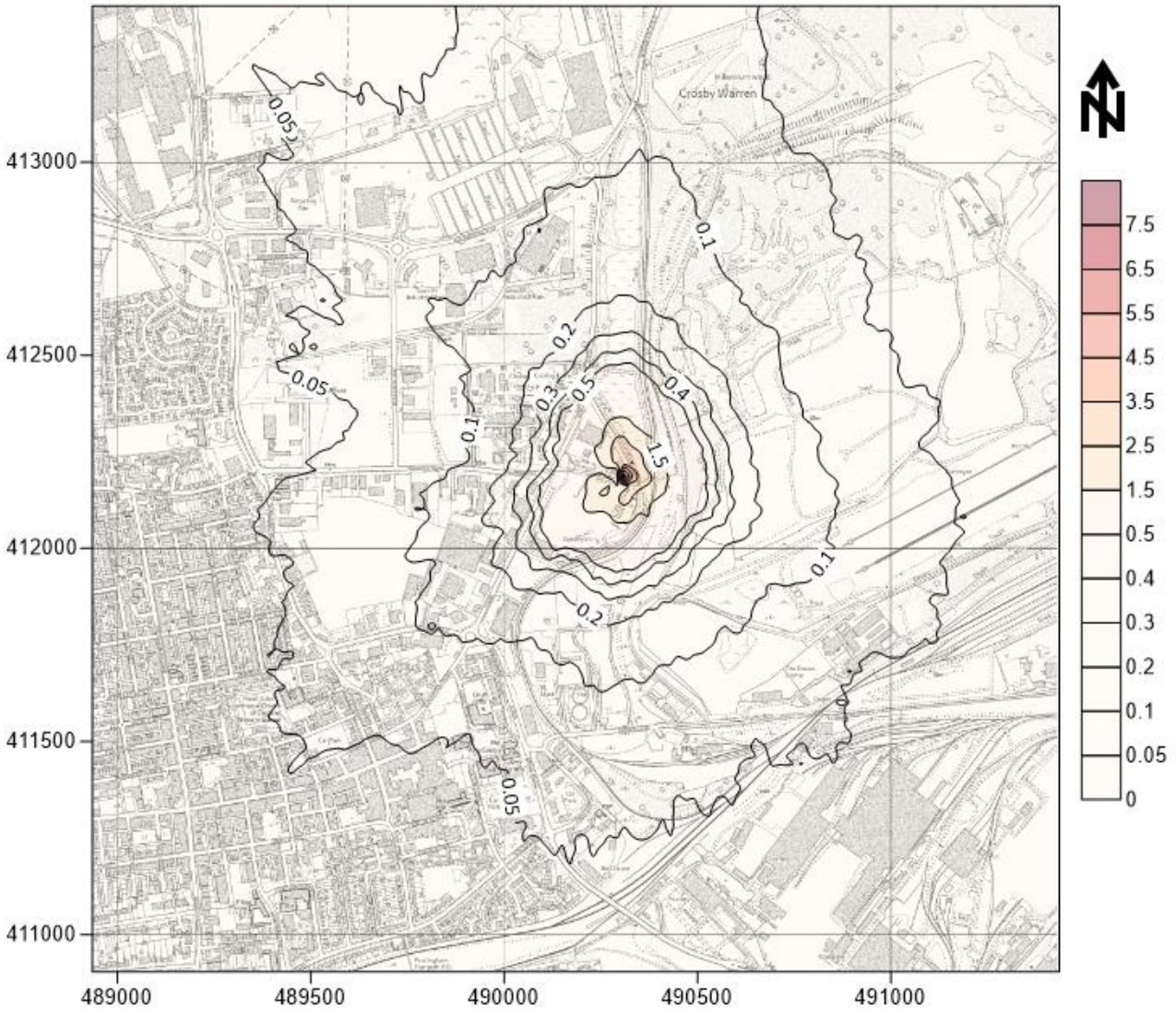


Figure V Figure 4 - Modelled 90.4th percentile of 24-hour mean PM10 concentrations (μg.m^{-3}) based upon 2013 meteorological data (process contribution only)

Oaktree Environmental Ltd
Lime House
2 Road Two
Winsford
Cheshire
CW7 3QZ

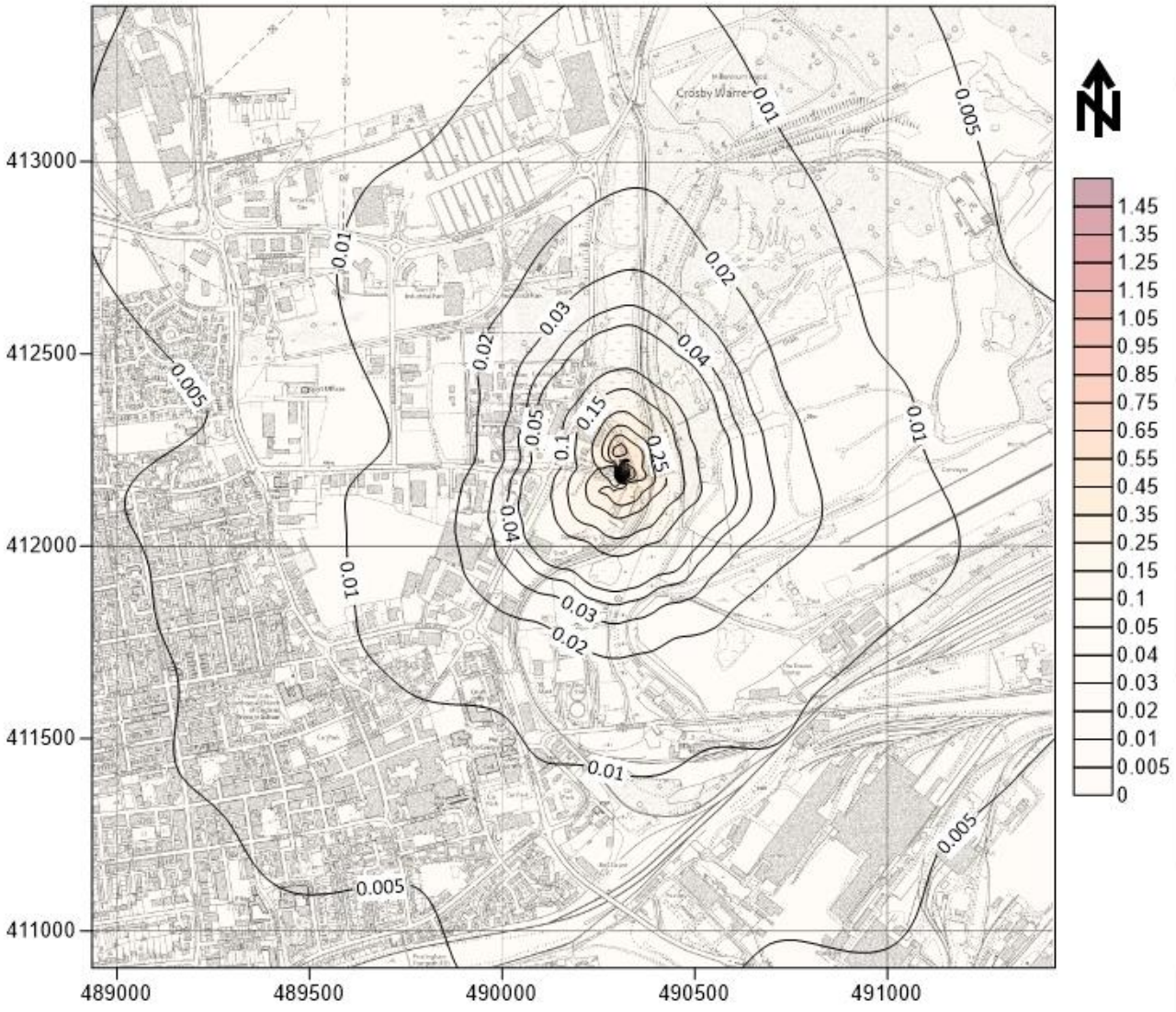


Figure V Figure 5 - Modelled annual mean PM2.5 concentrations ($\mu g.m^{-3}$) based upon 2013 meteorological data (process contribution only)

Oaktree Environmental Ltd
Lime House
2 Road Two
Winsford
Cheshire
CW7 3QZ

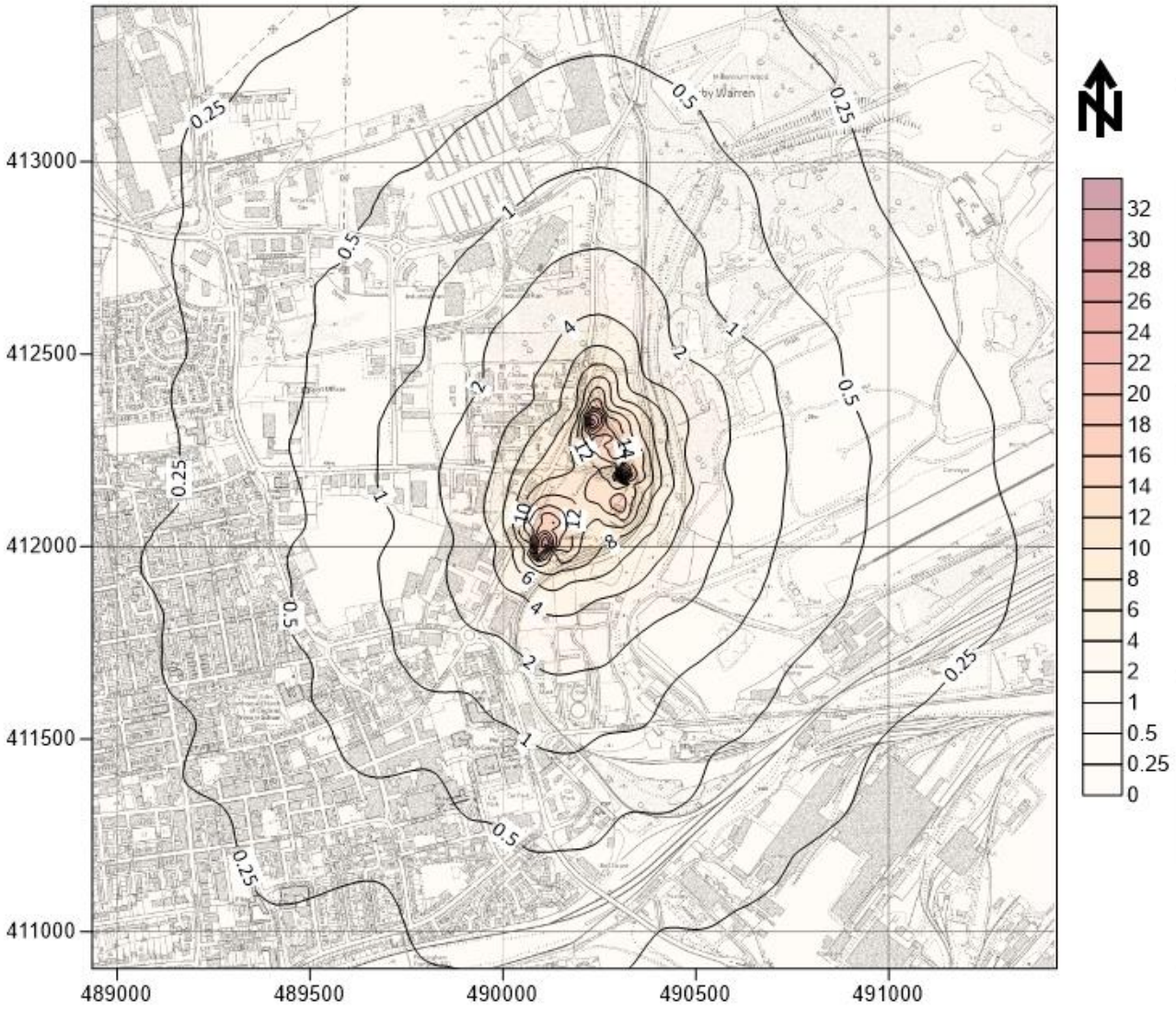


Figure V Figure 6 - Modelled annual mean total nitrogen oxides concentrations ($\mu g.m^{-3}$) based upon 2013 meteorological data (process contribution only)

Oaktree Environmental Ltd
Lime House
2 Road Two
Winsford
Cheshire
CW7 3QZ

Appendix VI

Emissions Monitoring Reports

Stack Emissions Monitoring Report

commissioned by Ellgia Ltd

Job Reference: JOB-838

Operator Name
Ellgia Ltd | Scunthorpe

Operator Address
Pitt Bottom, Winterton Road
Scunthorpe, North Lincolnshire
DN15 0DH
EPR Permit

Report Date | Version Number
11/10/2023 | Version 1

Dates of the Monitoring Campaign
28/09/2023

Release Point
P179 - Welding Bay

Atesta Ltd Primary Contact
Alastair Wolff | m: 07506 729 226
e: alastair.wolff@atesta.com

Monitoring Organisation Name & Address
Atesta Ltd
Unit 2, Asher Court, Lyncastle Way
Appleton, Warrington
WA4 4ST

10706

Monitoring Report Written By
Ben Metcalfe | Team Leader
MCERTS Level 2 | MM 21 1659 | TE1 TE4 | expires on 29/10/2026

Monitoring Report Approved By
Matt Pendlebury | Technical Support Manager
MCERTS Level 2 | MM 04 535 | TE1 TE2 TE3 TE4 | expires on 17/06/2024

info@atesta.com
T: 0800 970 8945
atesta.com

Report Contents and Monitoring Objectives

Report Contents

Monitoring Objective

The monitoring objective was to conduct stack emissions monitoring, as requested by the customer, for a number of prescribed pollutants.

Special Requirements

There were no special requirements for this monitoring campaign.

Opinions and Interpretations

Any opinions or interpretations contained within this test report are outside the scope of Atesta's MCERTS / ISO 17025 accreditation.

Part 1: Executive Summary - Monitoring Results Summary

Monitoring Results - Summary

	EXPRESSED AS A CONCENTRATION				EXPRESSED AS A MASS EMISSION					
test parameter	**result**	**uncertainty in result +/-**	**limit** (ELV)	**units**	**result**	**uncertainty in result +/-**	**limit** (ELV)	**units**	**reference conditions**	**accreditation status**
Sulphur Dioxide	1.1	0.088		mg/m^3	0.24	0.022		g/hr	STP, wet	MCERTS
Total VOCs (as Carbon)	1.3	0.089		mg/m^3	0.28	0.023		g/hr	STP, wet	MCERTS
Oxides of Nitrogen (as NO_2)	120	4.3		mg/m^3	25.9	1.6		g/hr	STP, wet	MCERTS
Carbon Monoxide	89.6	3.6		mg/m^3	19.4	1.2		g/hr	STP, wet	MCERTS
Oxygen	19.2	0.55		% v/v					dry	MCERTS
Stack Gas Water Vapour	6.4	0.26		% v/v					actual	MCERTS
Stack Gas Temperature	182			°C					actual	MCERTS
Stack Gas Velocity	19.9	0.33		m/s					actual	MCERTS
Stack Gas Flow Rate (ACTUAL)	359	17.4		m^3/hr					actual	MCERTS
Stack Gas Flow Rate (REF)	218	10.5		m^3/hr					STP, wet	MCERTS

The stack gas water vapour, temperature, velocity and flow rates in the above table are calculated as an average of all of the results recorded during this monitoring campaign

The uncertainty in the result is reported at a 95% Confidence Interval in the same units as the monitoring result. In practice, this means that 95 times out of 100, the true result will lie within the stated range.

Part 1: Executive Summary - Monitoring Results Further Details

Monitoring Results - Further Details

		EXPRESSED AS A CONCENTRATION				EXPRESSED AS A MASS EMISSION							
test parameter	**run**	**result**	**uncertainty in result +/-**	**limit** (ELV)	**units**	**result**	**uncertainty in result +/-**	**limit** (ELV)	**units**	**sampling date | times**	**run time** (mins)	**H_2O** (% v/v)	**reference conditions**
Sulphur Dioxide	R1	1.1	0.088		mg/m³	0.24	0.022		g/hr	28/09/2023 | 12:47 - 13:17	30	6.4	STP, wet
Total VOCs (as Carbon)	R1	1.3	0.089		mg/m³	0.28	0.023		g/hr	28/09/2023 | 12:47 - 13:17	30		STP, wet
Oxides of Nitrogen (as NO_2)	R1	120	4.3		mg/m³	25.9	1.6		g/hr	28/09/2023 | 12:47 - 13:17	30		STP, wet
Carbon Monoxide	R1	89.6	3.6		mg/m³	19.4	1.2		g/hr	28/09/2023 | 12:47 - 13:17	30		STP, wet
Oxygen	R1	19.2	0.55		% v/v					28/09/2023 | 12:47 - 13:17	30		dry
Velocity & Flow Rate Traverse	R1	19.9	0.33		m/s	359	17.4		m³/hr	28/09/2023 | 12:35 - 12:39			actual

The uncertainty in the result is reported at a 95% Confidence Interval in the same units as the monitoring result. In practice, this means that 95 times out of 100, the true result will lie within the stated range.

Part 1: Executive Summary - Monitoring and Analytical Methods

Monitoring and Analytical Methods

where analysis required	MONITORING					ANALYSIS					
test parameter	**laboratory**	**accreditation number**	**technical procedure**	**reference method**	**monitoring status**	**laboratory**	**accreditation number**	**analytical procedure**	**analytical technique**	**analysis status**	**accreditation status**
Sulphur Dioxide	ATA	10706	TP-10	EN 14791	MCERTS	RPS	0605	C27	IC	MCERTS	MCERTS

where analysis not required	MONITORING						
test parameter	**laboratory**	**accreditation number**	**technical procedure**	**reference method**	**monitoring status**	**measurement technique & equipment**	**accreditation status**
Total VOCs (as Carbon)	ATA	10706	TP-21b	EN 12619	MCERTS	FID using iFID Mobile	MCERTS
Oxides of Nitrogen (as NO_2)	ATA	10706	TP-22a	EN 14792	MCERTS	Chemiluminescence using Horiba PG-350E	MCERTS
Carbon Monoxide	ATA	10706	TP-22b	EN 15058	MCERTS	NDIR using Horiba PG-350E	MCERTS
Oxygen	ATA	10706	TP-22d	EN 14789	MCERTS	Paramagnetism using Horiba PG-350E	MCERTS
Velocity & Flow Rate Traverse	ATA	10706	TP-04a	EN 16911-1 | TR 17078	MCERTS	Pitot Tube, Thermocouple & Thermomanometer	MCERTS

Summary of Monitoring Deviations (from Appendix 2)

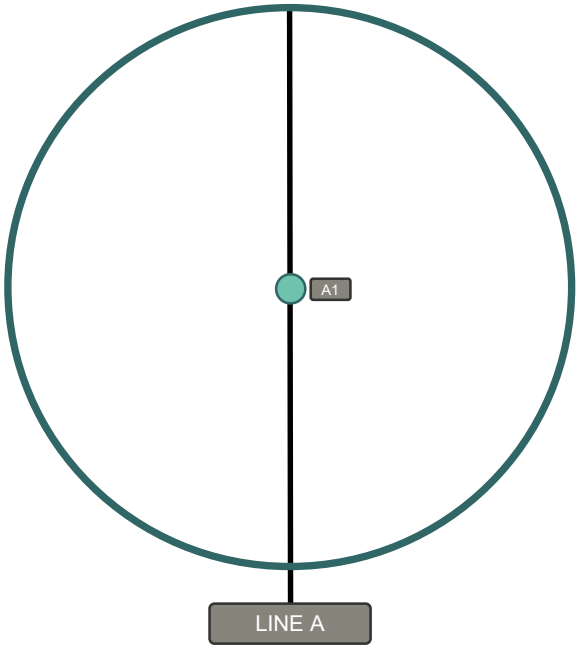
test parameter	run	details of monitoring deviation
All	1	There were no deviations associated with the monitoring employed.

Part 1: Executive Summary - Monitoring Location

Monitoring Location Photos

Identification of Sampling Points on a Duct Diagram

refer to Appendix 2 - Raw Data to see how the points on this diagram relate to the points used for each test



Part 1: Executive Summary - Duct and Sampling Platform Information

Duct Characteristics | Sampling Ports

parameter	units	value
shape	-	Circular
dimensions	-	Diameter = 0.08 m
area	m²	0.01
orientation	-	Horizontal

parameter	value
primary sample port size	Hole
primary sample port depth | cm	0
primary sample ports number of sampling lines available	1

summary of all sample ports available
Hole

Sampling Location General Information

general information	details
type | location | access	On the Ground | | On Ground Level

CEMS | Abatement Systems

parameter	details
abatement system/s	N/A
CEMS installed on the stack	N/A

Sampling Plane Validation Criteria Summary (EN 15259) from Stack Traverse/s

criteria in EN 15259	units	value	allowed	compliant
lowest differential pressure	Pa	223.0	> 5 Pa	Yes
lowest traverse velocity	m/s	19.9	-	-
highest traverse velocity	m/s	19.9	-	-
mean traverse velocity	m/s	19.9	-	-
ratio traverse velocities	: 1	1.00	< 3 : 1	Yes
angle of swirl compliance	°	< 15	< 15°	Yes
no local negative flow	-	Yes	-	Yes

Part 1: Executive Summary - Sampling Location and Operating Information

Process Details

process detail	details
plume appearance on day of monitoring	No visible plume
type of process	Combustion
batch or continuous process	On Demand
fuel type	Natural Gas
feedstock	N/A
typical load / throughput of plant	Normal operation
details of any unusual process occurrences	None

Part 2: Supporting Information - Appendix 1: Monitoring Personnel, Analysis Laboratories and Test Equipment Used

Monitoring Personnel

name	position	MCERTS level | number | expiry	MCERTS technical endorsements
Ben Metcalfe	Team Leader	MCERTS Level 2 | MM 21 1659 | 29/10/2026	TE1 TE4
Chris Rhodes	Senior Team Leader	MCERTS Level 2 | MM 02 117 | 18/05/2026	TE1 TE2 TE3 TE4
Cameron Murphy	Trainee	MCERTS Trainee | MM 23 1805 | 01/09/2028	-

Analysis Laboratories

laboratory	ISO 17025 accreditation number	laboratory short name	laboratory phone number
Atesta | North West	10706	ATA	0800 970 8945
RPS Laboratories | Salford	0605	RPS	0161 872 2443

Test Equipment Used

equipment type	A-EQ ID
Source sampling console	138
Low flow sampling MFCs	
ThermoFID / iFID mobile	401
Horiba PG-350E multigas analyser	6
Gasmet DX4000 FTIR	
Gasmet PSS	
Protea AtmosFIR	
Protea PIB Pump	
Gasmet syringe calibrator	
M&C PSS5-C conditioning unit	67
Digital thermomanometer	114
Top pan balance kit	385

equipment type	A-EQ ID
Pitot	134
Calipers	
Barometer	240
Timer	399
Tape measure	26
Heated head filter	
Heated tee	
10m heated line	33
1.5m heated line	
Odour barrel	
Vacuum chamber	
Dilution probe	

equipment type	A-EQ ID
10m umbilical	125
30m umbilical	
Heated probe	
Filter oven	
Ambient thermocouple	
Stack thermocouple	358
Exit thermocouple	
Condenser thermocouple	
Tubes kit thermocouple	
2-way heater controller	
Air sampling pump	
5-figure analytical balance	1

Part 2: Supporting Information - Appendix 2: Sulphur Dioxide | Run 1

Results

reference conditions are: STP, wet

parameter	units	result ± MU (95% CI)	units	result ± MU (95% CI)
Sulphur Dioxide	mg/m³	1.1 ± 0.088	g/hr	0.24 ± 0.022

Analytical Laboratory Information

parameter	details
name of analytical lab	RPS
lab analytical procedure	C27
lab analytical technique	IC | Analysis Accreditation: MCERTS
date analysis completed	11/10/2023

General Information

parameter	details
sampling date	28/09/2023
sampling times | testing team	12:47 - 13:17 | 30 minutes | tested by: BM | CR | CM
standard | technical procedure	EN 14791 | TP-10
volume metering device	Mass Flow Controller
probe material	Titanium
filter housing material	N/A
impinger material | capture media	Borosilicate Glass | H_2O_2

parameter	details
set flow rate	3 l/min
filter size, material & location	2µm Swagelok Element S/S | Out Stack | heated to N/A°C
number sampling lines available	1
number sampling lines used	1
number sampling points ideal per line	1
number sampling points used per line	1
sampling point IDs	A1

Quality Assurance

² The concentration in the last absorber was less than 5 times the analytical LOD.

		sample run			blank (taken on 28/09/2023)		
QA parameter	units	value	allowable	result	value	allowable	result
maximum allowable blank	mg/m³	-	-	-	0.86	N/A	N/A
leak test	%	2.00	2.00	Pass	1.80	2.00	Pass
absorption efficiency	%	71.3	N/A²	Pass	-	-	-
silica trap <50% faded	-	Yes	-	Pass	-	-	-
are water droplets present	-	No	-	-	-	-	-
water vapour MU	%	4.1	20.0	Pass	-	-	-

Breakdown of Results

reference conditions are: STP, wet

parameter	sample volume [m³]	LOD [mg]	impingers [front | back] [mg/l]	impinger volume [front | back] [ml]	mass total [mg]	LOD result [mg/m³]	result [mg/m³]	result reported [mg/m³]	mass emission [g/hr]
sample run	0.0579	0.018	0.19 | 0.16	240 | 115	0.064	0.31	1.1	**1.1**	0.24
blank	0.0579	0.016	0.16	310.0	0.05	0.27	0.86	**0.86**	

Part 2: Supporting Information - Appendix 2: Sulphur Dioxide | Run 1

Raw Data | Calculations

data	units	value
P_{bar}	mmHg	762.1
P_g	Pa	-103.0
P_s	mmHg	761.3
V_m (metered)	m³	0.0542
C_{stp}	-	0.3592

data	units	value
m_{wts}	g	3.0
M_w	g/mol	18.0
V_{mol}	m³/mol	0.0222
T_s	°C	185.0
R_{wv} (H_2O)	% v/v	6.4

data	units	value
$\%CO_{2d}$	% v/v (est)	1.50
$\%O_{2d}$	% v/v (est)	18.00
$\%O_{2w}$	% v/v (est)	N/A
$\%N_{2d}$	% v/v	80.50
$\%O_{2ref}$	% v/v	N/A
O_{2facd}	-	N/A
O_{2facw}	-	N/A

data	units	value
M_d	g/mol	28.96
M_s	g/mol	28.26
A_s	m²	0.01
θ (sample time)	mins	30

where (est) refers to an estimated value

metered volume calculations	units	value
allow favourable O_2 correction	-	N/A
vol actual stack conditions, $V_{ma} = (V_{mstw})(T_s + 273) / (P_s) / (C_{stp})$	m³	0.0969
vol dry, $V_{mstd} = V_m$	m³	0.0542
vol wet, $V_{mstw} = (V_{mstd})(100 / (100 - R_{wv}))$	m³	0.0579
vol dry O_2, $V_{mstdO_2} = (V_{mstd}) / (O_{2facd})$	m³	N/A
vol wet O_2, $V_{mstwO_2} = (V_{mstw}) / (O_{2facw})$	m³	N/A

velocity | volume flow rate calculations	units	value
velocity of stack gas, v_s = average of all velocity measurements	m/s	19.9
stack gas flow actual stack conditions, Q_a = average of all flow rate measurements	m³/hr	359.4

Measurement Uncertainty (MU) Calculations

parameter	units	value	standard MU	MU as %age	required standard	value	sens coeff.	MU | mg/m³
MFC meter volume, V_m	m³	0.0542	0.0003	0.50	≤2%	-	-	-
MFC volume STP, V_{mstd}	m³	-	-	-	-	0.1	20.4	0.0055
leak, L	% [1] | mg/m³ [2]	2 [1]	-	2.00	≤2%	0.013 [2]	1.00	0.013
laboratory result, L_r	% [1] | mg/m³ [2]	3.9 [1]	-	3.9	-	0.043 [2]	1.00	0.043
			combined MU					0.045
			expanded MU 95% CI (k = 1.96) including method deviations MU					0.088
			expanded MU 95% CI (k = 1.96) as percentage of measured value					7.9%
			expanded MU 95% CI (k = 1.96) as percentage of measured value for mass emission					9.3%

MU factor O_2 correction
N/A

overall MU for O_2 correction
N/A

method deviation factor
1.00

method and sampling deviations
Sampling was performed in full compliance with the Standard, technical procedure and regulatory requirements.

Part 2: Supporting Information - Appendix 2: Total VOCs (as Carbon) | Run 1

Results

reference conditions are: STP, wet

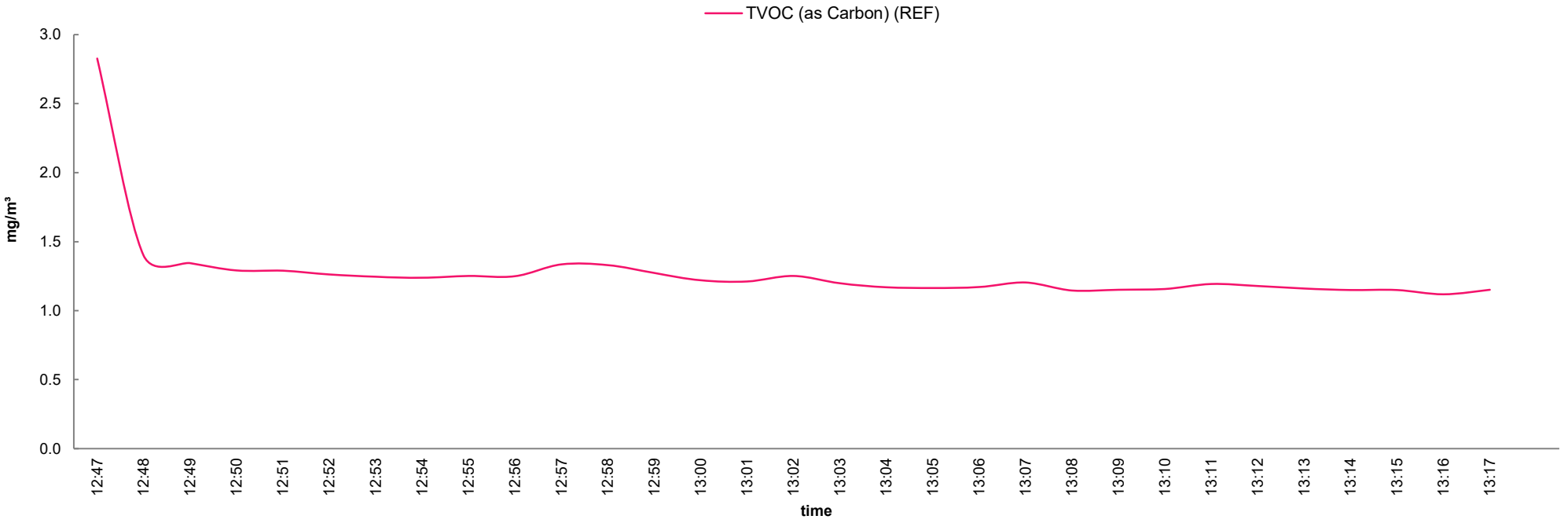
parameter	units	result ± MU (95% CI)	units	result ± MU (95% CI)
Total VOCs (as Carbon)	mg/m³	1.3 ± 0.089	g/hr	0.28 ± 0.023

General Information

parameter	details
sampling start date & time	28/09/2023 12:47
sampling end date & time	28/09/2023 13:17
test time | mins	30
testing team	BM | CR | CM
standard | technical procedure	EN 12619 | TP-21b
analyser type	iFID Mobile
heated head & line temperature	180°C

parameter	details
probe material	Titanium
filter size, material & location	2µm Swagelok Element S/S | Out Stack
number sampling lines available	1
number sampling lines used	1
number sampling points ideal per line	1
number sampling points used per line	1
sampling point IDs	A1

Plot of Emissions Over Time



Part 2: Supporting Information - Appendix 2: Total VOCs (as Carbon) | Run 1

Analyser Calibration Information with QA checks

where [A] = at analyser, [L] = down sampling line

	pre-test calibration events								post-test calibration events			quality assurance					
CAL ID	date & time	zero [A] [ppm]	span [A] [ppm]	zero [L] [ppm]	span [L] [ppm]	T_{90} [s]	leak [%]		date & time	zero [L] [ppm]	span [L] [ppm]	zero drift [%]		span drift [%]		allowable [%]	temp [°C]
1	28/09/23 12:18	0.00	79.58	0.06	79.42	11	0.2	P	28/09/23 13:31	0.80	78.90	0.9	P	-1.6	P	±5	17.0

Analyser Calibration Extended Information

CAL ID	performed by	drift corr. applied	log period [s]	CYL ID	CYL conc. [ppm]	CYL expiry	CYL MU [%]	zero gas type	span [CYL] gas type	span target [ppm]	range [ppm]	LOD [ppm]
1	BM	No	60	A-CYL-72	79.58	05/07/2027	1.0	Synthetic Air	10l 80ppm Propane in Air	79.58	AUTO	0.03

Part 2: Supporting Information - Appendix 2: Total VOCs (as Carbon) | Run 1

Measurement Uncertainty (MU) Calculations

general information	units	value
emission limit value (ELV) (REF)	mg/m³	N/A
measured concentration (REF)	mg/m³	1.3

MU budget			
parameter	units	min	max
ambient temp	°C	16.0	18.0
voltage	V	90.0	130.0

overall MU for O_2 correction
N/A

MU factor O_2 correction
N/A

	MU budget input parameters				MU budget		
performance characteristics	symbol	units	value	source	symbol	units	value
repeatability at zero	rz	% of value	0.05	MCERTS certificate MC050062	U_{rz}	mg/m³	0.00064
repeatability at span	rs	% of value	0.08	MCERTS certificate MC050062	U_{rs}	mg/m³	0.001
lack of fit	lof	% of value	2	maximum allowable	U_{lof}	mg/m³	0.015
maximum short term zero drift (ABS) [after drift correction]	dz	% of value	0.95	day of testing	U_{dz}	mg/m³	0.007
maximum short term span drift (ABS) [after drift correction]	ds	% of value	1.6	day of testing	U_{ds}	mg/m³	0.012
influence of sample gas flow	f	% of value	-0.42	MCERTS certificate MC050062	U_f	mg/m³	-0.0031
influence of sample gas pressure	p	% of value	0	MCERTS certificate MC050062	U_p	mg/m³	0
influence of ambient temperature zero point (/ 35k)	tz	% of value	-2.4	MCERTS certificate MC050062	U_{tz}	mg/m³	-0.00058
influence of ambient temperature span point (/ 35k)	ts	% of value	-2.7	MCERTS certificate MC050062	U_{ts}	mg/m³	-0.00066
influence of supply voltage (/ 60V)	v	% of value	-0.46	MCERTS certificate MC050062	U_v	mg/m³	-0.0023
cross sensitivity at zero	iz	% of value	3.8	MCERTS certificate MC050062	U_{iz}	mg/m³	0.028
cross sensitivity at span	is	% of value	3.9	MCERTS certificate MC050062	U_{is}	mg/m³	0.029
maximum leak	L	% of value	0.2	day of testing	U_L	mg/m³	0.0015
uncertainty associated with calibration gas	adj	% of value	1	span gas calibration certificate	U_{adj}	mg/m³	0.0064
		combined MU				mg/m³	0.045
		expanded MU 95% CI (k = 1.96)				mg/m³	0.089
		expanded MU 95% CI (k = 1.96) as percentage of measured value				%	7
		expanded MU 95% CI (k = 1.96) as percentage of measured value for mass emission				%	8.5

method and sampling deviations
Sampling was performed in full compliance with the Standard, technical procedure and regulatory requirements.

Part 2: Supporting Information - Appendix 2: Oxides of Nitrogen (as NO_2) | Run 1

Results

reference conditions are: STP, wet

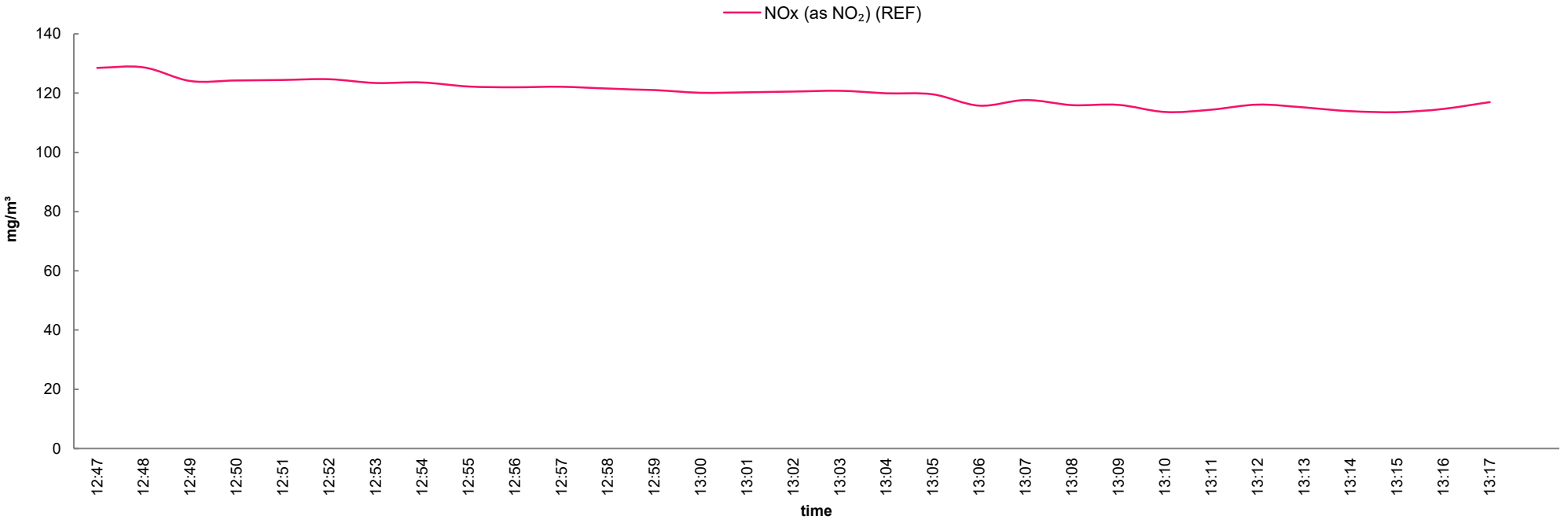
parameter	units	result ± MU (95% CI)	units	result ± MU (95% CI)
Oxides of Nitrogen (as NO_2)	mg/m³	120 ± 4.3	g/hr	25.9 ± 1.6

General Information

parameter	details
sampling start date & time	28/09/2023 12:47
sampling end date & time	28/09/2023 13:17
test time | mins	30
testing team	BM | CR | CM
standard | technical procedure	EN 14792 | TP-22a
analyser type	Horiba PG-350E
heated head & line temperature	180°C

parameter	details
probe material	Titanium
filter size, material & location	2µm Swagelok Element S/S | Within Heated Head
number sampling lines available	1
number sampling lines used	1
number sampling points ideal per line	1
number sampling points used per line	1
sampling point IDs	A1

Plot of Emissions Over Time



Part 2: Supporting Information - Appendix 2: Oxides of Nitrogen (as NO_2) | Run 1

Analyser Calibration Information with QA checks

where [A] = at analyser, [L] = down sampling line

	pre-test calibration events								post-test calibration events			quality assurance					
CAL ID	date & time	zero [A] [ppm]	span [A] [ppm]	zero [L] [ppm]	span [L] [ppm]	T_{90} [s]	leak [%]		date & time	zero [A] [ppm]	span [A] [ppm]	zero drift [%]		span drift [%]		allowable [%]	temp [°C]
1	28/09/23 12:18	0.00	202.12	1.80	200.10	45	1.0	P	28/09/23 13:23	1.80	200.80	0.9	P	-1.5	P	±5	17.0

Analyser Calibration Extended Information

CAL ID	performed by	drift corr. applied	log period [s]	CYL ID	CYL conc. [ppm]	CYL expiry	CYL MU [%]	zero gas type	span [CYL] gas type	span target [ppm]	range [ppm]	LOD [ppm]
1	BM	No	60	A-CYL-61	202.12	29/07/2025	1.2	Nitrogen 5.2	10l 200ppm NO | 160ppm CO | 16% CO2 in Nitrogen	202.12	250	0.09

Part 2: Supporting Information - Appendix 2: Oxides of Nitrogen (as NO_2) | Run 1

Measurement Uncertainty (MU) Calculations

general information	units	value
emission limit value (ELV) (REF)	mg/m³	N/A
measured concentration (REF)	mg/m³	120

MU budget			
parameter	units	min	max
ambient temp	°C	16.0	18.0
voltage	V	90.0	130.0

overall MU for O_2 correction
N/A

MU factor O_2 correction
N/A

	MU budget input parameters				MU budget		
performance characteristics	symbol	units	value	source	symbol	units	value
repeatability at zero	rz	% of value	0	MCERTS certificate MC130223	U_{rz}	mg/m³	0
repeatability at span	rs	% of value	0.1	MCERTS certificate MC130223	U_{rs}	mg/m³	0.12
lack of fit	lof	% of value	2	maximum allowable	U_{lof}	mg/m³	1.4
maximum short term zero drift (ABS) [after drift correction]	dz	% of value	0.86	day of testing	U_{dz}	mg/m³	0.59
maximum short term span drift (ABS) [after drift correction]	ds	% of value	1.5	day of testing	U_{ds}	mg/m³	1
influence of sample gas flow	f	% of value	0.1	MCERTS certificate MC130223	U_f	mg/m³	0.069
influence of sample gas pressure	p	% of value	0	MCERTS certificate MC130223	U_p	mg/m³	0
influence of ambient temperature zero point (/ 35k)	tz	% of value	0	MCERTS certificate MC130223	U_{tz}	mg/m³	0
influence of ambient temperature span point (/ 35k)	ts	% of value	1.8	MCERTS certificate MC130223	U_{ts}	mg/m³	0.041
influence of supply voltage (/ 60V)	v	% of value	0.4	MCERTS certificate MC130223	U_v	mg/m³	0.18
cross sensitivity at zero	iz	% of value	0.63	MCERTS certificate MC130223	U_{iz}	mg/m³	0.44
cross sensitivity at span	is	% of value	-0.52	MCERTS certificate MC130223	U_{is}	mg/m³	-0.36
maximum leak	L	% of value	1	day of testing	U_L	mg/m³	0.69
uncertainty associated with calibration gas	adj	% of value	1.2	span gas calibration certificate	U_{adj}	mg/m³	0.72
		combined MU				mg/m³	2.2
		expanded MU 95% CI (k = 1.96)				mg/m³	4.3
		expanded MU 95% CI (k = 1.96) as percentage of measured value				%	3.5
		expanded MU 95% CI (k = 1.96) as percentage of measured value for mass emission				%	6

method and sampling deviations
Sampling was performed in full compliance with the Standard, technical procedure and regulatory requirements.

Part 2: Supporting Information - Appendix 2: Carbon Monoxide | Run 1

Results

reference conditions are: STP, wet

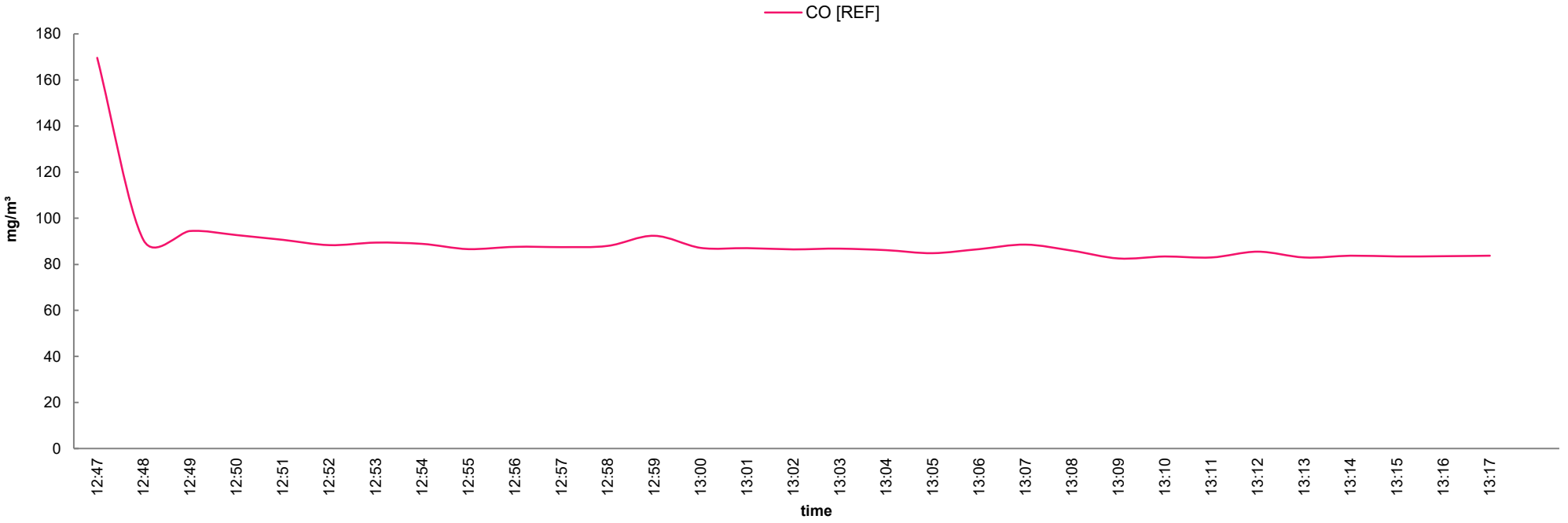
parameter	units	result ± MU (95% CI)	units	result ± MU (95% CI)
Carbon Monoxide	mg/m³	89.6 ± 3.6	g/hr	19.4 ± 1.2

General Information

parameter	details
sampling start date & time	28/09/2023 12:47
sampling end date & time	28/09/2023 13:17
test time | mins	30
testing team	BM | CR | CM
standard | technical procedure	EN 15058 | TP-22b
analyser type	Horiba PG-350E
heated head & line temperature	180°C

parameter	details
probe material	Titanium
filter size, material & location	2µm Swagelok Element S/S | Out Stack
number sampling lines available	1
number sampling lines used	1
number sampling points ideal per line	1
number sampling points used per line	1
sampling point IDs	A1

Plot of Emissions Over Time



Part 2: Supporting Information - Appendix 2: Carbon Monoxide | Run 1

Analyser Calibration Information with QA checks

where [A] = at analyser, [L] = down sampling line

	pre-test calibration events								post-test calibration events			quality assurance					
CAL ID	date & time	zero [A] [ppm]	span [A] [ppm]	zero [L] [ppm]	span [L] [ppm]	T_{90} [s]	leak [%]		date & time	zero [A] [ppm]	span [A] [ppm]	zero drift [%]		span drift [%]		allowable [%]	temp [°C]
1	28/09/23 12:18	0.00	157.90	1.00	155.00	43	1.8	P	28/09/23 13:23	0.10	155.60	0.3	P	-1.8	P	±5	17.0

Analyser Calibration Extended Information

CAL ID	performed by	drift corr. applied	log period [s]	CYL ID	CYL conc. [ppm]	CYL expiry	CYL MU [%]	zero gas type	span [CYL] gas type	span target [ppm]	range [ppm]	LOD [ppm]
1	BM	No	60	A-CYL-61	157.90	29/07/2025	1.0	Nitrogen 5.2	10l 200ppm NO | 160ppm CO | 16% CO2 in Nitrogen	157.90	200	0.32

Part 2: Supporting Information - Appendix 2: Carbon Monoxide | Run 1

Measurement Uncertainty (MU) Calculations

general information	units	value
emission limit value (ELV) (REF)	mg/m³	N/A
measured concentration (REF)	mg/m³	89.6

MU budget			
parameter	units	min	max
ambient temp	°C	16.0	18.0
voltage	V	90.0	130.0

overall MU for O_2 correction
N/A

MU factor O_2 correction
N/A

	MU budget input parameters				MU budget		
performance characteristics	symbol	units	value	source	symbol	units	value
repeatability at zero	rz	% of value	0.1	MCERTS certificate MC130223	U_{rz}	mg/m³	0.09
repeatability at span	rs	% of value	0.2	MCERTS certificate MC130223	U_{rs}	mg/m³	0.18
lack of fit	lof	% of value	2	maximum allowable	U_{lof}	mg/m³	1
maximum short term zero drift (ABS) [after drift correction]	dz	% of value	0.32	day of testing	U_{dz}	mg/m³	0.16
maximum short term span drift (ABS) [after drift correction]	ds	% of value	1.8	day of testing	U_{ds}	mg/m³	0.92
influence of sample gas flow	f	% of value	0.1	MCERTS certificate MC130223	U_f	mg/m³	0.052
influence of sample gas pressure	p	% of value	0	MCERTS certificate MC130223	U_p	mg/m³	0
influence of ambient temperature zero point (/ 35k)	tz	% of value	-0.2	MCERTS certificate MC130223	U_{tz}	mg/m³	-0.0034
influence of ambient temperature span point (/ 35k)	ts	% of value	2	MCERTS certificate MC130223	U_{ts}	mg/m³	0.034
influence of supply voltage (/ 60V)	v	% of value	0.5	MCERTS certificate MC130223	U_v	mg/m³	0.17
cross sensitivity at zero	iz	% of value	-0.48	MCERTS certificate MC130223	U_{iz}	mg/m³	-0.25
cross sensitivity at span	is	% of value	-0.87	MCERTS certificate MC130223	U_{is}	mg/m³	-0.45
maximum leak	L	% of value	1.8	day of testing	U_L	mg/m³	0.95
uncertainty associated with calibration gas	adj	% of value	1	span gas calibration certificate	U_{adj}	mg/m³	0.46
		combined MU				mg/m³	1.8
		expanded MU 95% CI (k = 1.96)				mg/m³	3.6
		expanded MU 95% CI (k = 1.96) as percentage of measured value				%	4
		expanded MU 95% CI (k = 1.96) as percentage of measured value for mass emission				%	6.3

method and sampling deviations
Sampling was performed in full compliance with the Standard, technical procedure and regulatory requirements.

Part 2: Supporting Information - Appendix 2: Oxygen | Run 1

Results

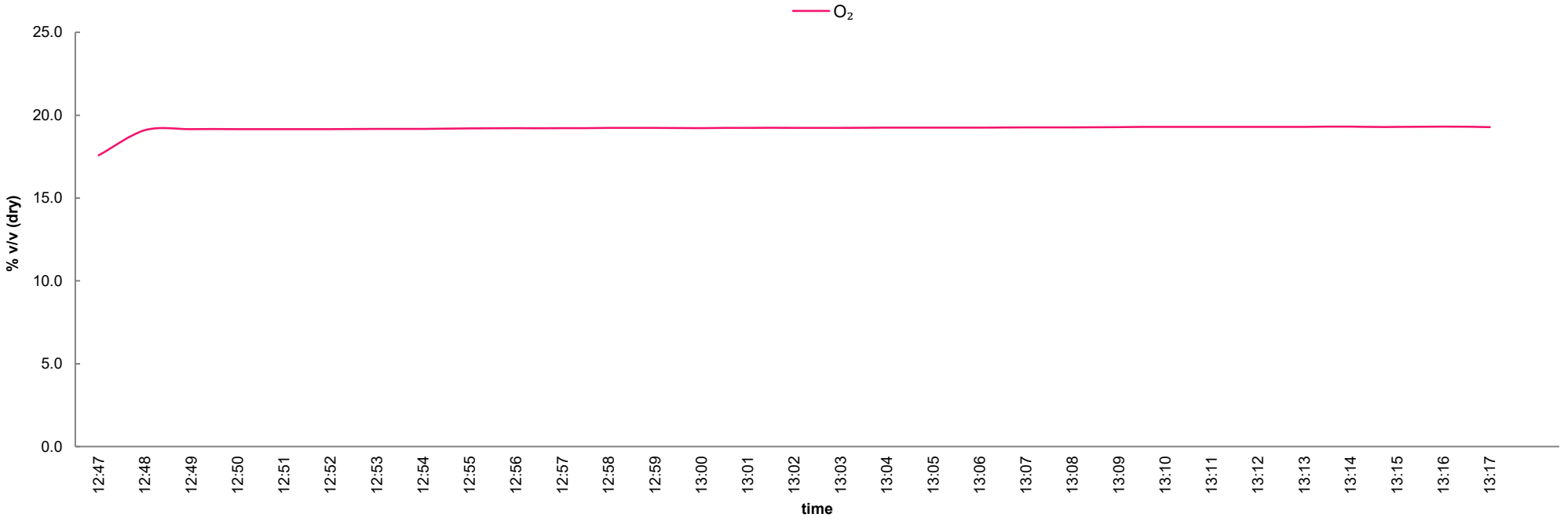
parameter	units	result ± MU (95% CI)
Oxygen	% v/v	19.2 ± 0.55

General Information

parameter	details
sampling start date & time	28/09/2023 12:47
sampling end date & time	28/09/2023 13:17
test time | mins	30
testing team	BM | CR | CM
standard | technical procedure	EN 14789 | TP-22d
analyser type	Horiba PG-350E
heated head & line temperature	180°C

parameter	details
probe material	Titanium
filter size, material & location	2µm Swagelok Element S/S | Out Stack
number sampling lines available	1
number sampling lines used	1
number sampling points ideal per line	1
number sampling points used per line	1
sampling point IDs	A1

Plot of Emissions Over Time



Part 2: Supporting Information - Appendix 2: Oxygen | Run 1

Analyser Calibration Information with QA checks

where [A] = at analyser, [L] = down sampling line

	pre-test calibration events								post-test calibration events			quality assurance					
CAL ID	date & time	zero [A] [% v/v]	span [A] [% v/v]	zero [L] [% v/v]	span [L] [% v/v]	T_{90} [s]	leak [%]		date & time	zero [A] [% v/v]	span [A] [% v/v]	zero drift [%]		span drift [%]		allowable [%]	temp [°C]
1	28/09/23 12:18	0.00	21.29	0.01	21.04	26	1.2	P	28/09/23 13:23	0.08	20.60	0.1	P	-3.3	P	±5	17.0

Analyser Calibration Extended Information

CAL ID	performed by	drift corr. applied	log period [s]	CYL ID	CYL conc. [% v/v]	CYL expiry	CYL MU [%]	zero gas type	span [CYL] gas type	span target [% v/v]	range [% v/v]	LOD [% v/v]
1	BM	Yes	60	A-CYL-105	21.29	22/06/2028	1.2	Nitrogen 5.2	10l Synthetic Air	21.29	25	0.03

Part 2: Supporting Information - Appendix 2: Oxygen | Run 1

Measurement Uncertainty (MU) Calculations

general information	units	value
measured concentration (dry)	% v/v	19.2

MU budget			
parameter	units	min	max
ambient temp	°C	16.0	18.0
voltage	V	90.0	130.0

	MU budget input parameters				MU budget		
performance characteristics	symbol	units	value	source	symbol	units	value
repeatability at zero	rz	% of value	0.02	MCERTS certificate MC130223	U_{rz}	% v/v	0.0038
repeatability at span	rs	% of value	0.02	MCERTS certificate MC130223	U_{rs}	% v/v	0.0038
lack of fit	lof	% of value	2	maximum allowable	U_{lof}	% v/v	0.22
maximum short term zero drift (ABS) [after drift correction]	dz	% of value	0	day of testing	U_{dz}	% v/v	0
maximum short term span drift (ABS) [after drift correction]	ds	% of value	0	day of testing	U_{ds}	% v/v	0
influence of sample gas flow	f	% of value	-0.01	MCERTS certificate MC130223	U_{f}	% v/v	-0.0011
influence of sample gas pressure	p	% of value	0	MCERTS certificate MC130223	U_{p}	% v/v	0
influence of ambient temperature zero point (/ 35k)	tz	% of value	-0.4	MCERTS certificate MC130223	U_{tz}	% v/v	-0.0015
influence of ambient temperature span point (/ 35k)	ts	% of value	-0.15	MCERTS certificate MC130223	U_{ts}	% v/v	-0.00055
influence of supply voltage (/ 60V)	v	% of value	0.02	MCERTS certificate MC130223	U_{v}	% v/v	0.0015
cross sensitivity at zero	iz	% of value	0	MCERTS certificate MC130223	U_{iz}	% v/v	0
cross sensitivity at span	is	% of value	0	MCERTS certificate MC130223	U_{is}	% v/v	0
maximum leak	L	% of value	1.2	day of testing	U_{L}	% v/v	0.13
uncertainty associated with calibration gas	adj	% of value	1.2	span gas calibration certificate	U_{adj}	% v/v	0.12
		combined MU				% v/v	0.28
		expanded MU 95% CI (k = 1.96)				% v/v	0.55
		expanded MU 95% CI (k = 1.96) as percentage of measured value				%	2.9

method and sampling deviations
Sampling was performed in full compliance with the Standard, technical procedure and regulatory requirements.

Part 2: Supporting Information - Appendix 2: Velocity & Flow Rate Traverse | Run 1

Supporting Information

parameter	units	value
barometric pressure	kPa	101.6
average wet density	kg/m³	0.765
average stack static pressure	Pa	-103.0
pitot tube coefficient, C_p	-	0.827

General Information

parameter	details
traverse date	28/09/2023
traverse times | performed by	12:35 - 12:39 | performed by: BM | CR | CM
standard | technical procedure	EN 16911-1 | TR 17078 | TP-04a
device used	S-type Pitot with KIMO MP 210 (500Pa module)

Limit of Detection (LOD) is 1 m/s for this device combination

Quality Assurance

parameter	details
result of pitot stagnation test	Pass
result of pitot leak check (pre)	Pass
result of pitot leak check (post)	Pass
water droplets present	No

NM = Not Measured

Line A

static pressure = -103 Pa

Pt	Depth | m	ΔP | Pa	Temp | °C	Vel | m/s	Swirl | °
1	0.04	223.0	178.1	19.9	< 15

Part 2: Supporting Information - Appendix 2: Velocity & Flow Rate Traverse | Run 1

Measurement Uncertainty (MU) Calculations

parameter	units	value
standard uncertainty on the coefficient of the pitot tube	-	0.0015
standard uncertainty associated with the mean local dynamic pressures	Pa	3.6
standard uncertainty associated with the molar mass of the gas	-	0.000034
standard uncertainty associated with the temperature	K	2.3
standard uncertainty associated with the absolute pressure in the duct	Pa	176
standard uncertainty associated with the density of the gas effluent	kg/m³	0.0042
standard uncertainty associated with the local velocities	m/s	0.17
standard uncertainty associated with the mean velocity	m/s	0.17

parameter	units	value
standard uncertainty associated with the mean velocity (95% CI)	m/s	0.33
standard uncertainty associated with the mean velocity (95% CI), relative	%	1.7
standard uncertainty associated with the volume flow rate @ actual (95% CI)	m³/hr	17.4
standard uncertainty associated with the volume flow rate @ actual (95% CI), relative	%	4.8
standard uncertainty associated with the volume flow rate @ ref 1 (95% CI)	m³/hr	10.5
standard uncertainty associated with the volume flow rate @ ref 1 (95% CI), relative	%	4.8

method and sampling deviations
Sampling was performed in full compliance with the Standard, technical procedure and regulatory requirements.

Stack Emissions Monitoring Report

commissioned by Ellgia Ltd

Job Reference: JOB-838

Operator Name
Ellgia Ltd | Scunthorpe

Operator Address
Pitt Bottom, Winterton Road
Scunthorpe, North Lincolnshire
DN15 0DH
EPR Permit

Report Date | Version Number
11/10/2023 | Version 1

Dates of the Monitoring Campaign
27/09/2023 - 28/09/2023

Release Point
P182 - SRF Line

Atesta Ltd Primary Contact
Alastair Wolff | m: 07506 729 226
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Monitoring Report Written By
Ben Metcalfe | Team Leader
MCERTS Level 2 | MM 21 1659 | TE1 TE4 | expires on 29/10/2026

Monitoring Report Approved By
Matt Pendlebury | Technical Support Manager
MCERTS Level 2 | MM 04 535 | TE1 TE2 TE3 TE4 | expires on 17/06/2024

Report Contents and Monitoring Objectives

Report Contents

Monitoring Objective

The monitoring objective was to conduct stack emissions monitoring, as requested by the customer, for a number of prescribed pollutants.

Special Requirements

There were no special requirements for this monitoring campaign.

Opinions and Interpretations

Any opinions or interpretations contained within this test report are outside the scope of Atesta's MCERTS / ISO 17025 accreditation.

Part 1: Executive Summary - Monitoring Results Summary

Monitoring Results - Summary

	EXPRESSED AS A CONCENTRATION				EXPRESSED AS A MASS EMISSION					
test parameter	**result**	**uncertainty in result +/-**	**limit** (ELV)	**units**	**result**	**uncertainty in result +/-**	**limit** (ELV)	**units**	**reference conditions**	**accreditation status**
Sulphur Dioxide	0.98	0.075		mg/m^3	0.70	0.064		g/hr	STP, wet	MCERTS
Total VOCs (as Carbon)	1.1	0.071		mg/m^3	0.77	0.064		g/hr	STP, wet	MCERTS
Oxides of Nitrogen (as NO_2)	239	6.6		mg/m^3	173	9.6		g/hr	STP, wet	MCERTS
Carbon Monoxide	95.8	3.3		mg/m^3	69.2	4.1		g/hr	STP, wet	MCERTS
Oxygen	18.5	0.52		% v/v					dry	MCERTS
Stack Gas Water Vapour	2.3	0.18		% v/v					actual	MCERTS
Stack Gas Temperature	493			°C					actual	MCERTS
Stack Gas Velocity	31.8	0.52		m/s					actual	MCERTS
Stack Gas Flow Rate (ACTUAL)	2023	97.4		m^3/hr					actual	MCERTS
Stack Gas Flow Rate (REF)	724	34.8		m^3/hr					STP, wet	MCERTS

The stack gas water vapour, temperature, velocity and flow rates in the above table are calculated as an average of all of the results recorded during this monitoring campaign

The uncertainty in the result is reported at a 95% Confidence Interval in the same units as the monitoring result. In practice, this means that 95 times out of 100, the true result will lie within the stated range.

Part 1: Executive Summary - Monitoring Results Further Details

Monitoring Results - Further Details

		EXPRESSED AS A CONCENTRATION				EXPRESSED AS A MASS EMISSION							
test parameter	**run**	**result**	**uncertainty in result +/-**	**limit** (ELV)	**units**	**result**	**uncertainty in result +/-**	**limit** (ELV)	**units**	**sampling date | times**	**run time** (mins)	**H_2O** (% v/v)	**reference conditions**
Sulphur Dioxide	R1	0.98	0.075		mg/m³	0.70	0.064		g/hr	28/09/2023 | 10:33 - 11:03	30	2.3	STP, wet
Total VOCs (as Carbon)	R1	1.1	0.071		mg/m³	0.77	0.064		g/hr	27/09/2023 | 12:57 - 13:27	30		STP, wet
Oxides of Nitrogen (as NO_2)	R1	239	6.6		mg/m³	173	9.6		g/hr	27/09/2023 | 12:57 - 13:27	30		STP, wet
Carbon Monoxide	R1	95.8	3.3		mg/m³	69.2	4.1		g/hr	27/09/2023 | 12:57 - 13:27	30		STP, wet
Oxygen	R1	18.5	0.52		% v/v					27/09/2023 | 12:57 - 13:27	30		dry
Velocity & Flow Rate Traverse	R1	31.8	0.52		m/s	2023	97.4		m³/hr	27/09/2023 | 12:38 - 12:42			actual

The uncertainty in the result is reported at a 95% Confidence Interval in the same units as the monitoring result. In practice, this means that 95 times out of 100, the true result will lie within the stated range.

Part 1: Executive Summary - Monitoring and Analytical Methods

Monitoring and Analytical Methods

where analysis required	MONITORING					ANALYSIS					
test parameter	**laboratory**	**accreditation number**	**technical procedure**	**reference method**	**monitoring status**	**laboratory**	**accreditation number**	**analytical procedure**	**analytical technique**	**analysis status**	**accreditation status**
Sulphur Dioxide	ATA	10706	TP-10	EN 14791	MCERTS	RPS	0605	C27	IC	MCERTS	MCERTS

where analysis not required	MONITORING					
test parameter	**laboratory**	**accreditation number**	**technical procedure**	**reference method**	**monitoring status**	**measurement technique & equipment**	**accreditation status**
Total VOCs (as Carbon)	ATA	10706	TP-21b	EN 12619	MCERTS	FID using iFID Mobile	MCERTS
Oxides of Nitrogen (as NO_2)	ATA	10706	TP-22a	EN 14792	MCERTS	Chemiluminescence using Horiba PG-350E	MCERTS
Carbon Monoxide	ATA	10706	TP-22b	EN 15058	MCERTS	NDIR using Horiba PG-350E	MCERTS
Oxygen	ATA	10706	TP-22d	EN 14789	MCERTS	Paramagnetism using Horiba PG-350E	MCERTS
Velocity & Flow Rate Traverse	ATA	10706	TP-04a	EN 16911-1 | TR 17078	MCERTS	Pitot Tube, Thermocouple & Thermomanometer	MCERTS

Summary of Monitoring Deviations (from Appendix 2)

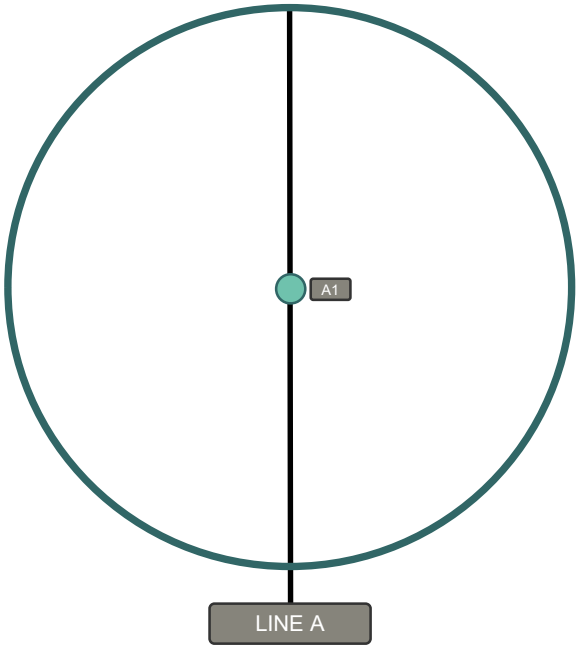
test parameter	run	details of monitoring deviation
All	1	There were no deviations associated with the monitoring employed.

Part 1: Executive Summary - Monitoring Location

Monitoring Location Photos

Identification of Sampling Points on a Duct Diagram

refer to Appendix 2 - Raw Data to see how the points on this diagram relate to the points used for each test



Part 1: Executive Summary - Duct and Sampling Platform Information

Duct Characteristics | Sampling Ports

parameter	units	value
shape	-	Circular
dimensions	-	Diameter = 0.15 m
area	m²	0.02
orientation	-	Horizontal

parameter	value
primary sample port size	Hole
primary sample port depth | cm	0
primary sample ports number of sampling lines available	1

summary of all sample ports available
Hole

Sampling Location General Information

general information	details
type | location | access	On the Ground | | On Ground Level

CEMS | Abatement Systems

parameter	details
abatement system/s	N/A
CEMS installed on the stack	N/A

Sampling Plane Validation Criteria Summary (EN 15259) from Stack Traverse/s

criteria in EN 15259	units	value	allowed	compliant
lowest differential pressure	Pa	343.0	> 5 Pa	Yes
lowest traverse velocity	m/s	31.8	-	-
highest traverse velocity	m/s	31.8	-	-
mean traverse velocity	m/s	31.8	-	-
ratio traverse velocities	: 1	1.00	< 3 : 1	Yes
angle of swirl compliance	°	< 15	< 15°	Yes
no local negative flow	-	Yes	-	Yes

Part 1: Executive Summary - Sampling Location and Operating Information

Process Details

process detail	details
plume appearance on day of monitoring	No visible plume
type of process	Combustion
batch or continuous process	On Demand
fuel type	Natural Gas
feedstock	N/A
typical load / throughput of plant	Normal operation
details of any unusual process occurrences	None

Part 2: Supporting Information - Appendix 1: Monitoring Personnel, Analysis Laboratories and Test Equipment Used

Monitoring Personnel

name	position	MCERTS level | number | expiry	MCERTS technical endorsements
Ben Metcalfe	Team Leader	MCERTS Level 2 | MM 21 1659 | 29/10/2026	TE1 TE4
Chris Rhodes	Senior Team Leader	MCERTS Level 2 | MM 02 117 | 18/05/2026	TE1 TE2 TE3 TE4
Cameron Murphy	Trainee	MCERTS Trainee | MM 23 1805 | 01/09/2028	-

Analysis Laboratories

laboratory	ISO 17025 accreditation number	laboratory short name	laboratory phone number
Atesta | North West	10706	ATA	0800 970 8945
RPS Laboratories | Salford	0605	RPS	0161 872 2443

Test Equipment Used

equipment type	A-EQ ID
Source sampling console	
Low flow sampling MFCs	138
ThermoFID / iFID mobile	401
Horiba PG-350E multigas analyser	6
Gasmet DX4000 FTIR	
Gasmet PSS	
Protea AtmosFIR	
Protea PIB Pump	
Gasmet syringe calibrator	
M&C PSS5-C conditioning unit	67
Digital thermomanometer	114
Top pan balance kit	385

equipment type	A-EQ ID
Pitot	134
Calipers	
Barometer	240
Timer	399
Tape measure	26
Heated head filter	
Heated tee	
10m heated line	33
1.5m heated line	
Odour barrel	
Vacuum chamber	
Dilution probe	

equipment type	A-EQ ID
10m umbilical	
30m umbilical	
Heated probe	
Filter oven	
Ambient thermocouple	
Stack thermocouple	358
Exit thermocouple	
Condenser thermocouple	
Tubes kit thermocouple	
2-way heater controller	
Air sampling pump	
5-figure analytical balance	1

Part 2: Supporting Information - Appendix 2: Sulphur Dioxide | Run 1

Results

reference conditions are: STP, wet

parameter	units	result ± MU (95% CI)	units	result ± MU (95% CI)
Sulphur Dioxide	mg/m³	0.98 ± 0.075	g/hr	0.7 ± 0.064

Analytical Laboratory Information

parameter	details
name of analytical lab	RPS
lab analytical procedure	C27
lab analytical technique	IC | Analysis Accreditation: MCERTS
date analysis completed	11/10/2023

General Information

parameter	details
sampling date	28/09/2023
sampling times | testing team	10:33 - 11:03 | 30 minutes | tested by: BM | CR | CM
standard | technical procedure	EN 14791 | TP-10
volume metering device	Mass Flow Controller
probe material	Titanium
filter housing material	N/A
impinger material | capture media	Borosilicate Glass | H_2O_2

parameter	details
set flow rate	4 l/min
filter size, material & location	2µm Swagelok Element S/S | Out Stack | heated to N/A°C
number sampling lines available	1
number sampling lines used	1
number sampling points ideal per line	1
number sampling points used per line	1
sampling point IDs	A1

Quality Assurance

² The concentration in the last absorber was less than 5 times the analytical LOD.

		sample run			blank (taken on 28/09/2023)		
QA parameter	units	value	allowable	result	value	allowable	result
maximum allowable blank	mg/m³	-	-	-	0.72	N/A	N/A
leak test	%	1.25	2.00	Pass	1.00	2.00	Pass
absorption efficiency	%	70.2	N/A²	Pass	-	-	-
silica trap <50% faded	-	Yes	-	Pass	-	-	-
are water droplets present	-	No	-	-	-	-	-
water vapour MU	%	7.9	20.0	Pass	-	-	-

Breakdown of Results

reference conditions are: STP, wet

parameter	sample volume [m³]	LOD [mg]	impingers [front | back] [mg/l]	impinger volume [front | back] [ml]	mass total [mg]	LOD result [mg/m³]	result [mg/m³]	result reported [mg/m³]	mass emission [g/hr]
sample run	0.0685	0.018	0.19 | 0.17	247 | 117	0.067	0.27	0.98	**0.98**	0.7
blank	0.0685	0.016	0.16	310.0	0.05	0.23	0.72	**0.72**	

Part 2: Supporting Information - Appendix 2: Sulphur Dioxide | Run 1

Raw Data | Calculations

data	units	value
P_{bar}	mmHg	762.1
P_g	Pa	331.0
P_s	mmHg	764.5
V_m (metered)	m³	0.0669
C_{stp}	-	0.3592

data	units	value
m_{wts}	g	1.3
M_w	g/mol	18.0
V_{mol}	m³/mol	0.0222
T_s	°C	495.5
R_{wv} (H_2O)	% v/v	2.3

data	units	value
$\%CO_{2d}$	% v/v (est)	1.50
$\%O_{2d}$	% v/v (est)	18.00
$\%O_{2w}$	% v/v (est)	N/A
$\%N_{2d}$	% v/v	80.50
$\%O_{2ref}$	% v/v	N/A
O_{2facd}	-	N/A
O_{2facw}	-	N/A

data	units	value
M_d	g/mol	28.96
M_s	g/mol	28.70
A_s	m²	0.02
θ (sample time)	mins	30

where (est) refers to an estimated value

metered volume calculations	units	value
allow favourable O_2 correction	-	N/A
vol actual stack conditions, $V_{ma} = (V_{mstw})(T_s + 273) / (P_s) / (C_{stp})$	m³	0.1917
vol dry, $V_{mstd} = V_m$	m³	0.0669
vol wet, $V_{mstw} = (V_{mstd})(100 / (100 - R_{wv}))$	m³	0.0685
vol dry O_2, $V_{mstdO_2} = (V_{mstd}) / (O_{2facd})$	m³	N/A
vol wet O_2, $V_{mstwO_2} = (V_{mstw}) / (O_{2facw})$	m³	N/A

velocity | volume flow rate calculations	units	value
velocity of stack gas, v_s = average of all velocity measurements	m/s	31.8
stack gas flow actual stack conditions, Q_a = average of all flow rate measurements	m³/hr	2022.9

Measurement Uncertainty (MU) Calculations

parameter	units	value	standard MU	MU as %age	required standard	value	sens coeff.	MU | mg/m³
MFC meter volume, V_m	m³	0.0669	0.0003	0.50	≤2%	-	-	-
MFC volume STP, V_{mstd}	m³	-	-	-	-	0.1	14.6	0.0049
leak, L	% [1] | mg/m³ [2]	1.25 [1]	-	1.25	≤2%	0.007 [2]	1.00	0.007
laboratory result, L_r	% [1] | mg/m³ [2]	3.9 [1]	-	3.9	-	0.038 [2]	1.00	0.038
			combined MU					0.039
			expanded MU 95% CI (k = 1.96) including method deviations MU					0.075
			expanded MU 95% CI (k = 1.96) as percentage of measured value					7.7%
			expanded MU 95% CI (k = 1.96) as percentage of measured value for mass emission					9.1%

MU factor O_2 correction
N/A

overall MU for O_2 correction
N/A

method deviation factor
1.00

method and sampling deviations
Sampling was performed in full compliance with the Standard, technical procedure and regulatory requirements.

Part 2: Supporting Information - Appendix 2: Total VOCs (as Carbon) | Run 1

Results

reference conditions are: STP, wet

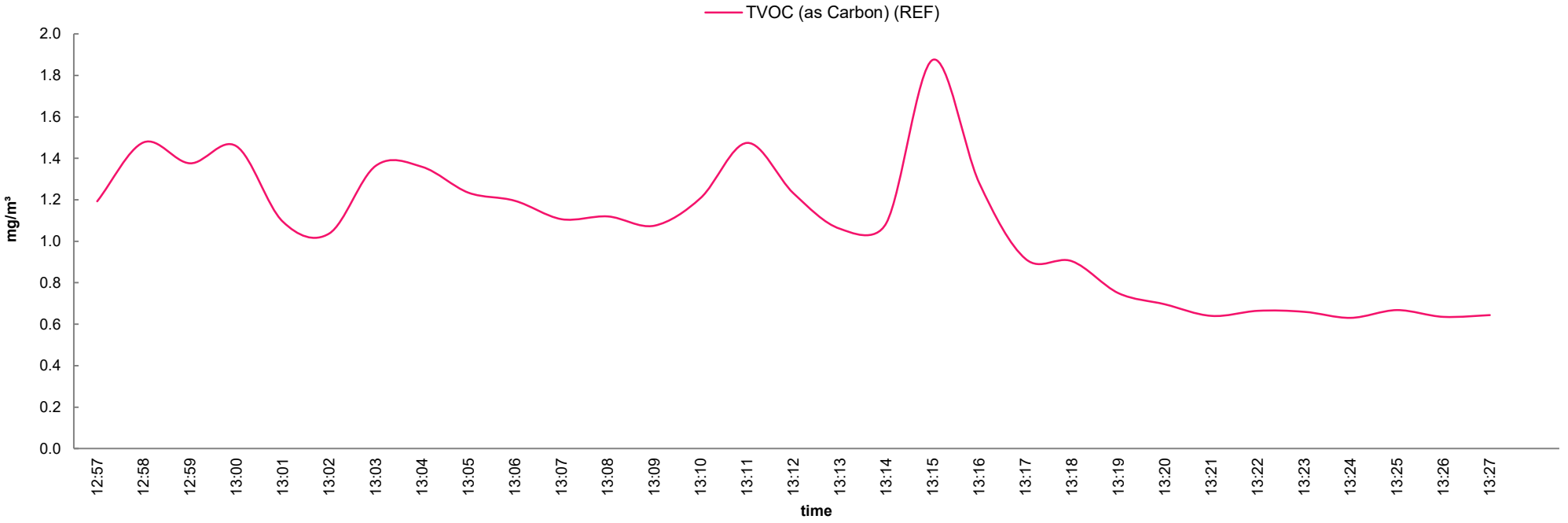
parameter	units	result ± MU (95% CI)	units	result ± MU (95% CI)
Total VOCs (as Carbon)	mg/m³	1.1 ± 0.071	g/hr	0.77 ± 0.064

General Information

parameter	details
sampling start date & time	27/09/2023 12:57
sampling end date & time	27/09/2023 13:27
test time | mins	30
testing team	BM | CR | CM
standard | technical procedure	EN 12619 | TP-21b
analyser type	iFID Mobile
heated head & line temperature	180°C

parameter	details
probe material	Titanium
filter size, material & location	2µm Swagelok Element S/S | Out Stack
number sampling lines available	1
number sampling lines used	1
number sampling points ideal per line	1
number sampling points used per line	1
sampling point IDs	A1

Plot of Emissions Over Time



Part 2: Supporting Information - Appendix 2: Total VOCs (as Carbon) | Run 1

Analyser Calibration Information with QA checks

where [A] = at analyser, [L] = down sampling line

	pre-test calibration events								post-test calibration events			quality assurance			
CAL ID	date & time	zero [A] [ppm]	span [A] [ppm]	zero [L] [ppm]	span [L] [ppm]	T_{90} [s]	leak [%]		date & time	zero [L] [ppm]	span [L] [ppm]	zero drift [%]	span drift [%]	allowable [%]	temp [°C]
1	27/09/23 10:43	0.00	79.58	1.06	79.20	15	0.5	P						±5	

Analyser Calibration Extended Information

CAL ID	performed by	drift corr. applied	log period [s]	CYL ID	CYL conc. [ppm]	CYL expiry	CYL MU [%]	zero gas type	span [CYL] gas type	span target [ppm]	range [ppm]	LOD [ppm]
1	BM		60	A-CYL-72	79.58	05/07/2027	1.0	Synthetic Air	10l 80ppm Propane in Air	79.58	AUTO	0.03

Part 2: Supporting Information - Appendix 2: Total VOCs (as Carbon) | Run 1

Measurement Uncertainty (MU) Calculations

general information	units	value
emission limit value (ELV) (REF)	mg/m³	N/A
measured concentration (REF)	mg/m³	1.1

MU budget			
parameter	units	min	max
ambient temp	°C	12.0	12.0
voltage	V	90.0	130.0

overall MU for O_2 correction
N/A

MU factor O_2 correction
N/A

	MU budget input parameters				MU budget		
performance characteristics	symbol	units	value	source	symbol	units	value
repeatability at zero	rz	% of value	0.05	MCERTS certificate MC050062	U_{rz}	mg/m³	0.00053
repeatability at span	rs	% of value	0.08	MCERTS certificate MC050062	U_{rs}	mg/m³	0.00085
lack of fit	lof	% of value	2	maximum allowable	U_{lof}	mg/m³	0.012
maximum short term zero drift (ABS) [after drift correction]	dz	% of value	0	day of testing	U_{dz}	mg/m³	0
maximum short term span drift (ABS) [after drift correction]	ds	% of value	0	day of testing	U_{ds}	mg/m³	0
influence of sample gas flow	f	% of value	-0.42	MCERTS certificate MC050062	U_f	mg/m³	-0.0026
influence of sample gas pressure	p	% of value	0	MCERTS certificate MC050062	U_p	mg/m³	0
influence of ambient temperature zero point (/ 35k)	tz	% of value	-2.4	MCERTS certificate MC050062	U_{tz}	mg/m³	0
influence of ambient temperature span point (/ 35k)	ts	% of value	-2.7	MCERTS certificate MC050062	U_{ts}	mg/m³	0
influence of supply voltage (/ 60V)	v	% of value	-0.46	MCERTS certificate MC050062	U_v	mg/m³	-0.0019
cross sensitivity at zero	iz	% of value	3.8	MCERTS certificate MC050062	U_{iz}	mg/m³	0.023
cross sensitivity at span	is	% of value	3.9	MCERTS certificate MC050062	U_{is}	mg/m³	0.024
maximum leak	L	% of value	0.48	day of testing	U_L	mg/m³	0.0029
uncertainty associated with calibration gas	adj	% of value	1	span gas calibration certificate	U_{adj}	mg/m³	0.0053
		combined MU				mg/m³	0.036
		expanded MU 95% CI (k = 1.96)				mg/m³	0.071
		expanded MU 95% CI (k = 1.96) as percentage of measured value				%	6.7
		expanded MU 95% CI (k = 1.96) as percentage of measured value for mass emission				%	8.2

method and sampling deviations
Sampling was performed in full compliance with the Standard, technical procedure and regulatory requirements.

Part 2: Supporting Information - Appendix 2: Oxides of Nitrogen (as NO_2) | Run 1

Results

reference conditions are: STP, wet

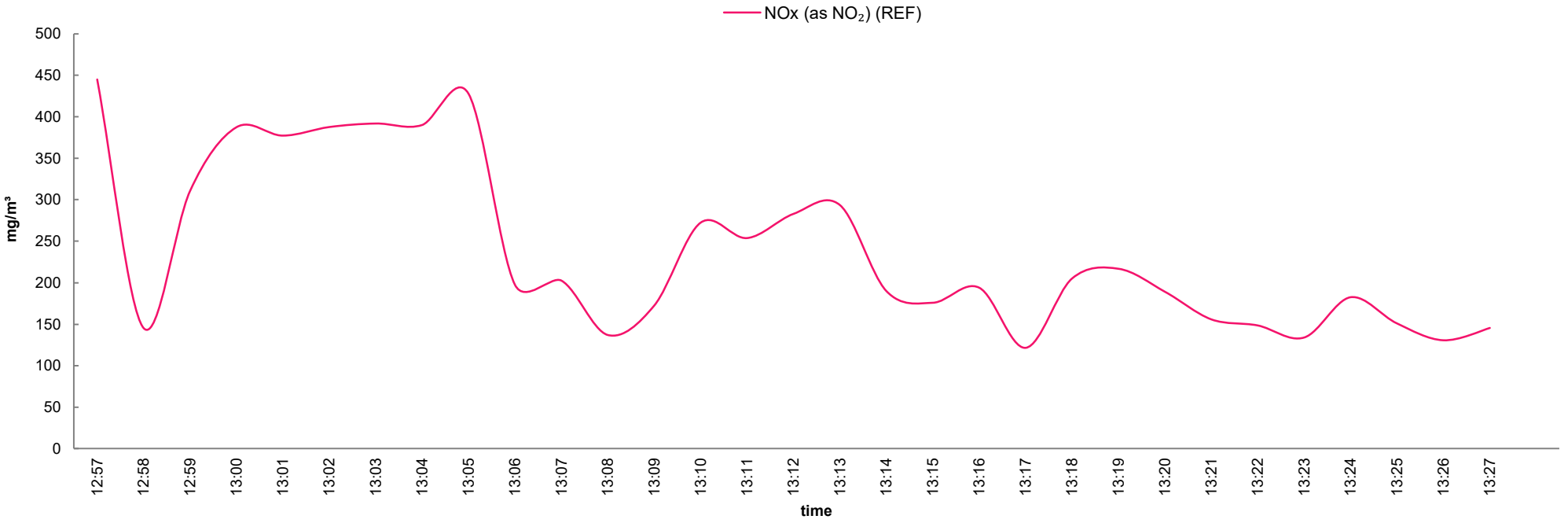
parameter	units	result ± MU (95% CI)	units	result ± MU (95% CI)
Oxides of Nitrogen (as NO_2)	mg/m³	239 ± 6.6	g/hr	173 ± 9.6

General Information

parameter	details
sampling start date & time	27/09/2023 12:57
sampling end date & time	27/09/2023 13:27
test time | mins	30
testing team	BM | CR | CM
standard | technical procedure	EN 14792 | TP-22a
analyser type	Horiba PG-350E
heated head & line temperature	180°C

parameter	details
probe material	Titanium
filter size, material & location	2µm Swagelok Element S/S | Within Heated Head
number sampling lines available	1
number sampling lines used	1
number sampling points ideal per line	1
number sampling points used per line	1
sampling point IDs	A1

Plot of Emissions Over Time



Part 2: Supporting Information - Appendix 2: Oxides of Nitrogen (as NO_2) | Run 1

Analyser Calibration Information with QA checks

where [A] = at analyser, [L] = down sampling line

	pre-test calibration events								post-test calibration events			quality assurance					
CAL ID	date & time	zero [A] [ppm]	span [A] [ppm]	zero [L] [ppm]	span [L] [ppm]	T_{90} [s]	leak [%]		date & time	zero [A] [ppm]	span [A] [ppm]	zero drift [%]		span drift [%]		allowable [%]	temp [°C]
1	27/09/23 10:51	0.00	202.12	0.00	203.10	46	0.0	P	27/09/23 00:00	0.10	193.00	0.1	P	-4.6	P	±5	13.5

Analyser Calibration Extended Information

CAL ID	performed by	drift corr. applied	log period [s]	CYL ID	CYL conc. [ppm]	CYL expiry	CYL MU [%]	zero gas type	span [CYL] gas type	span target [ppm]	range [ppm]	LOD [ppm]
1	BM	Yes	60	A-CYL-61	202.12	29/07/2025	1.2	Nitrogen 5.2	10l 200ppm NO | 160ppm CO | 16% CO2 in Nitrogen	202.12	250	0.09

Part 2: Supporting Information - Appendix 2: Oxides of Nitrogen (as NO_2) | Run 1

Measurement Uncertainty (MU) Calculations

general information	units	value
emission limit value (ELV) (REF)	mg/m³	N/A
measured concentration (REF)	mg/m³	239

MU budget			
parameter	units	min	max
ambient temp	°C	12.0	15.0
voltage	V	90.0	130.0

overall MU for O_2 correction
N/A

MU factor O_2 correction
N/A

	MU budget input parameters				MU budget		
performance characteristics	symbol	units	value	source	symbol	units	value
repeatability at zero	rz	% of value	0	MCERTS certificate MC130223	U_{rz}	mg/m³	0
repeatability at span	rs	% of value	0.1	MCERTS certificate MC130223	U_{rs}	mg/m³	0.24
lack of fit	lof	% of value	2	maximum allowable	U_{lof}	mg/m³	2.8
maximum short term zero drift (ABS) [after drift correction]	dz	% of value	0	day of testing	U_{dz}	mg/m³	0
maximum short term span drift (ABS) [after drift correction]	ds	% of value	0	day of testing	U_{ds}	mg/m³	0
influence of sample gas flow	f	% of value	0.1	MCERTS certificate MC130223	U_f	mg/m³	0.14
influence of sample gas pressure	p	% of value	0	MCERTS certificate MC130223	U_p	mg/m³	0
influence of ambient temperature zero point (/ 35k)	tz	% of value	0	MCERTS certificate MC130223	U_{tz}	mg/m³	0
influence of ambient temperature span point (/ 35k)	ts	% of value	1.8	MCERTS certificate MC130223	U_{ts}	mg/m³	0.12
influence of supply voltage (/ 60V)	v	% of value	0.4	MCERTS certificate MC130223	U_v	mg/m³	0.37
cross sensitivity at zero	iz	% of value	0.63	MCERTS certificate MC130223	U_{iz}	mg/m³	0.87
cross sensitivity at span	is	% of value	-0.52	MCERTS certificate MC130223	U_{is}	mg/m³	-0.72
maximum leak	L	% of value	0	day of testing	U_L	mg/m³	0
uncertainty associated with calibration gas	adj	% of value	1.2	span gas calibration certificate	U_{adj}	mg/m³	1.4
		combined MU				mg/m³	3.3
		expanded MU 95% CI (k = 1.96)				mg/m³	6.6
		expanded MU 95% CI (k = 1.96) as percentage of measured value				%	2.7
		expanded MU 95% CI (k = 1.96) as percentage of measured value for mass emission				%	5.5

method and sampling deviations
Sampling was performed in full compliance with the Standard, technical procedure and regulatory requirements.

Part 2: Supporting Information - Appendix 2: Carbon Monoxide | Run 1

Results

reference conditions are: STP, wet

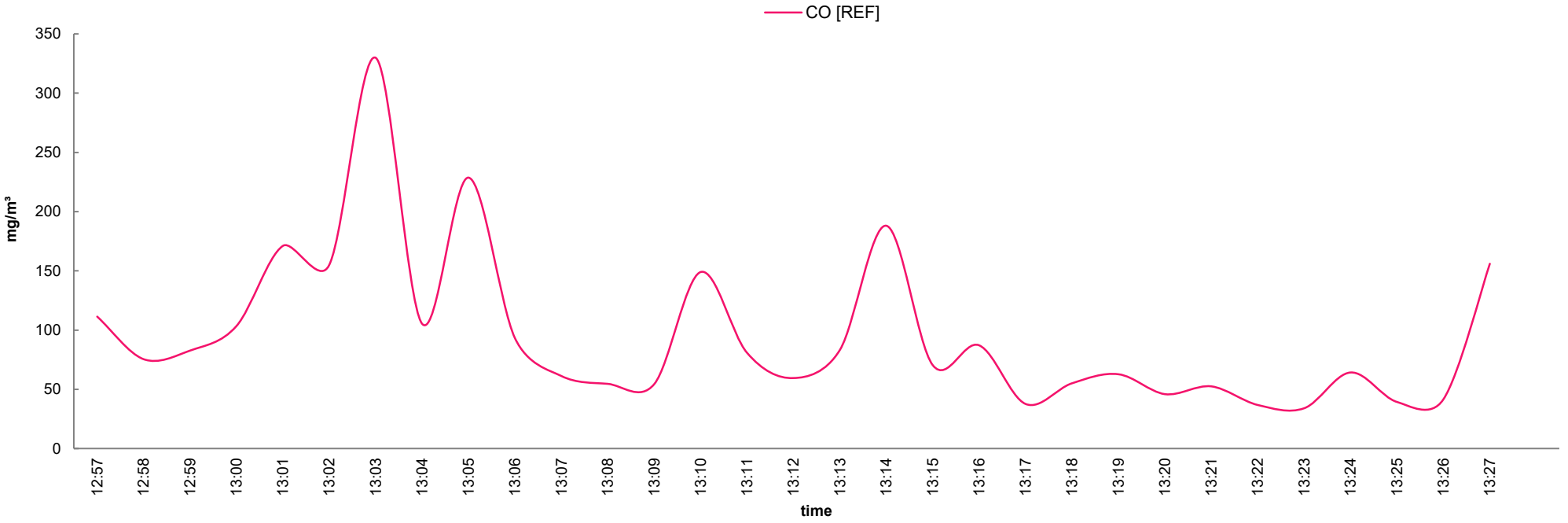
parameter	units	result ± MU (95% CI)	units	result ± MU (95% CI)
Carbon Monoxide	mg/m³	95.8 ± 3.3	g/hr	69.2 ± 4.1

General Information

parameter	details
sampling start date & time	27/09/2023 12:57
sampling end date & time	27/09/2023 13:27
test time | mins	30
testing team	BM | CR | CM
standard | technical procedure	EN 15058 | TP-22b
analyser type	Horiba PG-350E
heated head & line temperature	180°C

parameter	details
probe material	Titanium
filter size, material & location	2µm Swagelok Element S/S | Out Stack
number sampling lines available	1
number sampling lines used	1
number sampling points ideal per line	1
number sampling points used per line	1
sampling point IDs	A1

Plot of Emissions Over Time



Part 2: Supporting Information - Appendix 2: Carbon Monoxide | Run 1

Analyser Calibration Information with QA checks

where [A] = at analyser, [L] = down sampling line

	pre-test calibration events								post-test calibration events			quality assurance					
CAL ID	date & time	zero [A] [ppm]	span [A] [ppm]	zero [L] [ppm]	span [L] [ppm]	T_{90} [s]	leak [%]		date & time	zero [A] [ppm]	span [A] [ppm]	zero drift [%]		span drift [%]		allowable [%]	temp [°C]
1	27/09/23 10:51	0.00	157.90	-0.50	155.00	35	1.8	P	27/09/23 00:00	-0.80	152.00	-0.1	P	-3.7	P	±5	13.5

Analyser Calibration Extended Information

CAL ID	performed by	drift corr. applied	log period [s]	CYL ID	CYL conc. [ppm]	CYL expiry	CYL MU [%]	zero gas type	span [CYL] gas type	span target [ppm]	range [ppm]	LOD [ppm]
1	BM	Yes	60	A-CYL-61	157.90	29/07/2025	1.0	Nitrogen 5.2	10l 200ppm NO | 160ppm CO | 16% CO2 in Nitrogen	157.90	200	0.32

Part 2: Supporting Information - Appendix 2: Carbon Monoxide | Run 1

Measurement Uncertainty (MU) Calculations

general information	units	value
emission limit value (ELV) (REF)	mg/m³	N/A
measured concentration (REF)	mg/m³	95.8

MU budget			
parameter	units	min	max
ambient temp	°C	12.0	15.0
voltage	V	90.0	130.0

overall MU for O_2 correction
N/A

MU factor O_2 correction
N/A

	MU budget input parameters				MU budget		
performance characteristics	symbol	units	value	source	symbol	units	value
repeatability at zero	rz	% of value	0.1	MCERTS certificate MC130223	U_{rz}	mg/m³	0.096
repeatability at span	rs	% of value	0.2	MCERTS certificate MC130223	U_{rs}	mg/m³	0.19
lack of fit	lof	% of value	2	maximum allowable	U_{lof}	mg/m³	1.1
maximum short term zero drift (ABS) [after drift correction]	dz	% of value	0	day of testing	U_{dz}	mg/m³	0
maximum short term span drift (ABS) [after drift correction]	ds	% of value	0	day of testing	U_{ds}	mg/m³	0
influence of sample gas flow	f	% of value	0.1	MCERTS certificate MC130223	U_f	mg/m³	0.055
influence of sample gas pressure	p	% of value	0	MCERTS certificate MC130223	U_p	mg/m³	0
influence of ambient temperature zero point (/ 35k)	tz	% of value	-0.2	MCERTS certificate MC130223	U_{tz}	mg/m³	-0.0055
influence of ambient temperature span point (/ 35k)	ts	% of value	2	MCERTS certificate MC130223	U_{ts}	mg/m³	0.055
influence of supply voltage (/ 60V)	v	% of value	0.5	MCERTS certificate MC130223	U_v	mg/m³	0.18
cross sensitivity at zero	iz	% of value	-0.48	MCERTS certificate MC130223	U_{iz}	mg/m³	-0.27
cross sensitivity at span	is	% of value	-0.87	MCERTS certificate MC130223	U_{is}	mg/m³	-0.48
maximum leak	L	% of value	1.8	day of testing	U_L	mg/m³	1
uncertainty associated with calibration gas	adj	% of value	1	span gas calibration certificate	U_{adj}	mg/m³	0.49
		combined MU				mg/m³	1.7
		expanded MU 95% CI (k = 1.96)				mg/m³	3.3
		expanded MU 95% CI (k = 1.96) as percentage of measured value				%	3.5
		expanded MU 95% CI (k = 1.96) as percentage of measured value for mass emission				%	5.9

method and sampling deviations
Sampling was performed in full compliance with the Standard, technical procedure and regulatory requirements.

Part 2: Supporting Information - Appendix 2: Oxygen | Run 1

Results

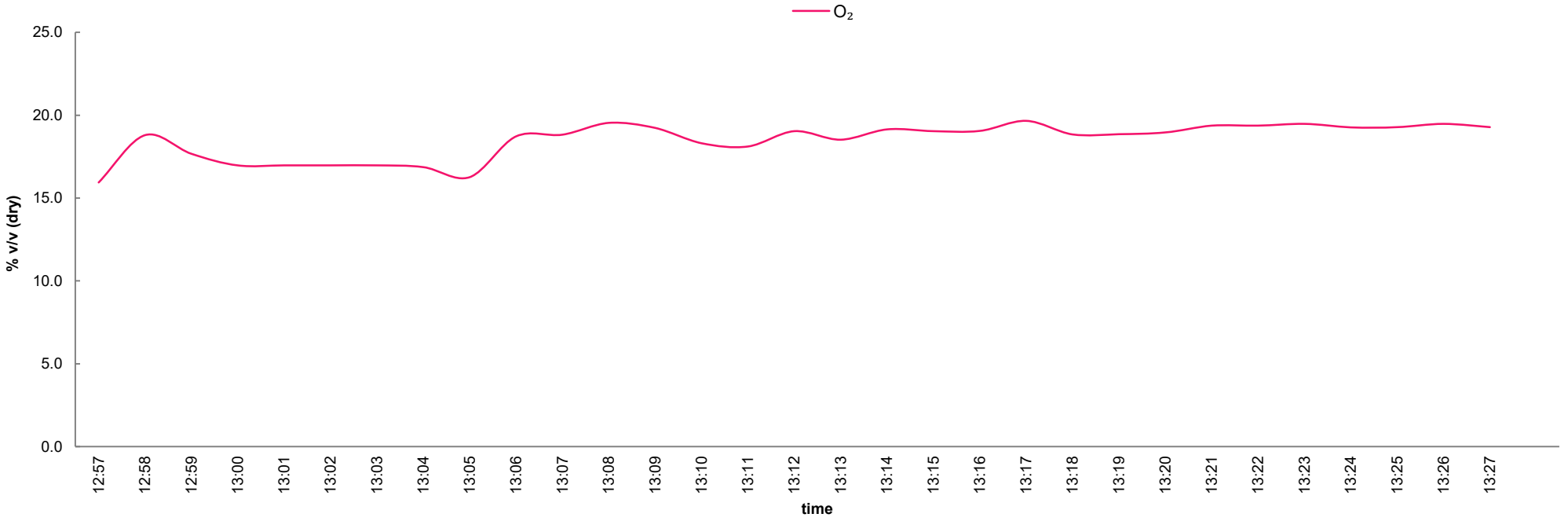
parameter	units	result ± MU (95% CI)
Oxygen	% v/v	18.5 ± 0.52

General Information

parameter	details
sampling start date & time	27/09/2023 12:57
sampling end date & time	27/09/2023 13:27
test time | mins	30
testing team	BM | CR | CM
standard | technical procedure	EN 14789 | TP-22d
analyser type	Horiba PG-350E
heated head & line temperature	180°C

parameter	details
probe material	Titanium
filter size, material & location	2µm Swagelok Element S/S | Out Stack
number sampling lines available	1
number sampling lines used	1
number sampling points ideal per line	1
number sampling points used per line	1
sampling point IDs	A1

Plot of Emissions Over Time



Part 2: Supporting Information - Appendix 2: Oxygen | Run 1

Analyser Calibration Information with QA checks

where [A] = at analyser, [L] = down sampling line

	pre-test calibration events								post-test calibration events			quality assurance					
CAL ID	date & time	zero [A] [% v/v]	span [A] [% v/v]	zero [L] [% v/v]	span [L] [% v/v]	T_{90} [s]	leak [%]		date & time	zero [A] [% v/v]	span [A] [% v/v]	zero drift [%]		span drift [%]		allowable [%]	temp [°C]
1	27/09/23 10:51	0.00	21.29	-0.06	21.06	47	1.1	P	27/09/23 00:00	0.15	20.90	0.9	P	-2.7	P	±5	13.5

Analyser Calibration Extended Information

CAL ID	performed by	drift corr. applied	log period [s]	CYL ID	CYL conc. [% v/v]	CYL expiry	CYL MU [%]	zero gas type	span [CYL] gas type	span target [% v/v]	range [% v/v]	LOD [% v/v]
1	BM	Yes	60	A-CYL-105	21.29	22/06/2028	1.2	Nitrogen 5.2	10l Synthetic Air	21.29	25	0.03

Part 2: Supporting Information - Appendix 2: Oxygen | Run 1

Measurement Uncertainty (MU) Calculations

general information	units	value
measured concentration (dry)	% v/v	18.5

MU budget			
parameter	units	min	max
ambient temp	°C	12.0	15.0
voltage	V	90.0	130.0

	MU budget input parameters				MU budget		
performance characteristics	symbol	units	value	source	symbol	units	value
repeatability at zero	rz	% of value	0.02	MCERTS certificate MC130223	U_{rz}	% v/v	0.0037
repeatability at span	rs	% of value	0.02	MCERTS certificate MC130223	U_{rs}	% v/v	0.0037
lack of fit	lof	% of value	2	maximum allowable	U_{lof}	% v/v	0.21
maximum short term zero drift (ABS) [after drift correction]	dz	% of value	0	day of testing	U_{dz}	% v/v	0
maximum short term span drift (ABS) [after drift correction]	ds	% of value	0	day of testing	U_{ds}	% v/v	0
influence of sample gas flow	f	% of value	-0.01	MCERTS certificate MC130223	U_{f}	% v/v	-0.0011
influence of sample gas pressure	p	% of value	0	MCERTS certificate MC130223	U_{p}	% v/v	0
influence of ambient temperature zero point (/ 35k)	tz	% of value	-0.4	MCERTS certificate MC130223	U_{tz}	% v/v	-0.0021
influence of ambient temperature span point (/ 35k)	ts	% of value	-0.15	MCERTS certificate MC130223	U_{ts}	% v/v	-0.00079
influence of supply voltage (/ 60V)	v	% of value	0.02	MCERTS certificate MC130223	U_{v}	% v/v	0.0014
cross sensitivity at zero	iz	% of value	0	MCERTS certificate MC130223	U_{iz}	% v/v	0
cross sensitivity at span	is	% of value	0	MCERTS certificate MC130223	U_{is}	% v/v	0
maximum leak	L	% of value	1.1	day of testing	U_{L}	% v/v	0.12
uncertainty associated with calibration gas	adj	% of value	1.2	span gas calibration certificate	U_{adj}	% v/v	0.11
		combined MU				% v/v	0.27
		expanded MU 95% CI (k = 1.96)				% v/v	0.52
		expanded MU 95% CI (k = 1.96) as percentage of measured value				%	2.8

method and sampling deviations
Sampling was performed in full compliance with the Standard, technical procedure and regulatory requirements.

Part 2: Supporting Information - Appendix 2: Velocity & Flow Rate Traverse | Run 1

Supporting Information

parameter	units	value
barometric pressure	kPa	101.3
average wet density	kg/m³	0.459
average stack static pressure	Pa	331.0
pitot tube coefficient, C_p	-	0.827

General Information

parameter	details
traverse date	27/09/2023
traverse times | performed by	12:38 - 12:42 | performed by: BM | CR | CM
standard | technical procedure	EN 16911-1 | TR 17078 | TP-04a
device used	S-type Pitot with KIMO MP 210 (500Pa module)

Limit of Detection (LOD) is 1 m/s for this device combination

Quality Assurance

parameter	details
result of pitot stagnation test	Pass
result of pitot leak check (pre)	Pass
result of pitot leak check (post)	Pass
water droplets present	No

NM = Not Measured

Line A

static pressure = 331 Pa

Pt	Depth | m	ΔP | Pa	Temp | °C	Vel | m/s	Swirl | °
1	0.08	343.0	491.0	31.8	< 15

Part 2: Supporting Information - Appendix 2: Velocity & Flow Rate Traverse | Run 1

Measurement Uncertainty (MU) Calculations

parameter	units	value
standard uncertainty on the coefficient of the pitot tube	-	0.0015
standard uncertainty associated with the mean local dynamic pressures	Pa	5.4
standard uncertainty associated with the molar mass of the gas	-	0.000024
standard uncertainty associated with the temperature	K	3.9
standard uncertainty associated with the absolute pressure in the duct	Pa	176
standard uncertainty associated with the density of the gas effluent	kg/m³	0.0025
standard uncertainty associated with the local velocities	m/s	0.27
standard uncertainty associated with the mean velocity	m/s	0.27

parameter	units	value
standard uncertainty associated with the mean velocity (95% CI)	m/s	0.52
standard uncertainty associated with the mean velocity (95% CI), relative	%	1.6
standard uncertainty associated with the volume flow rate @ actual (95% CI)	m³/hr	97.4
standard uncertainty associated with the volume flow rate @ actual (95% CI), relative	%	4.8
standard uncertainty associated with the volume flow rate @ ref 1 (95% CI)	m³/hr	34.8
standard uncertainty associated with the volume flow rate @ ref 1 (95% CI), relative	%	4.8

method and sampling deviations
Sampling was performed in full compliance with the Standard, technical procedure and regulatory requirements.

Stack Emissions Monitoring Report

commissioned by Ellgia Ltd

Job Reference: JOB-838

Operator Name
Ellgia Ltd | Scunthorpe

Operator Address
Pitt Bottom, Winterton Road
Scunthorpe, North Lincolnshire
DN15 0DH
EPR Permit

Report Date | Version Number
11/10/2023 | Version 1

Dates of the Monitoring Campaign
27/09/2023

Release Point
P183 - SRF Line

Atesta Ltd Primary Contact
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Monitoring Report Written By
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MCERTS Level 2 | MM 21 1659 | TE1 TE4 | expires on 29/10/2026

Monitoring Report Approved By
Matt Pendlebury | Technical Support Manager
MCERTS Level 2 | MM 04 535 | TE1 TE2 TE3 TE4 | expires on 17/06/2024

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Report Contents and Monitoring Objectives

Report Contents

TITLE PAGE

CONTENTS AND MONITORING OBJECTIVES

PART 1: EXECUTIVE SUMMARY
- Monitoring Results
- Monitoring and Analytical Methods (incorporating Method Deviations if applicable)
- Monitoring Location
- Duct and Sampling Platform Information
- Operating Information

PART 2: SUPPORTING INFORMATION
- Appendix 1 - Monitoring Personnel, Analysis Laboratories and Test Equipment Used
- Appendix 2 - Results and Calculations

Monitoring Objective

The monitoring objective was to conduct stack emissions monitoring to demonstrate compliance against a set of emission limit values (ELVs) as specified in the Site's Environmental Permit.

Special Requirements

There were no special requirements for this monitoring campaign.

Opinions and Interpretations

Any opinions or interpretations contained within this test report are outside the scope of Atesta's MCERTS / ISO 17025 accreditation.

Part 1: Executive Summary - Monitoring Results Summary

Monitoring Results - Summary

	EXPRESSED AS A CONCENTRATION				EXPRESSED AS A MASS EMISSION					
test parameter	**result**	**uncertainty in result +/-**	**limit** (ELV)	**units**	**result**	**uncertainty in result +/-**	**limit** (ELV)	**units**	**reference conditions**	**accreditation status**
Sulphur Dioxide	5.2	0.42		mg/m^3	4.1	0.39		g/hr	STP, wet	MCERTS
Total VOCs (as Carbon)	1.1	0.079		mg/m^3	0.89	0.075		g/hr	STP, wet	MCERTS
Oxides of Nitrogen (as NO_2)	271	7.4		mg/m^3	213	11.8		g/hr	STP, wet	MCERTS
Carbon Monoxide	99.2	3.4		mg/m^3	78.0	4.6		g/hr	STP, wet	MCERTS
Oxygen	18.4	0.52		% v/v					dry	MCERTS
Stack Gas Water Vapour	5.0	0.25		% v/v					actual	MCERTS
Stack Gas Temperature	520			°C					actual	MCERTS
Stack Gas Velocity	35.8	0.58		m/s					actual	MCERTS
Stack Gas Flow Rate (ACTUAL)	2280	110		m^3/hr					actual	MCERTS
Stack Gas Flow Rate (REF)	788	37.9		m^3/hr					STP, wet	MCERTS

The stack gas water vapour, temperature, velocity and flow rates in the above table are calculated as an average of all of the results recorded during this monitoring campaign

The uncertainty in the result is reported at a 95% Confidence Interval in the same units as the monitoring result. In practice, this means that 95 times out of 100, the true result will lie within the stated range.

Part 1: Executive Summary - Monitoring Results Further Details

Monitoring Results - Further Details

		EXPRESSED AS A CONCENTRATION				EXPRESSED AS A MASS EMISSION							
test parameter	**run**	**result**	**uncertainty in result +/-**	**limit** (ELV)	**units**	**result**	**uncertainty in result +/-**	**limit** (ELV)	**units**	**sampling date | times**	**run time** (mins)	**H_2O** (% v/v)	**reference conditions**
Sulphur Dioxide	R1	5.2	0.42		mg/m³	4.1	0.39		g/hr	28/09/2023 | 10:33 - 11:03	30	5.0	STP, wet
Total VOCs (as Carbon)	R1	1.1	0.079		mg/m³	0.89	0.075		g/hr	27/09/2023 | 12:07 - 12:37	30		STP, wet
Oxides of Nitrogen (as NO_2)	R1	271	7.4		mg/m³	213	11.8		g/hr	27/09/2023 | 12:07 - 12:37	30		STP, wet
Carbon Monoxide	R1	99.2	3.4		mg/m³	78.0	4.6		g/hr	27/09/2023 | 12:07 - 12:37	30		STP, wet
Oxygen	R1	18.4	0.52		% v/v					27/09/2023 | 12:07 - 12:37	30		dry
Velocity & Flow Rate Traverse	R1	35.8	0.58		m/s	2280	110		m³/hr	27/09/2023 | 13:03 - 13:08			actual

The uncertainty in the result is reported at a 95% Confidence Interval in the same units as the monitoring result. In practice, this means that 95 times out of 100, the true result will lie within the stated range.

Part 1: Executive Summary - Monitoring and Analytical Methods

Monitoring and Analytical Methods

where analysis required	MONITORING					ANALYSIS					
test parameter	**laboratory**	**accreditation number**	**technical procedure**	**reference method**	**monitoring status**	**laboratory**	**accreditation number**	**analytical procedure**	**analytical technique**	**analysis status**	**accreditation status**
Sulphur Dioxide	ATA	10706	TP-10	EN 14791	MCERTS	RPS	0605	C27	IC	MCERTS	MCERTS

where analysis not required	MONITORING					
test parameter	**laboratory**	**accreditation number**	**technical procedure**	**reference method**	**monitoring status**	**measurement technique & equipment**	**accreditation status**
Total VOCs (as Carbon)	ATA	10706	TP-21b	EN 12619	MCERTS	FID using iFID Mobile	MCERTS
Oxides of Nitrogen (as NO_2)	ATA	10706	TP-22a	EN 14792	MCERTS	Chemiluminescence using Horiba PG-350E	MCERTS
Carbon Monoxide	ATA	10706	TP-22b	EN 15058	MCERTS	NDIR using Horiba PG-350E	MCERTS
Oxygen	ATA	10706	TP-22d	EN 14789	MCERTS	Paramagnetism using Horiba PG-350E	MCERTS
Velocity & Flow Rate Traverse	ATA	10706	TP-04a	EN 16911-1 | TR 17078	MCERTS	Pitot Tube, Thermocouple & Thermomanometer	MCERTS

Summary of Monitoring Deviations (from Appendix 2)

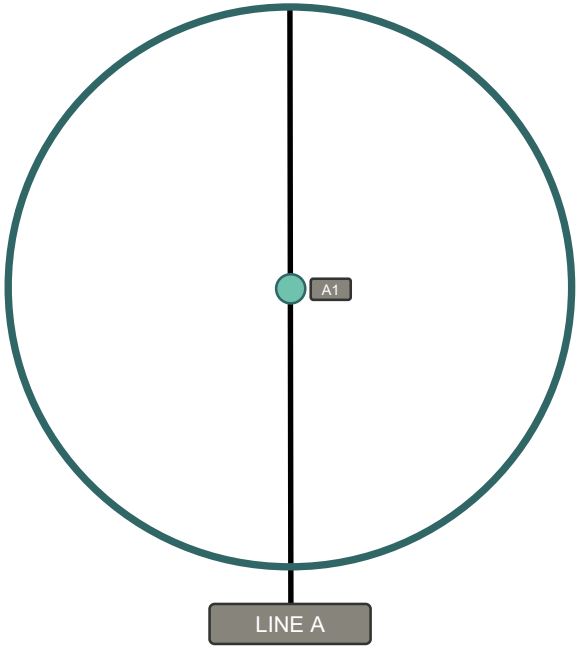
test parameter	run	details of monitoring deviation
All	1	There were no deviations associated with the monitoring employed.

Part 1: Executive Summary - Monitoring Location

Monitoring Location Photos

Identification of Sampling Points on a Duct Diagram

refer to Appendix 2 - Raw Data to see how the points on this diagram relate to the points used for each test



Part 1: Executive Summary - Duct and Sampling Platform Information

Duct Characteristics | Sampling Ports

parameter	units	value
shape	-	Circular
dimensions	-	Diameter = 0.15 m
area	m²	0.02
orientation	-	Horizontal

parameter	value
primary sample port size	Hole
primary sample port depth | cm	0
primary sample ports number of sampling lines available	1

summary of all sample ports available
Hole

Sampling Location General Information

general information	details
type | location | access	On the Ground | | On Ground Level

CEMS | Abatement Systems

parameter	details
abatement system/s	N/A
CEMS installed on the stack	N/A

Sampling Plane Validation Criteria Summary (EN 15259) from Stack Traverse/s

criteria in EN 15259	units	value	allowed	compliant
lowest differential pressure	Pa	416.8	> 5 Pa	Yes
lowest traverse velocity	m/s	35.8	-	-
highest traverse velocity	m/s	35.8	-	-
mean traverse velocity	m/s	35.8	-	-
ratio traverse velocities	: 1	1.00	< 3 : 1	Yes
angle of swirl compliance	°	< 15	< 15°	Yes
no local negative flow	-	Yes	-	Yes

Part 1: Executive Summary - Sampling Location and Operating Information

Process Details

process detail	details
plume appearance on day of monitoring	No visible plume
type of process	Combustion
batch or continuous process	On Demand
fuel type	Natural Gas
feedstock	N/A
typical load / throughput of plant	Normal operation
details of any unusual process occurrences	None

Part 2: Supporting Information - Appendix 1: Monitoring Personnel, Analysis Laboratories and Test Equipment Used

Monitoring Personnel

name	position	MCERTS level | number | expiry	MCERTS technical endorsements
Ben Metcalfe	Team Leader	MCERTS Level 2 | MM 21 1659 | 29/10/2026	TE1 TE4
Chris Rhodes	Senior Team Leader	MCERTS Level 2 | MM 02 117 | 18/05/2026	TE1 TE2 TE3 TE4
Cameron Murphy	Trainee	MCERTS Trainee | MM 23 1805 | 01/09/2028	-

Analysis Laboratories

laboratory	ISO 17025 accreditation number	laboratory short name	laboratory phone number
Atesta | North West	10706	ATA	0800 970 8945
RPS Laboratories | Salford	0605	RPS	0161 872 2443

Test Equipment Used

equipment type	A-EQ ID
Source sampling console	49
Low flow sampling MFCs	
ThermoFID / iFID mobile	401
Horiba PG-350E multigas analyser	6
Gasmet DX4000 FTIR	
Gasmet PSS	
Protea AtmosFIR	
Protea PIB Pump	
Gasmet syringe calibrator	
M&C PSS5-C conditioning unit	67
Digital thermomanometer	114
Top pan balance kit	385

equipment type	A-EQ ID
Pitot	134
Calipers	
Barometer	240
Timer	399
Tape measure	26
Heated head filter	
Heated tee	
10m heated line	33
1.5m heated line	
Odour barrel	
Vacuum chamber	
Dilution probe	

equipment type	A-EQ ID
10m umbilical	125
30m umbilical	
Heated probe	
Filter oven	
Ambient thermocouple	
Stack thermocouple	358
Exit thermocouple	
Condenser thermocouple	
Tubes kit thermocouple	
2-way heater controller	
Air sampling pump	
5-figure analytical balance	1

Part 2: Supporting Information - Appendix 2: Sulphur Dioxide | Run 1

Results

reference conditions are: STP, wet

parameter	units	result ± MU (95% CI)	units	result ± MU (95% CI)
Sulphur Dioxide	mg/m³	5.2 ± 0.42	g/hr	4.1 ± 0.39

Analytical Laboratory Information

parameter	details
name of analytical lab	RPS
lab analytical procedure	C27
lab analytical technique	IC | Analysis Accreditation: MCERTS
date analysis completed	11/10/2023

General Information

parameter	details
sampling date	28/09/2023
sampling times | testing team	10:33 - 11:03 | 30 minutes | tested by: BM | CR | CM
standard | technical procedure	EN 14791 | TP-10
volume metering device	XD-502 Digital Source Sampling Console
probe material	Titanium
filter housing material	Titanium
impinger material | capture media	Borosilicate Glass | H_2O_2

parameter	details
filter size, material & location	47mm QF | Out Stack | heated to N/A°C
number sampling lines available	1
number sampling lines used	1
number sampling points ideal per line	1
number sampling points used per line	1
sampling point IDs	A1

Quality Assurance

		sample run			blank (taken on 28/09/2023)		
QA parameter	units	value	allowable	result	value	allowable	result
maximum allowable blank	mg/m³	-	-	-	0.81	N/A	N/A
leak test	%	0.20	2.00	Pass	2.00	2.00	Pass
absorption efficiency	%	95.7	95	Pass	-	-	-
silica trap <50% faded	-	Yes	-	Pass	-	-	-
are water droplets present	-	No	-	-	-	-	-
water vapour MU	%	4.9	20.0	Pass	-	-	-

Breakdown of Results

reference conditions are: STP, wet

parameter	sample volume [m³]	LOD [mg]	impingers [front | back] [mg/l]	impinger volume [front | back] [ml]	mass total [mg]	LOD result [mg/m³]	result [mg/m³]	result reported [mg/m³]	mass emission [g/hr]
sample run	0.0614	0.018	1 | 0.32	307 | 43	0.32	0.28	5.2	**5.2**	4.1
blank	0.0614	0.016	0.16	310.0	0.05	0.25	0.81	**0.81**	

Part 2: Supporting Information - Appendix 2: Sulphur Dioxide | Run 1

Raw Data | Calculations

data	units	value
P_{bar}	mmHg	762.1
P_g	Pa	361.0
$\Delta H_@$	mmH_2O	42.1
P_m	mmHg	765.2
P_s	mmHg	764.8
V_m (metered)	m³	0.0609
Y_d	-	1.0178
C_{stp}	-	0.3592

data	units	value
T_m	°C	18.0
ΔH_{av}	Pa	25.0
m_{wts}	g	2.5
M_w	g/mol	18.0
V_{mol}	m³/mol	0.0222
T_s	°C	523.0
R_{wv} (H_2O)	% v/v	5.0

data	units	value
$\%CO_{2d}$	% v/v (est)	1.50
$\%O_{2d}$	% v/v (est)	18.00
$\%O_{2w}$	% v/v (est)	N/A
$\%N_{2d}$	% v/v	80.50
$\%O_{2ref}$	% v/v	N/A
O_{2facd}	-	N/A
O_{2facw}	-	N/A

data	units	value
M_d	g/mol	28.96
M_s	g/mol	28.41
A_s	m²	0.02
θ (sample time)	mins	30

where (est) refers to an estimated value

metered volume calculations	units	value
allow favourable O_2 correction	-	N/A
vol actual stack conditions, $V_{ma} = (V_{mstw})(T_s + 273) / (P_s) / (C_{stp})$	m³	0.1779
vol dry, $V_{mstd} = (V_m)(Y_d)(C_{stp})((P_{bar} + (\Delta H_{av} / 9.80665 / 13.6)) / (T_m + 273))$	m³	0.0583
vol wet, $V_{mstw} = (V_{mstd})(100 / (100 - R_{wv}))$	m³	0.0614
vol dry O_2, $V_{mstdO_2} = (V_{mstd}) / (O_{2facd})$	m³	N/A
vol wet O_2, $V_{mstwO_2} = (V_{mstw}) / (O_{2facw})$	m³	N/A

velocity | volume flow rate calculations	units	value
velocity of stack gas, v_s = average of all velocity measurements	m/s	35.8
stack gas flow actual stack conditions, Q_a = average of all flow rate measurements	m³/hr	2280.2

Measurement Uncertainty (MU) Calculations

parameter	units	value	standard MU	MU as %age	required standard	value	sens coeff.	MU | mg/m³
DGM meter volume, V_m	m³	0.0609	0.0003	0.50	≤2%	-	-	-
DGM temperature, T_m	K	291.0	2.0	0.69	≤1%	-	-	-
DGM pressure, P_m	kPa	102.0	0.50	0.49	≤1%	-	-	-
DGM humidity, H_m	% v/v	0	1.0	1.00	≤1%	-	-	-
DGM volume STP, V_{mstd}	m³	-	-	-	-	0.0583	89.56	0.074
leak, L	% [1] | mg/m³ [2]	0.48 [1]	-	0.48	≤2%	0.015 [2]	1.00	0.015
laboratory result, L_r	% [1] | mg/m³ [2]	3.9 [1]	-	3.9	-	0.2 [2]	1.00	0.2
			combined MU					0.21
			expanded MU 95% CI (k = 1.96) including method deviations MU					0.42
			expanded MU 95% CI (k = 1.96) as percentage of measured value					8.1%
			expanded MU 95% CI (k = 1.96) as percentage of measured value for mass emission					9.4%

MU factor O_2 correction
N/A

overall MU for O_2 correction
N/A

method deviation factor
1.00

method and sampling deviations
Sampling was performed in full compliance with the Standard, technical procedure and regulatory requirements.

Part 2: Supporting Information - Appendix 2: Total VOCs (as Carbon) | Run 1

Results

reference conditions are: STP, wet

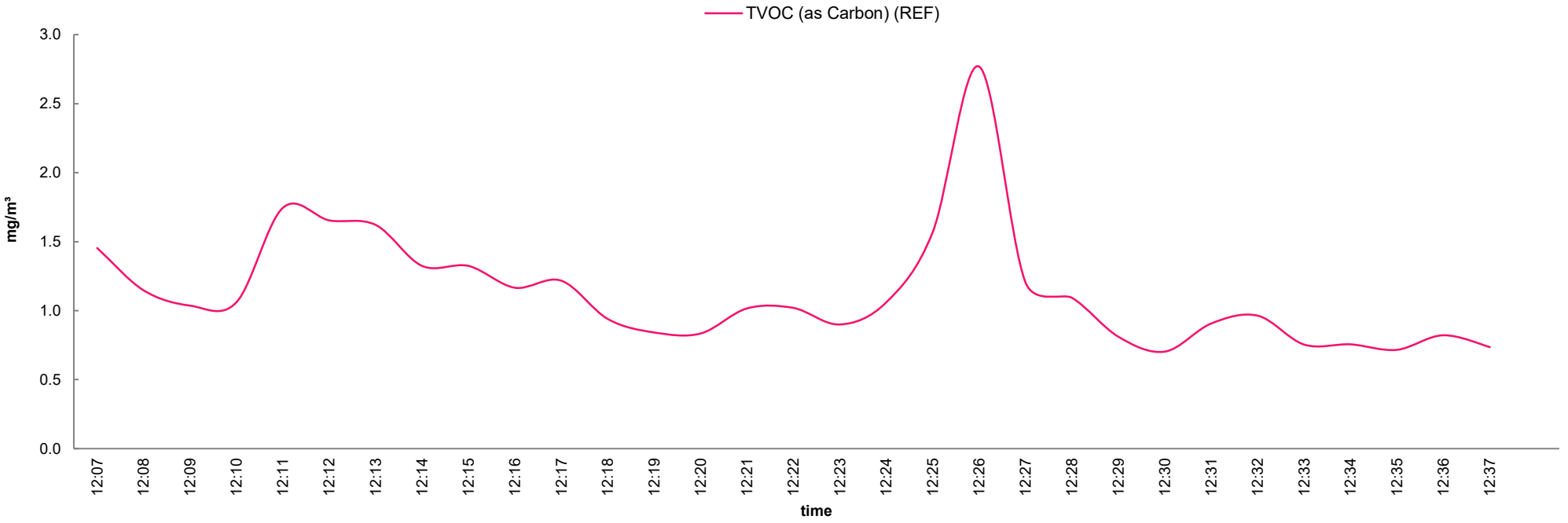
parameter	units	result ± MU (95% CI)	units	result ± MU (95% CI)
Total VOCs (as Carbon)	mg/m³	1.1 ± 0.079	g/hr	0.89 ± 0.075

General Information

parameter	details
sampling start date & time	27/09/2023 12:07
sampling end date & time	27/09/2023 12:37
test time | mins	30
testing team	BM | CR | CM
standard | technical procedure	EN 12619 | TP-21b
analyser type	iFID Mobile
heated head & line temperature	180°C

parameter	details
probe material	Titanium
filter size, material & location	2µm Swagelok Element S/S | Out Stack
number sampling lines available	1
number sampling lines used	1
number sampling points ideal per line	1
number sampling points used per line	1
sampling point IDs	A1

Plot of Emissions Over Time



Part 2: Supporting Information - Appendix 2: Total VOCs (as Carbon) | Run 1

Analyser Calibration Information with QA checks

where [A] = at analyser, [L] = down sampling line

	pre-test calibration events								post-test calibration events			quality assurance					
CAL ID	date & time	zero [A] [ppm]	span [A] [ppm]	zero [L] [ppm]	span [L] [ppm]	T_{90} [s]	leak [%]		date & time	zero [L] [ppm]	span [L] [ppm]	zero drift [%]		span drift [%]		allowable [%]	temp [°C]
1	27/09/23 10:43	0.00	79.58	1.06	79.20	15	0.5	P	27/09/23 13:42	-0.20	78.20	-1.6	P	0.3	P	±5	13.5

Analyser Calibration Extended Information

CAL ID	performed by	drift corr. applied	log period [s]	CYL ID	CYL conc. [ppm]	CYL expiry	CYL MU [%]	zero gas type	span [CYL] gas type	span target [ppm]	range [ppm]	LOD [ppm]
1	BM	No	60	A-CYL-72	79.58	05/07/2027	1.0	Synthetic Air	10l 80ppm Propane in Air	79.58	AUTO	0.03

Part 2: Supporting Information - Appendix 2: Total VOCs (as Carbon) | Run 1

Measurement Uncertainty (MU) Calculations

general information	units	value
emission limit value (ELV) (REF)	mg/m³	N/A
measured concentration (REF)	mg/m³	1.1

MU budget			
parameter	units	min	max
ambient temp	°C	12.0	15.0
voltage	V	90.0	130.0

overall MU for O_2 correction
N/A

MU factor O_2 correction
N/A

	MU budget input parameters				MU budget		
performance characteristics	symbol	units	value	source	symbol	units	value
repeatability at zero	rz	% of value	0.05	MCERTS certificate MC050062	U_{rz}	mg/m³	0.00057
repeatability at span	rs	% of value	0.08	MCERTS certificate MC050062	U_{rs}	mg/m³	0.00091
lack of fit	lof	% of value	2	maximum allowable	U_{lof}	mg/m³	0.013
maximum short term zero drift (ABS) [after drift correction]	dz	% of value	1.6	day of testing	U_{dz}	mg/m³	0.011
maximum short term span drift (ABS) [after drift correction]	ds	% of value	0.33	day of testing	U_{ds}	mg/m³	0.0021
influence of sample gas flow	f	% of value	-0.42	MCERTS certificate MC050062	U_f	mg/m³	-0.0028
influence of sample gas pressure	p	% of value	0	MCERTS certificate MC050062	U_p	mg/m³	0
influence of ambient temperature zero point (/ 35k)	tz	% of value	-2.4	MCERTS certificate MC050062	U_{tz}	mg/m³	-0.00078
influence of ambient temperature span point (/ 35k)	ts	% of value	-2.7	MCERTS certificate MC050062	U_{ts}	mg/m³	-0.00088
influence of supply voltage (/ 60V)	v	% of value	-0.46	MCERTS certificate MC050062	U_v	mg/m³	-0.002
cross sensitivity at zero	iz	% of value	3.8	MCERTS certificate MC050062	U_{iz}	mg/m³	0.025
cross sensitivity at span	is	% of value	3.9	MCERTS certificate MC050062	U_{is}	mg/m³	0.026
maximum leak	L	% of value	0.48	day of testing	U_L	mg/m³	0.0031
uncertainty associated with calibration gas	adj	% of value	1	span gas calibration certificate	U_{adj}	mg/m³	0.0057
		combined MU				mg/m³	0.04
		expanded MU 95% CI (k = 1.96)				mg/m³	0.079
		expanded MU 95% CI (k = 1.96) as percentage of measured value				%	6.9
		expanded MU 95% CI (k = 1.96) as percentage of measured value for mass emission				%	8.4

method and sampling deviations
Sampling was performed in full compliance with the Standard, technical procedure and regulatory requirements.

Part 2: Supporting Information - Appendix 2: Oxides of Nitrogen (as NO_2) | Run 1

Results

reference conditions are: STP, wet

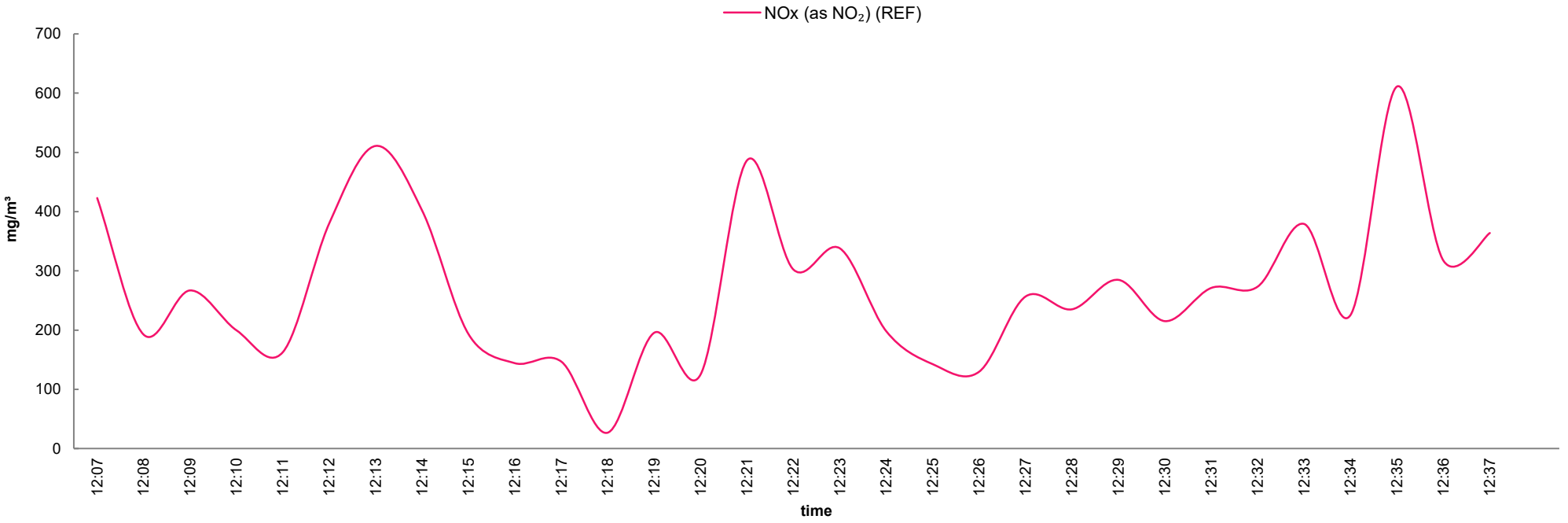
parameter	units	result ± MU (95% CI)	units	result ± MU (95% CI)
Oxides of Nitrogen (as NO_2)	mg/m³	271 ± 7.4	g/hr	213 ± 11.8

General Information

parameter	details
sampling start date & time	27/09/2023 12:07
sampling end date & time	27/09/2023 12:37
test time | mins	30
testing team	BM | CR | CM
standard | technical procedure	EN 14792 | TP-22a
analyser type	Horiba PG-350E
heated head & line temperature	180°C

parameter	details
probe material	Titanium
filter size, material & location	2µm Swagelok Element S/S | Within Heated Head
number sampling lines available	1
number sampling lines used	1
number sampling points ideal per line	1
number sampling points used per line	1
sampling point IDs	A1

Plot of Emissions Over Time



Part 2: Supporting Information - Appendix 2: Oxides of Nitrogen (as NO_2) | Run 1

Analyser Calibration Information with QA checks

where [A] = at analyser, [L] = down sampling line

	pre-test calibration events								post-test calibration events			quality assurance					
CAL ID	date & time	zero [A] [ppm]	span [A] [ppm]	zero [L] [ppm]	span [L] [ppm]	T_{90} [s]	leak [%]		date & time	zero [A] [ppm]	span [A] [ppm]	zero drift [%]		span drift [%]		allowable [%]	temp [°C]
1	27/09/23 10:51	0.00	202.12	0.00	203.10	46	0.0	P	27/09/23 14:00	0.10	193.00	0.1	P	-4.6	P	±5	13.5

Analyser Calibration Extended Information

CAL ID	performed by	drift corr. applied	log period [s]	CYL ID	CYL conc. [ppm]	CYL expiry	CYL MU [%]	zero gas type	span [CYL] gas type	span target [ppm]	range [ppm]	LOD [ppm]
1	BM	Yes	60	A-CYL-61	202.12	29/07/2025	1.2	Nitrogen 5.2	10l 200ppm NO | 160ppm CO | 16% CO2 in Nitrogen	202.12	250	0.09

Part 2: Supporting Information - Appendix 2: Oxides of Nitrogen (as NO_2) | Run 1

Measurement Uncertainty (MU) Calculations

general information	units	value
emission limit value (ELV) (REF)	mg/m³	N/A
measured concentration (REF)	mg/m³	271

MU budget			
parameter	units	min	max
ambient temp	°C	12.0	15.0
voltage	V	90.0	130.0

overall MU for O_2 correction
N/A

MU factor O_2 correction
N/A

	MU budget input parameters				MU budget		
performance characteristics	symbol	units	value	source	symbol	units	value
repeatability at zero	rz	% of value	0	MCERTS certificate MC130223	U_{rz}	mg/m³	0
repeatability at span	rs	% of value	0.1	MCERTS certificate MC130223	U_{rs}	mg/m³	0.27
lack of fit	lof	% of value	2	maximum allowable	U_{lof}	mg/m³	3.1
maximum short term zero drift (ABS) [after drift correction]	dz	% of value	0	day of testing	U_{dz}	mg/m³	0
maximum short term span drift (ABS) [after drift correction]	ds	% of value	0	day of testing	U_{ds}	mg/m³	0
influence of sample gas flow	f	% of value	0.1	MCERTS certificate MC130223	U_f	mg/m³	0.16
influence of sample gas pressure	p	% of value	0	MCERTS certificate MC130223	U_p	mg/m³	0
influence of ambient temperature zero point (/ 35k)	tz	% of value	0	MCERTS certificate MC130223	U_{tz}	mg/m³	0
influence of ambient temperature span point (/ 35k)	ts	% of value	1.8	MCERTS certificate MC130223	U_{ts}	mg/m³	0.14
influence of supply voltage (/ 60V)	v	% of value	0.4	MCERTS certificate MC130223	U_v	mg/m³	0.42
cross sensitivity at zero	iz	% of value	0.63	MCERTS certificate MC130223	U_{iz}	mg/m³	0.99
cross sensitivity at span	is	% of value	-0.52	MCERTS certificate MC130223	U_{is}	mg/m³	-0.81
maximum leak	L	% of value	0	day of testing	U_L	mg/m³	0
uncertainty associated with calibration gas	adj	% of value	1.2	span gas calibration certificate	U_{adj}	mg/m³	1.6
		combined MU				mg/m³	3.8
		expanded MU 95% CI (k = 1.96)				mg/m³	7.4
		expanded MU 95% CI (k = 1.96) as percentage of measured value				%	2.7
		expanded MU 95% CI (k = 1.96) as percentage of measured value for mass emission				%	5.5

method and sampling deviations
Sampling was performed in full compliance with the Standard, technical procedure and regulatory requirements.

Part 2: Supporting Information - Appendix 2: Carbon Monoxide | Run 1

Results

reference conditions are: STP, wet

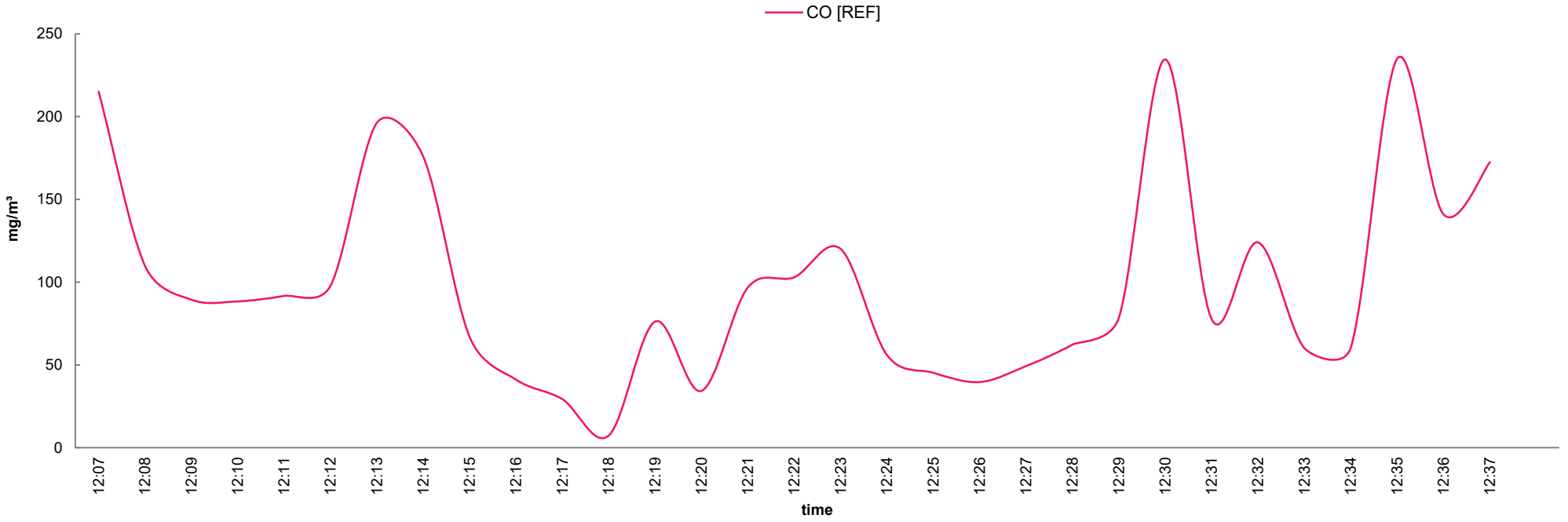
parameter	units	result ± MU (95% CI)	units	result ± MU (95% CI)
Carbon Monoxide	mg/m³	99.2 ± 3.4	g/hr	78 ± 4.6

General Information

parameter	details
sampling start date & time	27/09/2023 12:07
sampling end date & time	27/09/2023 12:37
test time | mins	30
testing team	BM | CR | CM
standard | technical procedure	EN 15058 | TP-22b
analyser type	Horiba PG-350E
heated head & line temperature	180°C

parameter	details
probe material	Titanium
filter size, material & location	2µm Swagelok Element S/S | Out Stack
number sampling lines available	1
number sampling lines used	1
number sampling points ideal per line	1
number sampling points used per line	1
sampling point IDs	A1

Plot of Emissions Over Time



Part 2: Supporting Information - Appendix 2: Carbon Monoxide | Run 1

Analyser Calibration Information with QA checks

where [A] = at analyser, [L] = down sampling line

	pre-test calibration events								post-test calibration events			quality assurance					
CAL ID	date & time	zero [A] [ppm]	span [A] [ppm]	zero [L] [ppm]	span [L] [ppm]	T_{90} [s]	leak [%]		date & time	zero [A] [ppm]	span [A] [ppm]	zero drift [%]		span drift [%]		allowable [%]	temp [°C]
1	27/09/23 10:51	0.00	157.90	-0.50	155.00	35	1.8	P	27/09/23 14:00	-0.80	152.00	-0.1	P	-3.7	P	±5	13.5

Analyser Calibration Extended Information

CAL ID	performed by	drift corr. applied	log period [s]	CYL ID	CYL conc. [ppm]	CYL expiry	CYL MU [%]	zero gas type	span [CYL] gas type	span target [ppm]	range [ppm]	LOD [ppm]
1	BM	Yes	60	A-CYL-61	157.90	29/07/2025	1.0	Nitrogen 5.2	10l 200ppm NO | 160ppm CO | 16% CO2 in Nitrogen	157.90	200	0.32

Part 2: Supporting Information - Appendix 2: Carbon Monoxide | Run 1

Measurement Uncertainty (MU) Calculations

general information	units	value
emission limit value (ELV) (REF)	mg/m³	N/A
measured concentration (REF)	mg/m³	99.2

MU budget			
parameter	units	min	max
ambient temp	°C	12.0	15.0
voltage	V	90.0	130.0

overall MU for O_2 correction
N/A

MU factor O_2 correction
N/A

	MU budget input parameters				MU budget		
performance characteristics	symbol	units	value	source	symbol	units	value
repeatability at zero	rz	% of value	0.1	MCERTS certificate MC130223	U_{rz}	mg/m³	0.099
repeatability at span	rs	% of value	0.2	MCERTS certificate MC130223	U_{rs}	mg/m³	0.2
lack of fit	lof	% of value	2	maximum allowable	U_{lof}	mg/m³	1.1
maximum short term zero drift (ABS) [after drift correction]	dz	% of value	0	day of testing	U_{dz}	mg/m³	0
maximum short term span drift (ABS) [after drift correction]	ds	% of value	0	day of testing	U_{ds}	mg/m³	0
influence of sample gas flow	f	% of value	0.1	MCERTS certificate MC130223	U_f	mg/m³	0.057
influence of sample gas pressure	p	% of value	0	MCERTS certificate MC130223	U_p	mg/m³	0
influence of ambient temperature zero point (/ 35k)	tz	% of value	-0.2	MCERTS certificate MC130223	U_{tz}	mg/m³	-0.0057
influence of ambient temperature span point (/ 35k)	ts	% of value	2	MCERTS certificate MC130223	U_{ts}	mg/m³	0.057
influence of supply voltage (/ 60V)	v	% of value	0.5	MCERTS certificate MC130223	U_v	mg/m³	0.19
cross sensitivity at zero	iz	% of value	-0.48	MCERTS certificate MC130223	U_{iz}	mg/m³	-0.27
cross sensitivity at span	is	% of value	-0.87	MCERTS certificate MC130223	U_{is}	mg/m³	-0.5
maximum leak	L	% of value	1.8	day of testing	U_L	mg/m³	1.1
uncertainty associated with calibration gas	adj	% of value	1	span gas calibration certificate	U_{adj}	mg/m³	0.51
		combined MU				mg/m³	1.8
		expanded MU 95% CI (k = 1.96)				mg/m³	3.4
		expanded MU 95% CI (k = 1.96) as percentage of measured value				%	3.5
		expanded MU 95% CI (k = 1.96) as percentage of measured value for mass emission				%	5.9

method and sampling deviations
Sampling was performed in full compliance with the Standard, technical procedure and regulatory requirements.

Part 2: Supporting Information - Appendix 2: Oxygen | Run 1

Results

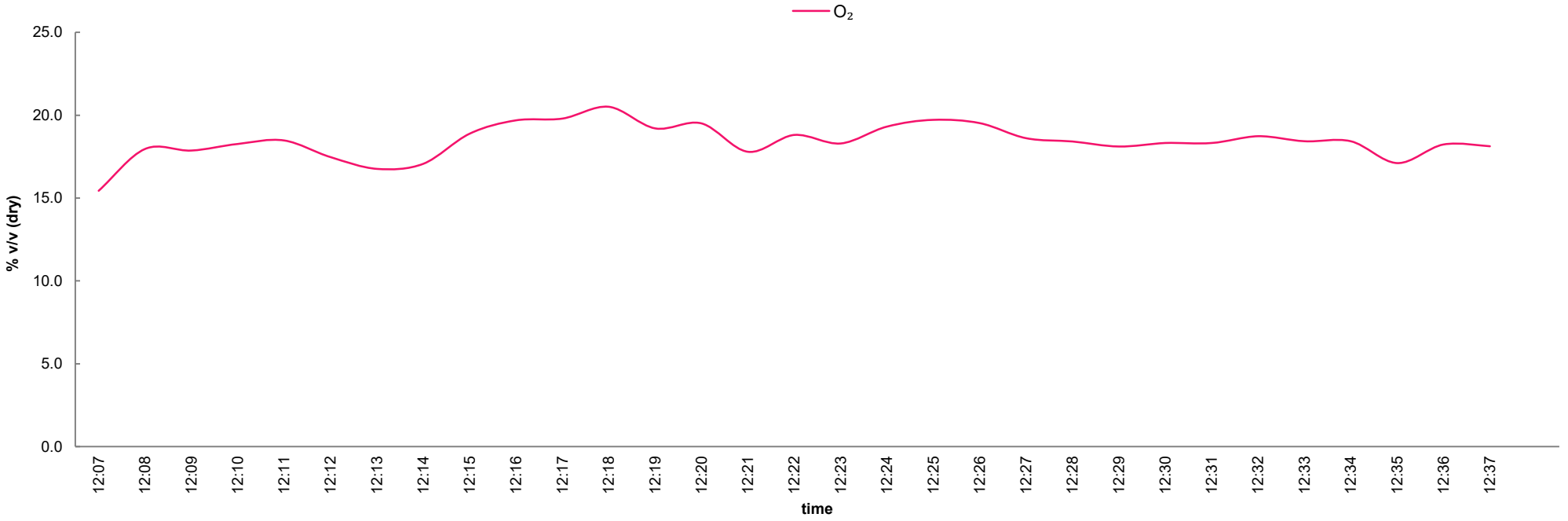
parameter	units	result ± MU (95% CI)
Oxygen	% v/v	18.4 ± 0.52

General Information

parameter	details
sampling start date & time	27/09/2023 12:07
sampling end date & time	27/09/2023 12:37
test time | mins	30
testing team	BM | CR | CM
standard | technical procedure	EN 14789 | TP-22d
analyser type	Horiba PG-350E
heated head & line temperature	180°C

parameter	details
probe material	Titanium
filter size, material & location	2µm Swagelok Element S/S | Within Heated Head
number sampling lines available	1
number sampling lines used	1
number sampling points ideal per line	1
number sampling points used per line	1
sampling point IDs	A1

Plot of Emissions Over Time



Part 2: Supporting Information - Appendix 2: Oxygen | Run 1

Analyser Calibration Information with QA checks

where [A] = at analyser, [L] = down sampling line

	pre-test calibration events								post-test calibration events			quality assurance					
CAL ID	date & time	zero [A] [% v/v]	span [A] [% v/v]	zero [L] [% v/v]	span [L] [% v/v]	T_{90} [s]	leak [%]		date & time	zero [A] [% v/v]	span [A] [% v/v]	zero drift [%]		span drift [%]		allowable [%]	temp [°C]
1	27/09/23 10:51	0.00	21.29	-0.06	21.06	47	1.1	P	27/09/23 14:00	0.15	20.90	0.9	P	-2.7	P	±5	13.5

Analyser Calibration Extended Information

CAL ID	performed by	drift corr. applied	log period [s]	CYL ID	CYL conc. [% v/v]	CYL expiry	CYL MU [%]	zero gas type	span [CYL] gas type	span target [% v/v]	range [% v/v]	LOD [% v/v]
1	BM	Yes	60	A-CYL-105	21.29	22/06/2028	1.2	Nitrogen 5.2	10l Synthetic Air	21.29	25	0.03

Part 2: Supporting Information - Appendix 2: Oxygen | Run 1

Measurement Uncertainty (MU) Calculations

general information	units	value
measured concentration (dry)	% v/v	18.4

MU budget			
parameter	units	min	max
ambient temp	°C	12.0	15.0
voltage	V	90.0	130.0

	MU budget input parameters				MU budget		
performance characteristics	symbol	units	value	source	symbol	units	value
repeatability at zero	rz	% of value	0.02	MCERTS certificate MC130223	U_{rz}	% v/v	0.0037
repeatability at span	rs	% of value	0.02	MCERTS certificate MC130223	U_{rs}	% v/v	0.0037
lack of fit	lof	% of value	2	maximum allowable	U_{lof}	% v/v	0.21
maximum short term zero drift (ABS) [after drift correction]	dz	% of value	0	day of testing	U_{dz}	% v/v	0
maximum short term span drift (ABS) [after drift correction]	ds	% of value	0	day of testing	U_{ds}	% v/v	0
influence of sample gas flow	f	% of value	-0.01	MCERTS certificate MC130223	U_{f}	% v/v	-0.0011
influence of sample gas pressure	p	% of value	0	MCERTS certificate MC130223	U_{p}	% v/v	0
influence of ambient temperature zero point (/ 35k)	tz	% of value	-0.4	MCERTS certificate MC130223	U_{tz}	% v/v	-0.0021
influence of ambient temperature span point (/ 35k)	ts	% of value	-0.15	MCERTS certificate MC130223	U_{ts}	% v/v	-0.00079
influence of supply voltage (/ 60V)	v	% of value	0.02	MCERTS certificate MC130223	U_{v}	% v/v	0.0014
cross sensitivity at zero	iz	% of value	0	MCERTS certificate MC130223	U_{iz}	% v/v	0
cross sensitivity at span	is	% of value	0	MCERTS certificate MC130223	U_{is}	% v/v	0
maximum leak	L	% of value	1.1	day of testing	U_{L}	% v/v	0.11
uncertainty associated with calibration gas	adj	% of value	1.2	span gas calibration certificate	U_{adj}	% v/v	0.11
		combined MU				% v/v	0.27
		expanded MU 95% CI (k = 1.96)				% v/v	0.52
		expanded MU 95% CI (k = 1.96) as percentage of measured value				%	2.8

method and sampling deviations
Sampling was performed in full compliance with the Standard, technical procedure and regulatory requirements.

Part 2: Supporting Information - Appendix 2: Velocity & Flow Rate Traverse | Run 1

Supporting Information

parameter	units	value
barometric pressure	kPa	101.3
average wet density	kg/m³	0.439
average stack static pressure	Pa	361.2
pitot tube coefficient, C_p	-	0.827

General Information

parameter	details
traverse date	27/09/2023
traverse times | performed by	13:03 - 13:08 | performed by: BM | CR | CM
standard | technical procedure	EN 16911-1 | TR 17078 | TP-04a
device used	S-type Pitot with KIMO MP 210 (500Pa module)

Limit of Detection (LOD) is 1 m/s for this device combination

Quality Assurance

parameter	details
result of pitot stagnation test	Pass
result of pitot leak check (pre)	Pass
result of pitot leak check (post)	Pass
water droplets present	No

NM = Not Measured

Line A

static pressure = 361.2 Pa

Pt	Depth | m	ΔP | Pa	Temp | °C	Vel | m/s	Swirl | °
1	0.08	416.8	517.9	35.8	< 15

Part 2: Supporting Information - Appendix 2: Velocity & Flow Rate Traverse | Run 1

Measurement Uncertainty (MU) Calculations

parameter	units	value
standard uncertainty on the coefficient of the pitot tube	-	0.0015
standard uncertainty associated with the mean local dynamic pressures	Pa	6.5
standard uncertainty associated with the molar mass of the gas	-	0.00003
standard uncertainty associated with the temperature	K	4
standard uncertainty associated with the absolute pressure in the duct	Pa	176
standard uncertainty associated with the density of the gas effluent	kg/m³	0.0024
standard uncertainty associated with the local velocities	m/s	0.3
standard uncertainty associated with the mean velocity	m/s	0.3

parameter	units	value
standard uncertainty associated with the mean velocity (95% CI)	m/s	0.58
standard uncertainty associated with the mean velocity (95% CI), relative	%	1.6
standard uncertainty associated with the volume flow rate @ actual (95% CI)	m³/hr	110
standard uncertainty associated with the volume flow rate @ actual (95% CI), relative	%	4.8
standard uncertainty associated with the volume flow rate @ ref 1 (95% CI)	m³/hr	37.9
standard uncertainty associated with the volume flow rate @ ref 1 (95% CI), relative	%	4.8

method and sampling deviations
Sampling was performed in full compliance with the Standard, technical procedure and regulatory requirements.

Stack Emissions Monitoring Report

commissioned by Ellgia Ltd

Job Reference: JOB-838

Operator Name
Ellgia Ltd | Scunthorpe

Operator Address
Pitt Bottom, Winterton Road
Scunthorpe, North Lincolnshire
DN15 0DH
EPR Permit

Report Date | Version Number
11/10/2023 | Version 1

Dates of the Monitoring Campaign
27/09/2023

Release Point
P193 - RDF

Atesta Ltd Primary Contact
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MCERTS Level 2 | MM 21 1659 | TE1 TE4 | expires on 29/10/2026

Monitoring Report Approved By
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Report Contents and Monitoring Objectives

Report Contents

Monitoring Objective

The monitoring objective was to conduct stack emissions monitoring to demonstrate compliance against a set of emission limit values (ELVs) as specified in the Site's Environmental Permit.

Special Requirements

There were no special requirements for this monitoring campaign.

Opinions and Interpretations

Any opinions or interpretations contained within this test report are outside the scope of Atesta's MCERTS / ISO 17025 accreditation.

Part 1: Executive Summary - Monitoring Results Summary

Monitoring Results - Summary

	EXPRESSED AS A CONCENTRATION				EXPRESSED AS A MASS EMISSION					
test parameter	**result**	**uncertainty in result +/-**	**limit** (ELV)	**units**	**result**	**uncertainty in result +/-**	**limit** (ELV)	**units**	**reference conditions**	**accreditation status**
Sulphur Dioxide	1.3	0.10		mg/m^3	2.2	0.20		g/hr	STP, wet	MCERTS
Total VOCs (as Carbon)	1.5	0.099		mg/m^3	2.5	0.21		g/hr	STP, wet	MCERTS
Oxides of Nitrogen (as NO_2)	171	5.1		mg/m^3	293	16.6		g/hr	STP, wet	MCERTS
Carbon Monoxide	89.9	3.3		mg/m^3	153	9.3		g/hr	STP, wet	MCERTS
Oxygen	19.0	0.54		% v/v					dry	MCERTS
Stack Gas Water Vapour	6.0	0.31		% v/v					actual	MCERTS
Stack Gas Temperature	188			°C					actual	MCERTS
Stack Gas Velocity	25.5	0.42		m/s					actual	MCERTS
Stack Gas Flow Rate (ACTUAL)	2879	139		m^3/hr					actual	MCERTS
Stack Gas Flow Rate (REF)	1708	82.2		m^3/hr					STP, wet	MCERTS

The stack gas water vapour, temperature, velocity and flow rates in the above table are calculated as an average of all of the results recorded during this monitoring campaign

The uncertainty in the result is reported at a 95% Confidence Interval in the same units as the monitoring result. In practice, this means that 95 times out of 100, the true result will lie within the stated range.

Part 1: Executive Summary - Monitoring Results Further Details

Monitoring Results - Further Details

		EXPRESSED AS A CONCENTRATION				EXPRESSED AS A MASS EMISSION							
test parameter	**run**	**result**	**uncertainty in result +/-**	**limit** (ELV)	**units**	**result**	**uncertainty in result +/-**	**limit** (ELV)	**units**	**sampling date | times**	**run time** (mins)	**H_2O** (% v/v)	**reference conditions**
Sulphur Dioxide	R1	1.3	0.10		mg/m³	2.2	0.20		g/hr	27/09/2023 | 15:29 - 15:59	30	6.0	STP, wet
Total VOCs (as Carbon)	R1	1.5	0.099		mg/m³	2.5	0.21		g/hr	27/09/2023 | 15:29 - 15:59	30		STP, wet
Oxides of Nitrogen (as NO_2)	R1	171	5.1		mg/m³	293	16.6		g/hr	27/09/2023 | 15:29 - 15:59	30		STP, wet
Carbon Monoxide	R1	89.9	3.3		mg/m³	153	9.3		g/hr	27/09/2023 | 15:29 - 15:59	30		STP, wet
Oxygen	R1	19.0	0.54		% v/v					27/09/2023 | 15:29 - 15:59	30		dry
Velocity & Flow Rate Traverse	R1	25.5	0.42		m/s	2879	139		m³/hr	27/09/2023 | 16:04 - 16:09			actual

The uncertainty in the result is reported at a 95% Confidence Interval in the same units as the monitoring result. In practice, this means that 95 times out of 100, the true result will lie within the stated range.

Part 1: Executive Summary - Monitoring and Analytical Methods

Monitoring and Analytical Methods

where analysis required	MONITORING					ANALYSIS					
test parameter	**laboratory**	**accreditation number**	**technical procedure**	**reference method**	**monitoring status**	**laboratory**	**accreditation number**	**analytical procedure**	**analytical technique**	**analysis status**	**accreditation status**
Sulphur Dioxide	ATA	10706	TP-10	EN 14791	MCERTS	RPS	0605	C27	IC	MCERTS	MCERTS

where analysis not required	MONITORING					
test parameter	**laboratory**	**accreditation number**	**technical procedure**	**reference method**	**monitoring status**	**measurement technique & equipment**	**accreditation status**
Total VOCs (as Carbon)	ATA	10706	TP-21b	EN 12619	MCERTS	FID using iFID Mobile	MCERTS
Oxides of Nitrogen (as NO_2)	ATA	10706	TP-22a	EN 14792	MCERTS	Chemiluminescence using Horiba PG-350E	MCERTS
Carbon Monoxide	ATA	10706	TP-22b	EN 15058	MCERTS	NDIR using Horiba PG-350E	MCERTS
Oxygen	ATA	10706	TP-22d	EN 14789	MCERTS	Paramagnetism using Horiba PG-350E	MCERTS
Velocity & Flow Rate Traverse	ATA	10706	TP-04a	EN 16911-1 | TR 17078	MCERTS	Pitot Tube, Thermocouple & Thermomanometer	MCERTS

Summary of Monitoring Deviations (from Appendix 2)

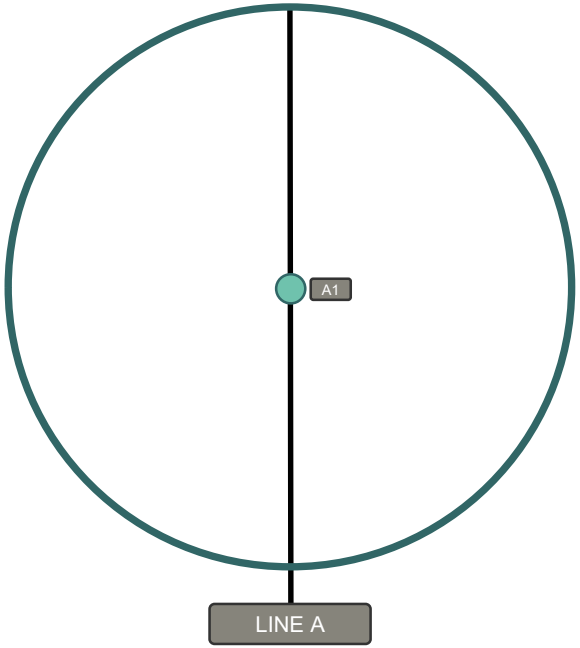
test parameter	run	details of monitoring deviation
All	1	There were no deviations associated with the monitoring employed.

Part 1: Executive Summary - Monitoring Location

Monitoring Location Photos

Identification of Sampling Points on a Duct Diagram

refer to Appendix 2 - Raw Data to see how the points on this diagram relate to the points used for each test



Part 1: Executive Summary - Duct and Sampling Platform Information

Duct Characteristics | Sampling Ports

parameter	units	value
shape	-	Circular
dimensions	-	Diameter = 0.20 m
area	m²	0.03
orientation	-	Horizontal

parameter	value
primary sample port size	Hole
primary sample port depth | cm	0
primary sample ports number of sampling lines available	1

summary of all sample ports available
Hole

Sampling Location General Information

general information	details
type | location | access	On the Ground | | On Ground Level

CEMS | Abatement Systems

parameter	details
abatement system/s	N/A
CEMS installed on the stack	N/A

Sampling Plane Validation Criteria Summary (EN 15259) from Stack Traverse/s

criteria in EN 15259	units	value	allowed	compliant
lowest differential pressure	Pa	359.0	> 5 Pa	Yes
lowest traverse velocity	m/s	25.5	-	-
highest traverse velocity	m/s	25.5	-	-
mean traverse velocity	m/s	25.5	-	-
ratio traverse velocities	: 1	1.00	< 3 : 1	Yes
angle of swirl compliance	°	< 15	< 15°	Yes
no local negative flow	-	Yes	-	Yes

Part 1: Executive Summary - Sampling Location and Operating Information

Process Details

process detail	details
plume appearance on day of monitoring	No visible plume
type of process	Combustion
batch or continuous process	On Demand
fuel type	Natural Gas
feedstock	N/A
typical load / throughput of plant	Normal operation
details of any unusual process occurrences	None

Part 2: Supporting Information - Appendix 1: Monitoring Personnel, Analysis Laboratories and Test Equipment Used

Monitoring Personnel

name	position	MCERTS level | number | expiry	MCERTS technical endorsements
Ben Metcalfe	Team Leader	MCERTS Level 2 | MM 21 1659 | 29/10/2026	TE1 TE4
Chris Rhodes	Senior Team Leader	MCERTS Level 2 | MM 02 117 | 18/05/2026	TE1 TE2 TE3 TE4
Cameron Murphy	Trainee	MCERTS Trainee | MM 23 1805 | 01/09/2028	-

Analysis Laboratories

laboratory	ISO 17025 accreditation number	laboratory short name	laboratory phone number
Atesta | North West	10706	ATA	0800 970 8945
RPS Laboratories | Salford	0605	RPS	0161 872 2443

Test Equipment Used

equipment type	A-EQ ID
Source sampling console	138
Low flow sampling MFCs	
ThermoFID / iFID mobile	401
Horiba PG-350E multigas analyser	6
Gasmet DX4000 FTIR	
Gasmet PSS	
Protea AtmosFIR	
Protea PIB Pump	
Gasmet syringe calibrator	
M&C PSS5-C conditioning unit	67
Digital thermomanometer	114
Top pan balance kit	385

equipment type	A-EQ ID
Pitot	134
Calipers	
Barometer	240
Timer	399
Tape measure	26
Heated head filter	
Heated tee	
10m heated line	33
1.5m heated line	
Odour barrel	
Vacuum chamber	
Dilution probe	

equipment type	A-EQ ID
10m umbilical	125
30m umbilical	
Heated probe	
Filter oven	
Ambient thermocouple	
Stack thermocouple	358
Exit thermocouple	
Condenser thermocouple	
Tubes kit thermocouple	
2-way heater controller	
Air sampling pump	
5-figure analytical balance	1

Part 2: Supporting Information - Appendix 2: Sulphur Dioxide | Run 1

Results

reference conditions are: STP, wet

parameter	units	result ± MU (95% CI)	units	result ± MU (95% CI)
Sulphur Dioxide	mg/m³	1.3 ± 0.1	g/hr	2.2 ± 0.2

Analytical Laboratory Information

parameter	details
name of analytical lab	RPS
lab analytical procedure	C27
lab analytical technique	IC | Analysis Accreditation: MCERTS
date analysis completed	11/10/2023

General Information

parameter	details
sampling date	27/09/2023
sampling times | testing team	15:29 - 15:59 | 30 minutes | tested by: BM | CR | CM
standard | technical procedure	EN 14791 | TP-10
volume metering device	Mass Flow Controller
probe material	Titanium
filter housing material	N/A
impinger material | capture media	Borosilicate Glass | H_2O_2

parameter	details
set flow rate	1.35 l/min
filter size, material & location	2µm Swagelok Element S/S | Out Stack | heated to N/A°C
number sampling lines available	1
number sampling lines used	1
number sampling points ideal per line	1
number sampling points used per line	1
sampling point IDs	A1

Quality Assurance

² The concentration in the last absorber was less than 5 times the analytical LOD.

		sample run			blank (taken on 28/09/2023)		
QA parameter	units	value	allowable	result	value	allowable	result
maximum allowable blank	mg/m³	-	-	-	1.2	N/A	N/A
leak test	%	0.67	2.00	Pass	2.00	2.00	Pass
absorption efficiency	%	73.1	N/A²	Pass	-	-	-
silica trap <50% faded	-	Yes	-	Pass	-	-	-
are water droplets present	-	No	-	-	-	-	-
water vapour MU	%	5.1	20.0	Pass	-	-	-

Breakdown of Results

reference conditions are: STP, wet

parameter	sample volume [m³]	LOD [mg]	impingers [front | back] [mg/l]	impinger volume [front | back] [ml]	mass total [mg]	LOD result [mg/m³]	result [mg/m³]	result reported [mg/m³]	mass emission [g/hr]
sample run	0.0431	0.017	0.17 | 0.14	240 | 107	0.056	0.4	1.3	**1.3**	2.2
blank	0.0431	0.016	0.16	310.0	0.05	0.36	1.2	**1.2**	

Part 2: Supporting Information - Appendix 2: Sulphur Dioxide | Run 1

Raw Data | Calculations

data	units	value
P_{bar}	mmHg	759.8
P_g	Pa	39.0
P_s	mmHg	760.1
V_m (metered)	m³	0.0405
C_{stp}	-	0.3592

data	units	value
m_{wts}	g	2.1
M_w	g/mol	18.0
V_{mol}	m³/mol	0.0222
T_s	°C	188.0
R_{wv} (H_2O)	% v/v	6.0

data	units	value
$\%CO_{2d}$	% v/v (est)	1.50
$\%O_{2d}$	% v/v (est)	18.00
$\%O_{2w}$	% v/v (est)	N/A
$\%N_{2d}$	% v/v	80.50
$\%O_{2ref}$	% v/v	N/A
O_{2facd}	-	N/A
O_{2facw}	-	N/A

data	units	value
M_d	g/mol	28.96
M_s	g/mol	28.30
A_s	m²	0.03
θ (sample time)	mins	30

where (est) refers to an estimated value

metered volume calculations	units	value
allow favourable O_2 correction	-	N/A
vol actual stack conditions, $V_{ma} = (V_{mstw})(T_s + 273) / (P_s) / (C_{stp})$	m³	0.0727
vol dry, $V_{mstd} = V_m$	m³	0.0405
vol wet, $V_{mstw} = (V_{mstd})(100 / (100 - R_{wv}))$	m³	0.0431
vol dry O_2, $V_{mstdO_2} = (V_{mstd}) / (O_{2facd})$	m³	N/A
vol wet O_2, $V_{mstwO_2} = (V_{mstw}) / (O_{2facw})$	m³	N/A

velocity | volume flow rate calculations	units	value
velocity of stack gas, v_s = average of all velocity measurements	m/s	25.5
stack gas flow actual stack conditions, Q_a = average of all flow rate measurements	m³/hr	2878.7

Measurement Uncertainty (MU) Calculations

parameter	units	value	standard MU	MU as %age	required standard	value	sens coeff.	MU | mg/m³
MFC meter volume, V_m	m³	0.0405	0.0002	0.50	≤2%	-	-	-
MFC volume STP, V_{mstd}	m³	-	-	-	-	0.0	32	0.0065
leak, L	% [1] | mg/m³ [2]	1.48 [1]	-	1.48	≤2%	0.011 [2]	1.00	0.011
laboratory result, L_r	% [1] | mg/m³ [2]	3.9 [1]	-	3.9	-	0.05 [2]	1.00	0.05
			combined MU					0.051
			expanded MU 95% CI (k = 1.96) including method deviations MU					0.1
			expanded MU 95% CI (k = 1.96) as percentage of measured value					7.8%
			expanded MU 95% CI (k = 1.96) as percentage of measured value for mass emission					9.2%

MU factor O_2 correction
N/A

overall MU for O_2 correction
N/A

method deviation factor
1.00

method and sampling deviations
Sampling was performed in full compliance with the Standard, technical procedure and regulatory requirements.

Part 2: Supporting Information - Appendix 2: Total VOCs (as Carbon) | Run 1

Results

reference conditions are: STP, wet

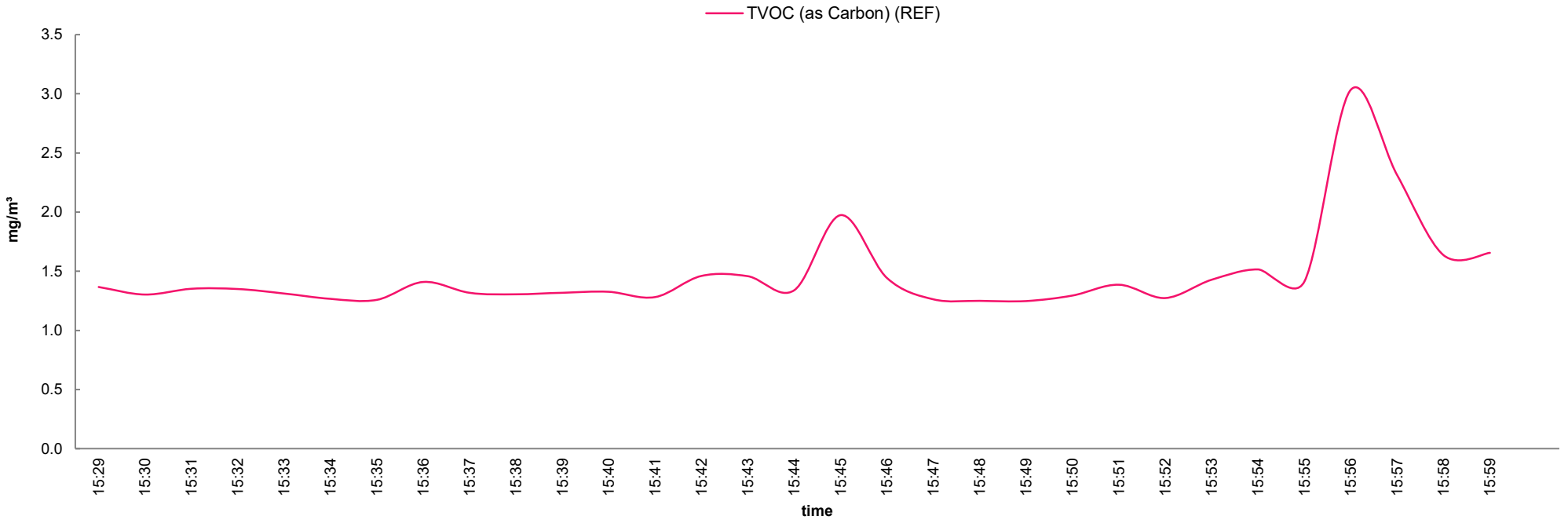
parameter	units	result ± MU (95% CI)	units	result ± MU (95% CI)
Total VOCs (as Carbon)	mg/m³	1.5 ± 0.099	g/hr	2.5 ± 0.21

General Information

parameter	details
sampling start date & time	27/09/2023 15:29
sampling end date & time	27/09/2023 15:59
test time | mins	30
testing team	BM | CR | CM
standard | technical procedure	EN 12619 | TP-21b
analyser type	iFID Mobile
heated head & line temperature	180°C

parameter	details
probe material	Titanium
filter size, material & location	2µm Swagelok Element S/S | Out Stack
number sampling lines available	1
number sampling lines used	1
number sampling points ideal per line	1
number sampling points used per line	1
sampling point IDs	A1

Plot of Emissions Over Time



Part 2: Supporting Information - Appendix 2: Total VOCs (as Carbon) | Run 1

Analyser Calibration Information with QA checks

where [A] = at analyser, [L] = down sampling line

	pre-test calibration events								post-test calibration events			quality assurance					
CAL ID	date & time	zero [A] [ppm]	span [A] [ppm]	zero [L] [ppm]	span [L] [ppm]	T_{90} [s]	leak [%]		date & time	zero [L] [ppm]	span [L] [ppm]	zero drift [%]		span drift [%]		allowable [%]	temp [°C]
1	27/09/23 14:40	0.00	79.58	0.27	79.50	11	0.1	P	27/09/23 16:19	0.16	78.90	-0.1	P	-0.6	P	±5	16.0

Analyser Calibration Extended Information

CAL ID	performed by	drift corr. applied	log period [s]	CYL ID	CYL conc. [ppm]	CYL expiry	CYL MU [%]	zero gas type	span [CYL] gas type	span target [ppm]	range [ppm]	LOD [ppm]
1	BM	No	60	A-CYL-72	79.58	05/07/2027	1.0	Synthetic Air	10l 80ppm Propane in Air	79.58	AUTO	0.03

Part 2: Supporting Information - Appendix 2: Total VOCs (as Carbon) | Run 1

Measurement Uncertainty (MU) Calculations

general information	units	value
emission limit value (ELV) (REF)	mg/m³	N/A
measured concentration (REF)	mg/m³	1.5

MU budget			
parameter	units	min	max
ambient temp	°C	16.0	16.0
voltage	V	90.0	130.0

overall MU for O_2 correction
N/A

MU factor O_2 correction
N/A

	MU budget input parameters				MU budget		
performance characteristics	symbol	units	value	source	symbol	units	value
repeatability at zero	rz	% of value	0.05	MCERTS certificate MC050062	U_{rz}	mg/m³	0.00073
repeatability at span	rs	% of value	0.08	MCERTS certificate MC050062	U_{rs}	mg/m³	0.0012
lack of fit	lof	% of value	2	maximum allowable	U_{lof}	mg/m³	0.017
maximum short term zero drift (ABS) [after drift correction]	dz	% of value	0.14	day of testing	U_{dz}	mg/m³	0.0012
maximum short term span drift (ABS) [after drift correction]	ds	% of value	0.62	day of testing	U_{ds}	mg/m³	0.0052
influence of sample gas flow	f	% of value	-0.42	MCERTS certificate MC050062	U_f	mg/m³	-0.0036
influence of sample gas pressure	p	% of value	0	MCERTS certificate MC050062	U_p	mg/m³	0
influence of ambient temperature zero point (/ 35k)	tz	% of value	-2.4	MCERTS certificate MC050062	U_{tz}	mg/m³	0
influence of ambient temperature span point (/ 35k)	ts	% of value	-2.7	MCERTS certificate MC050062	U_{ts}	mg/m³	0
influence of supply voltage (/ 60V)	v	% of value	-0.46	MCERTS certificate MC050062	U_v	mg/m³	-0.0026
cross sensitivity at zero	iz	% of value	3.8	MCERTS certificate MC050062	U_{iz}	mg/m³	0.032
cross sensitivity at span	is	% of value	3.9	MCERTS certificate MC050062	U_{is}	mg/m³	0.033
maximum leak	L	% of value	0.1	day of testing	U_L	mg/m³	0.00085
uncertainty associated with calibration gas	adj	% of value	1	span gas calibration certificate	U_{adj}	mg/m³	0.0073
		combined MU				mg/m³	0.05
		expanded MU 95% CI (k = 1.96)				mg/m³	0.099
		expanded MU 95% CI (k = 1.96) as percentage of measured value				%	6.7
		expanded MU 95% CI (k = 1.96) as percentage of measured value for mass emission				%	8.3

method and sampling deviations
Sampling was performed in full compliance with the Standard, technical procedure and regulatory requirements.

Part 2: Supporting Information - Appendix 2: Oxides of Nitrogen (as NO_2) | Run 1

Results

reference conditions are: STP, wet

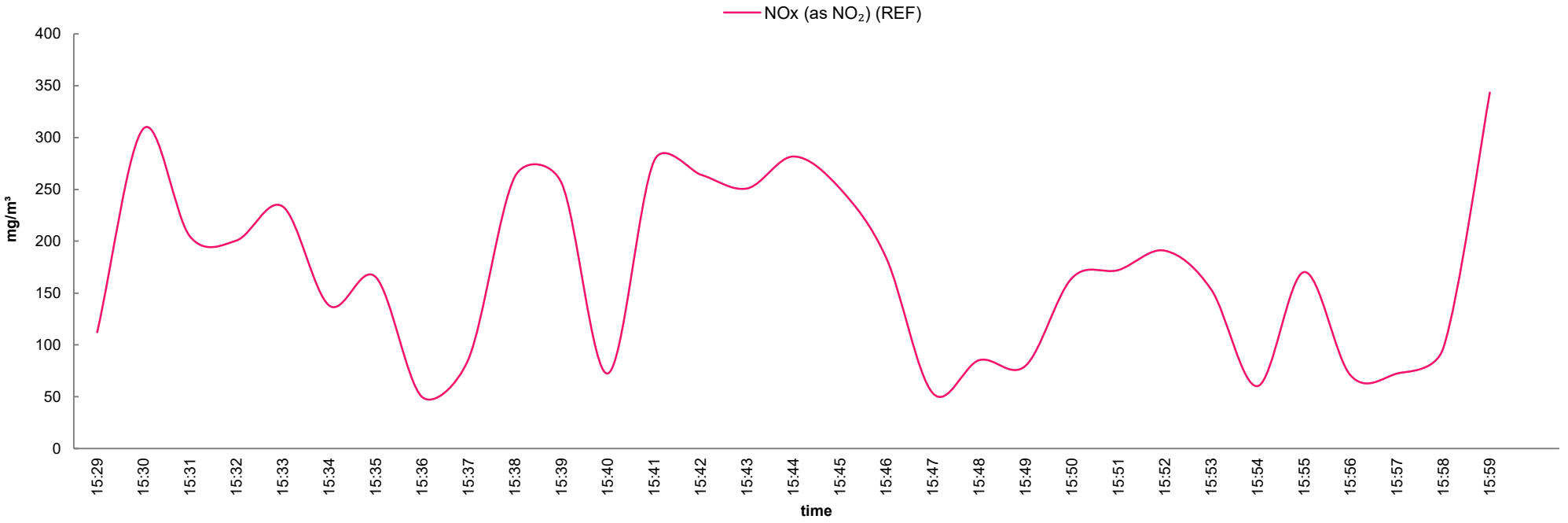
parameter	units	result ± MU (95% CI)	units	result ± MU (95% CI)
Oxides of Nitrogen (as NO_2)	mg/m³	171 ± 5.1	g/hr	293 ± 16.6

General Information

parameter	details
sampling start date & time	27/09/2023 15:29
sampling end date & time	27/09/2023 15:59
test time | mins	30
testing team	BM | CR | CM
standard | technical procedure	EN 14792 | TP-22a
analyser type	Horiba PG-350E
heated head & line temperature	180°C

parameter	details
probe material	Titanium
filter size, material & location	2µm Swagelok Element S/S | Within Heated Head
number sampling lines available	1
number sampling lines used	1
number sampling points ideal per line	1
number sampling points used per line	1
sampling point IDs	A1

Plot of Emissions Over Time



Part 2: Supporting Information - Appendix 2: Oxides of Nitrogen (as NO_2) | Run 1

Analyser Calibration Information with QA checks

where [A] = at analyser, [L] = down sampling line

	pre-test calibration events								post-test calibration events			quality assurance					
CAL ID	date & time	zero [A] [ppm]	span [A] [ppm]	zero [L] [ppm]	span [L] [ppm]	T_{90} [s]	leak [%]		date & time	zero [A] [ppm]	span [A] [ppm]	zero drift [%]		span drift [%]		allowable [%]	temp [°C]
1	27/09/23 14:45	0.00	202.12	0.10	200.60	28	0.8	P	27/09/23 16:16	0.20	200.80	0.1	P	-0.7	P	±5	16.0

Analyser Calibration Extended Information

CAL ID	performed by	drift corr. applied	log period [s]	CYL ID	CYL conc. [ppm]	CYL expiry	CYL MU [%]	zero gas type	span [CYL] gas type	span target [ppm]	range [ppm]	LOD [ppm]
1	BM	No	60	A-CYL-61	202.12	29/07/2025	1.2	Nitrogen 5.2	10l 200ppm NO | 160ppm CO | 16% CO2 in Nitrogen	202.12	250	0.09

Part 2: Supporting Information - Appendix 2: Oxides of Nitrogen (as NO_2) | Run 1

Measurement Uncertainty (MU) Calculations

general information	units	value
emission limit value (ELV) (REF)	mg/m³	N/A
measured concentration (REF)	mg/m³	171

MU budget			
parameter	units	min	max
ambient temp	°C	16.0	16.0
voltage	V	90.0	130.0

overall MU for O_2 correction
N/A

MU factor O_2 correction
N/A

	MU budget input parameters				MU budget		
performance characteristics	symbol	units	value	source	symbol	units	value
repeatability at zero	rz	% of value	0	MCERTS certificate MC130223	U_{rz}	mg/m³	0
repeatability at span	rs	% of value	0.1	MCERTS certificate MC130223	U_{rs}	mg/m³	0.17
lack of fit	lof	% of value	2	maximum allowable	U_{lof}	mg/m³	2
maximum short term zero drift (ABS) [after drift correction]	dz	% of value	0.05	day of testing	U_{dz}	mg/m³	0.05
maximum short term span drift (ABS) [after drift correction]	ds	% of value	0.7	day of testing	U_{ds}	mg/m³	0.7
influence of sample gas flow	f	% of value	0.1	MCERTS certificate MC130223	U_f	mg/m³	0.099
influence of sample gas pressure	p	% of value	0	MCERTS certificate MC130223	U_p	mg/m³	0
influence of ambient temperature zero point (/ 35k)	tz	% of value	0	MCERTS certificate MC130223	U_{tz}	mg/m³	0
influence of ambient temperature span point (/ 35k)	ts	% of value	1.8	MCERTS certificate MC130223	U_{ts}	mg/m³	0
influence of supply voltage (/ 60V)	v	% of value	0.4	MCERTS certificate MC130223	U_v	mg/m³	0.26
cross sensitivity at zero	iz	% of value	0.63	MCERTS certificate MC130223	U_{iz}	mg/m³	0.62
cross sensitivity at span	is	% of value	-0.52	MCERTS certificate MC130223	U_{is}	mg/m³	-0.51
maximum leak	L	% of value	0.75	day of testing	U_L	mg/m³	0.74
uncertainty associated with calibration gas	adj	% of value	1.2	span gas calibration certificate	U_{adj}	mg/m³	1
		combined MU				mg/m³	2.6
		expanded MU 95% CI (k = 1.96)				mg/m³	5.1
		expanded MU 95% CI (k = 1.96) as percentage of measured value				%	3
		expanded MU 95% CI (k = 1.96) as percentage of measured value for mass emission				%	5.7

method and sampling deviations
Sampling was performed in full compliance with the Standard, technical procedure and regulatory requirements.

Part 2: Supporting Information - Appendix 2: Carbon Monoxide | Run 1

Results

reference conditions are: STP, wet

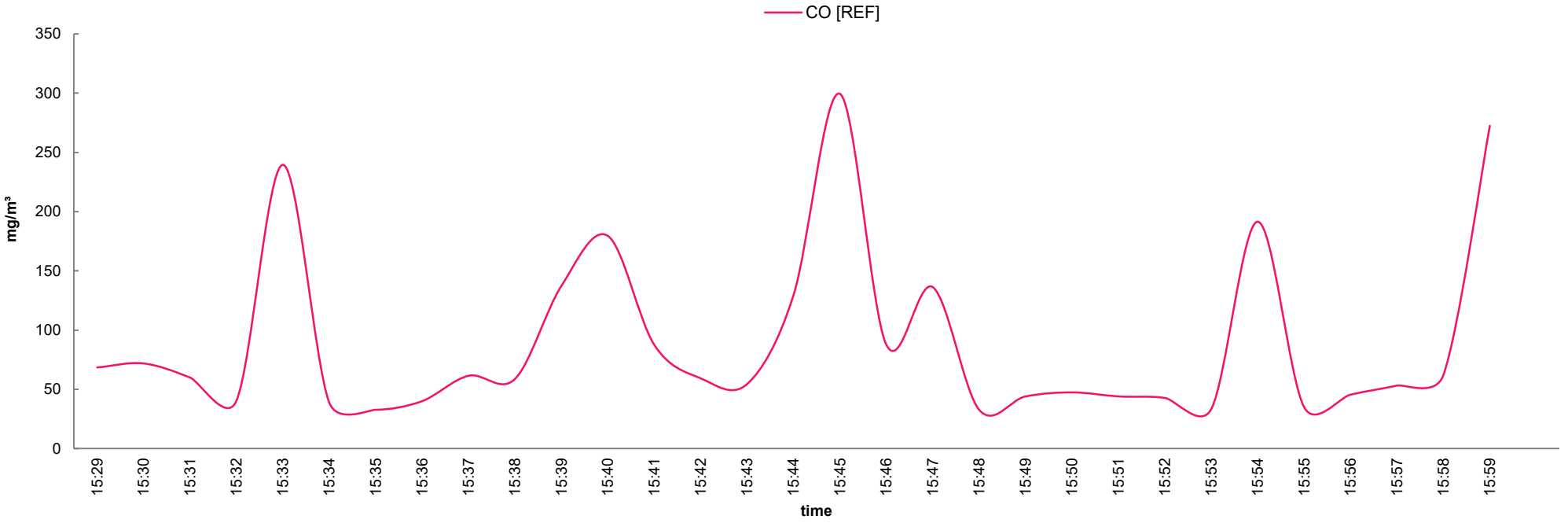
parameter	units	result ± MU (95% CI)	units	result ± MU (95% CI)
Carbon Monoxide	mg/m³	89.9 ± 3.3	g/hr	153 ± 9.3

General Information

parameter	details
sampling start date & time	27/09/2023 15:29
sampling end date & time	27/09/2023 15:59
test time | mins	30
testing team	BM | CR | CM
standard | technical procedure	EN 15058 | TP-22b
analyser type	Horiba PG-350E
heated head & line temperature	180°C

parameter	details
probe material	Titanium
filter size, material & location	2µm Swagelok Element S/S | Out Stack
number sampling lines available	1
number sampling lines used	1
number sampling points ideal per line	1
number sampling points used per line	1
sampling point IDs	A1

Plot of Emissions Over Time



Part 2: Supporting Information - Appendix 2: Carbon Monoxide | Run 1

Analyser Calibration Information with QA checks

where [A] = at analyser, [L] = down sampling line

	pre-test calibration events								post-test calibration events			quality assurance					
CAL ID	date & time	zero [A] [ppm]	span [A] [ppm]	zero [L] [ppm]	span [L] [ppm]	T_{90} [s]	leak [%]		date & time	zero [A] [ppm]	span [A] [ppm]	zero drift [%]		span drift [%]		allowable [%]	temp [°C]
1	27/09/23 14:45	0.00	157.90	0.00	155.50	24	1.5	P	27/09/23 16:16	0.60	156.30	0.4	P	-1.5	P	±5	16.0

Analyser Calibration Extended Information

CAL ID	performed by	drift corr. applied	log period [s]	CYL ID	CYL conc. [ppm]	CYL expiry	CYL MU [%]	zero gas type	span [CYL] gas type	span target [ppm]	range [ppm]	LOD [ppm]
1	BM	No	60	A-CYL-61	157.90	29/07/2025	1.0	Nitrogen 5.2	10l 200ppm NO | 160ppm CO | 16% CO2 in Nitrogen	157.90	200	0.32

Part 2: Supporting Information - Appendix 2: Carbon Monoxide | Run 1

Measurement Uncertainty (MU) Calculations

general information	units	value
emission limit value (ELV) (REF)	mg/m³	N/A
measured concentration (REF)	mg/m³	89.9

MU budget			
parameter	units	min	max
ambient temp	°C	16.0	16.0
voltage	V	90.0	130.0

overall MU for O_2 correction
N/A

MU factor O_2 correction
N/A

	MU budget input parameters				MU budget		
performance characteristics	symbol	units	value	source	symbol	units	value
repeatability at zero	rz	% of value	0.1	MCERTS certificate MC130223	U_{rz}	mg/m³	0.09
repeatability at span	rs	% of value	0.2	MCERTS certificate MC130223	U_{rs}	mg/m³	0.18
lack of fit	lof	% of value	2	maximum allowable	U_{lof}	mg/m³	1
maximum short term zero drift (ABS) [after drift correction]	dz	% of value	0.45	day of testing	U_{dz}	mg/m³	0.23
maximum short term span drift (ABS) [after drift correction]	ds	% of value	1.5	day of testing	U_{ds}	mg/m³	0.76
influence of sample gas flow	f	% of value	0.1	MCERTS certificate MC130223	U_f	mg/m³	0.052
influence of sample gas pressure	p	% of value	0	MCERTS certificate MC130223	U_p	mg/m³	0
influence of ambient temperature zero point (/ 35k)	tz	% of value	-0.2	MCERTS certificate MC130223	U_{tz}	mg/m³	0
influence of ambient temperature span point (/ 35k)	ts	% of value	2	MCERTS certificate MC130223	U_{ts}	mg/m³	0
influence of supply voltage (/ 60V)	v	% of value	0.5	MCERTS certificate MC130223	U_v	mg/m³	0.17
cross sensitivity at zero	iz	% of value	-0.48	MCERTS certificate MC130223	U_{iz}	mg/m³	-0.25
cross sensitivity at span	is	% of value	-0.87	MCERTS certificate MC130223	U_{is}	mg/m³	-0.45
maximum leak	L	% of value	1.5	day of testing	U_L	mg/m³	0.79
uncertainty associated with calibration gas	adj	% of value	1	span gas calibration certificate	U_{adj}	mg/m³	0.46
		combined MU				mg/m³	1.7
		expanded MU 95% CI (k = 1.96)				mg/m³	3.3
		expanded MU 95% CI (k = 1.96) as percentage of measured value				%	3.7
		expanded MU 95% CI (k = 1.96) as percentage of measured value for mass emission				%	6.1

method and sampling deviations
Sampling was performed in full compliance with the Standard, technical procedure and regulatory requirements.

Part 2: Supporting Information - Appendix 2: Oxygen | Run 1

Results

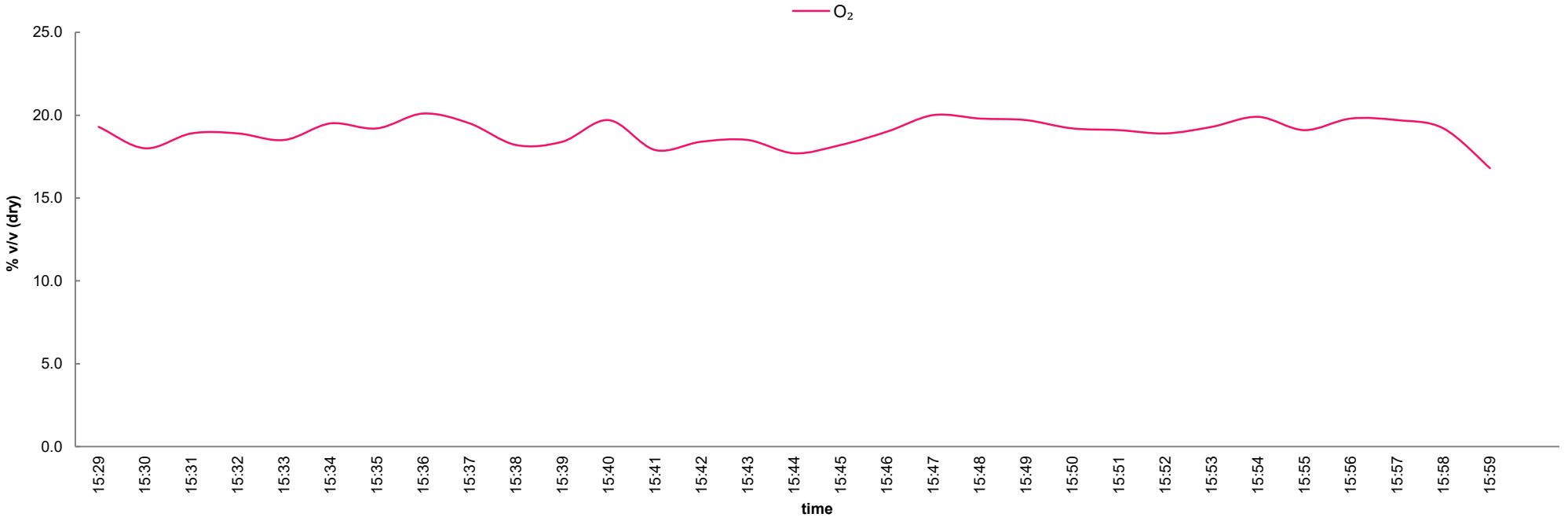
parameter	units	result ± MU (95% CI)
Oxygen	% v/v	19 ± 0.54

General Information

parameter	details
sampling start date & time	27/09/2023 15:29
sampling end date & time	27/09/2023 15:59
test time | mins	30
testing team	BM | CR | CM
standard | technical procedure	EN 14789 | TP-22d
analyser type	Horiba PG-350E
heated head & line temperature	180°C

parameter	details
probe material	Titanium
filter size, material & location	2µm Swagelok Element S/S | Out Stack
number sampling lines available	1
number sampling lines used	1
number sampling points ideal per line	1
number sampling points used per line	1
sampling point IDs	A1

Plot of Emissions Over Time



Part 2: Supporting Information - Appendix 2: Oxygen | Run 1

Analyser Calibration Information with QA checks

where [A] = at analyser, [L] = down sampling line

	pre-test calibration events								post-test calibration events			quality assurance					
CAL ID	date & time	zero [A] [% v/v]	span [A] [% v/v]	zero [L] [% v/v]	span [L] [% v/v]	T_{90} [s]	leak [%]		date & time	zero [A] [% v/v]	span [A] [% v/v]	zero drift [%]		span drift [%]		allowable [%]	temp [°C]
1	27/09/23 14:45	0.00	21.29	-0.03	21.08	36	1.0	P	27/09/23 16:16	-0.05	21.30	0.3	P	-0.3	P	±5	16.0

Analyser Calibration Extended Information

CAL ID	performed by	drift corr. applied	log period [s]	CYL ID	CYL conc. [% v/v]	CYL expiry	CYL MU [%]	zero gas type	span [CYL] gas type	span target [% v/v]	range [% v/v]	LOD [% v/v]
1	BM	No	60	A-CYL-105	21.29	22/06/2028	1.2	Nitrogen 5.2	10l Synthetic Air	21.29	25	0.03

Part 2: Supporting Information - Appendix 2: Oxygen | Run 1

Measurement Uncertainty (MU) Calculations

general information	units	value
measured concentration (dry)	% v/v	19

MU budget			
parameter	units	min	max
ambient temp	°C	16.0	16.0
voltage	V	90.0	130.0

	MU budget input parameters				MU budget		
performance characteristics	symbol	units	value	source	symbol	units	value
repeatability at zero	rz	% of value	0.02	MCERTS certificate MC130223	U_{rz}	% v/v	0.0038
repeatability at span	rs	% of value	0.02	MCERTS certificate MC130223	U_{rs}	% v/v	0.0038
lack of fit	lof	% of value	2	maximum allowable	U_{lof}	% v/v	0.22
maximum short term zero drift (ABS) [after drift correction]	dz	% of value	0.33	day of testing	U_{dz}	% v/v	0.036
maximum short term span drift (ABS) [after drift correction]	ds	% of value	0.28	day of testing	U_{ds}	% v/v	0.031
influence of sample gas flow	f	% of value	-0.01	MCERTS certificate MC130223	U_{f}	% v/v	-0.0011
influence of sample gas pressure	p	% of value	0	MCERTS certificate MC130223	U_{p}	% v/v	0
influence of ambient temperature zero point (/ 35k)	tz	% of value	-0.4	MCERTS certificate MC130223	U_{tz}	% v/v	0
influence of ambient temperature span point (/ 35k)	ts	% of value	-0.15	MCERTS certificate MC130223	U_{ts}	% v/v	0
influence of supply voltage (/ 60V)	v	% of value	0.02	MCERTS certificate MC130223	U_{v}	% v/v	0.0015
cross sensitivity at zero	iz	% of value	0	MCERTS certificate MC130223	U_{iz}	% v/v	0
cross sensitivity at span	is	% of value	0	MCERTS certificate MC130223	U_{is}	% v/v	0
maximum leak	L	% of value	0.99	day of testing	U_{L}	% v/v	0.11
uncertainty associated with calibration gas	adj	% of value	1.2	span gas calibration certificate	U_{adj}	% v/v	0.11
		combined MU				% v/v	0.27
		expanded MU 95% CI (k = 1.96)				% v/v	0.54
		expanded MU 95% CI (k = 1.96) as percentage of measured value				%	2.8

method and sampling deviations
Sampling was performed in full compliance with the Standard, technical procedure and regulatory requirements.

Part 2: Supporting Information - Appendix 2: Velocity & Flow Rate Traverse | Run 1

Supporting Information

parameter	units	value
barometric pressure	kPa	101.3
average wet density	kg/m³	0.750
average stack static pressure	Pa	39.1
pitot tube coefficient, C_p	-	0.827

General Information

parameter	details
traverse date	27/09/2023
traverse times | performed by	16:04 - 16:09 | performed by: BM | CR | CM
standard | technical procedure	EN 16911-1 | TR 17078 | TP-04a
device used	S-type Pitot with KIMO MP 210 (500Pa module)

Limit of Detection (LOD) is 1 m/s for this device combination

Quality Assurance

parameter	details
result of pitot stagnation test	Pass
result of pitot leak check (pre)	Pass
result of pitot leak check (post)	Pass
water droplets present	No

NM = Not Measured

Line A

static pressure = 39.1 Pa

Pt	Depth | m	ΔP | Pa	Temp | °C	Vel | m/s	Swirl | °
1	0.10	359.0	187.0	25.5	< 15

Part 2: Supporting Information - Appendix 2: Velocity & Flow Rate Traverse | Run 1

Measurement Uncertainty (MU) Calculations

parameter	units	value
standard uncertainty on the coefficient of the pitot tube	-	0.0015
standard uncertainty associated with the mean local dynamic pressures	Pa	5.6
standard uncertainty associated with the molar mass of the gas	-	0.000033
standard uncertainty associated with the temperature	K	2.3
standard uncertainty associated with the absolute pressure in the duct	Pa	176
standard uncertainty associated with the density of the gas effluent	kg/m³	0.0041
standard uncertainty associated with the local velocities	m/s	0.22
standard uncertainty associated with the mean velocity	m/s	0.21

parameter	units	value
standard uncertainty associated with the mean velocity (95% CI)	m/s	0.42
standard uncertainty associated with the mean velocity (95% CI), relative	%	1.6
standard uncertainty associated with the volume flow rate @ actual (95% CI)	m³/hr	139
standard uncertainty associated with the volume flow rate @ actual (95% CI), relative	%	4.8
standard uncertainty associated with the volume flow rate @ ref 1 (95% CI)	m³/hr	82.2
standard uncertainty associated with the volume flow rate @ ref 1 (95% CI), relative	%	4.8

method and sampling deviations
Sampling was performed in full compliance with the Standard, technical procedure and regulatory requirements.

STACK EMISSIONS MONITORING REPORT

Unit 5 Crown Industrial Estate
Kenwood Road
Stockport
SK5 6PH
Tel: 0161 443 0980

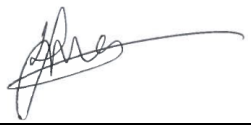
Your contact at SOCOTEC LTD
Dominic Houghton Business Manager - North Tel: 0161 443 0981 Email: dominic.houghton@socotec.com

Operator & Address:
Ellgia Ltd Winterton Road Scunthorpe DN15 0DH

Permit Reference:
EPR Permit: PGNn1/12(13)

Release Point:
Ariterm BIO1000SP Biomass Boiler

Sampling Date(s):
23rd October 2023

SOCOTEC Job Number:	LNO 18084
Report Date:	20th November 2023
Version:	1
Report By:	Mark Derbyshire
MCERTS Number:	MM 07 824
MCERTS Level:	MCERTS Level 2 - Team Leader
Technical Endorsements:	1, 2, 3 & 4
Report Approved By:	Lawrence Mason
MCERTS Number:	MM 07 849
Business Title:	MCERTS Level 2 - Team Leader
Technical Endorsements:	1, 2, 3 & 4
Signature:	

UKAS TESTING 1015

mCERTS THE ENVIRONMENT AGENCY'S MONITORING CERTIFICATION SCHEME

CONTENTS

EXECUTIVE SUMMARY

MONITORING OBJECTIVES

Ellgia Ltd operates a biomass boiler process at Scunthorpe which is subject to EPR Permit PGNn1/12(13), under the Environmental Permitting Regulations 2010.

SOCOTEC LTD were commissioned by Ellgia Ltd to carry out stack emissions monitoring to determine the release of prescribed pollutants from the following Plant under normal operating conditions.

The results of these tests shall be used to demonstrate compliance with a set of emission limit values for prescribed pollutants as specified in the Plant's EPR Permit, PGNn1/12(13).

Plant

Ariterm BIO1000SP Biomass Boiler

Operator

Ellgia Ltd
Winterton Road
Scunthorpe
DN15 0DH

Stack Emissions Monitoring Test House

SOCOTEC - Stockport Laboratory
Unit 5 Crown Industrial Estate
Kenwood Road
Stockport
SK5 6PH
UKAS and MCERTS Accreditation Number: 1015

Opinions and interpretations expressed herein are outside the scope of UKAS accreditation.
The results of this testing relate only to the emission release point(s) listed in the report.
MCERTS accredited results will only be claimed where both the sampling and analytical stages are MCERTS accredited.

EXECUTIVE SUMMARY

EMISSIONS SUMMARY					
Parameter	**Units**	**Result**	**Calculated Uncertainty +/-**	**Emission Limit Value (ELV)**	**Accreditation**
Total Particulate Matter	mg/m³	31	1.3	60	MCERTS
Particulate Emission Rate	g/hr	64	2.6	-	
Total Volatile Organic Compounds	mg/m³	9.1	1.3	20	MCERTS
Total Volatile Organic Compounds Emission Rate	g/hr	11	1.7	-	
Oxides of Nitrogen (as NO_2)	mg/m³	101	4.1	400	MCERTS
Oxides of Nitrogen (as NO_2) Emission Rate	g/hr	187	7.6	-	
Carbon Monoxide	mg/m³	175	1.5	250	MCERTS
Carbon Monoxide Emission Rate	g/hr	289	2.4	-	
Oxygen	% v/v	10.6	0.05	-	MCERTS
Moisture	%	2.1	0.09	-	MCERTS
Stack Gas Temperature	°C	60	-	-	MCERTS
Stack Gas Velocity	m/s	7.3	0.18	-	
Gas Volumetric Flow Rate (Actual)	m³/hr	2373	123	-	
Gas Volumetric Flow Rate (STP, Wet)	m³/hr	1923	99	-	
Gas Volumetric Flow Rate (STP, Dry)	m³/hr	1882	97	-	
Gas Volumetric Flow Rate at Reference Conditions	m³/hr	1954	101	-	

ND = None Detected,
Results at or below the limit of detection are highlighted by bold italic text.
The above volumetric flow rate is calculated using data from the preliminary survey. Mass emissions for non isokinetic tests are calculated using these values. For all isokinetic testing the mass emission is calculated using test specific flow data and not the above values.
Reference conditions are 273K, 101.3kPa, dry gas 11% Oxygen.

EXECUTIVE SUMMARY

MONITORING TIMES			
Parameter	**Sampling Date(s)**	**Sampling Times**	**Sampling Duration**
Total Particulate Matter Run 1	23 October 2023	11:40 - 12:20	40 minutes
Total Particulate Matter Run 2	23 October 2023	13:28 - 14:08	40 minutes
Total Particulate Matter Run 3	23 October 2023	14:15 - 14:55	40 minutes
Total Volatile Organic Compounds Run 1	23 October 2023	11:40 - 14:55	195 minutes
Combustion Gases	23 October 2023	11:40 - 14:55	195 minutes
Preliminary Stack Traverse	23 October 2023	11:10	-

EXECUTIVE SUMMARY

PROCESS DETAILS

Parameter	Process Details
Description of process	Biomass Boiler
Continuous or batch	Continuous
Product Details	Heat for Drying
Part of batch to be monitored (if applicable)	N/A
Normal load, throughput or continuous rating	1000 kW boiler
Fuel used during monitoring	Grade A recycled Wood
Abatement	Cyclone
Plume Appearance	Slight Plume visible

EXECUTIVE SUMMARY

Monitoring Methods

The selection of standard reference / alternative methods employed by SOCOTEC is determined, wherever possible by the hierarchy of method selection outlined in Environment Agency technical Guidance 'Monitoring stack emissions: techniques and standards for periodic monitoring'.

MONITORING METHODS							
Species	**Method** Standard Reference Method / Alternative Method	**SOCOTEC Technical Procedure**	**UKAS Lab Number**	**Method Accreditation**	**Limit of Detection (LOD)**	**Calculated MU +/- % Result**	**Calculated MU +/- % ELV**
Total Particulate Matter	SRM - BS EN 13284-1	AE 104	1015	MCERTS	0.32 mg/m³	4.1%	2.15%
Total Volatile Organic Compounds	SRM - BS EN 12619:2013	AE 102	1015	MCERTS	0.4 mg/m³	14.8%	6.7%
Oxides of Nitrogen	SRM - BS EN 14792:2017	AE 102	1015	MCERTS	1.17 mg/m³	4.1%	1.03%
Carbon Monoxide	SRM - BS EN 15058:2017	AE 102	1015	MCERTS	0.63 mg/m³	0.8%	0.5%
Oxygen	SRM - BS EN 14789:2017	AE 102	1015	MCERTS	0.01%	0.5%	N/A - No ELV
Moisture	BS EN 14790	AE 105	1015	MCERTS	0.02%	4.1%	N/A - No ELV
Velocity	SRM - EN ISO 16911-1	AE 154	1015	MCERTS	5 Pa	2.5%	N/A - No ELV
Volumetric Flow Rate	SRM - EN ISO 16911-1	AE 154	1015	MCERTS	-	5.2%	N/A - No ELV

BS EN 14790 has been validated over a range of 4 - 40%. It is however the prefered method of the Environment Agency for concentrations below 4%

EXECUTIVE SUMMARY

Analytical Methods

The following tables list the analytical methods employed together with the custody details. Unless otherwise stated the samples are archived at the analysis lab location.

SAMPLING METHODS WITH SUBSEQUENT ANALYSIS							
Species	**Analytical Technique**	**Analytical Procedure**	**UKAS Lab Number**	**Analysis Accreditation**	**Analysis Lab**	**Analysis Report No. Date of Analyis**	**Archive Period**
Total Particulate Matter	Gravimetric	AE 106	1015	MCERTS	SOCOTEC (Stockport)	N/A	8 Weeks

ON-SITE TESTING							
Species	**Analytical Technique**	**Analytical Procedure**	**UKAS Lab Number**	**Accreditation**	**Laboratory**	**Data Archive Location**	**Archive Period**
Total Volatile Organic Compounds	Flame Ionisation Detection	AE 102	1015	MCERTS	SOCOTEC (Stockport)	SOCOTEC (Stockport)	5 years
Oxides of Nitrogen	Chemiluminescence	AE 102	1015	MCERTS	SOCOTEC (Stockport)	SOCOTEC (Stockport)	5 years
Carbon Monoxide	Non Dispersive Infra Red	AE 102	1015	MCERTS	SOCOTEC (Stockport)	SOCOTEC (Stockport)	5 years
Oxygen	Paramagnetic	AE 102	1015	MCERTS	SOCOTEC (Stockport)	SOCOTEC (Stockport)	5 years
Moisture	Gravimetric	AE 105	1015	MCERTS	SOCOTEC (Stockport)	-	-

EXECUTIVE SUMMARY

SAMPLING LOCATION					
Sampling Plane Validation Criteria	**Value**	**Units**	**Requirement**	**Compliant**	**Method**
Lowest Differential Pressure	39	Pa	>= 5 Pa	Yes	BS EN 15259
Lowest Gas Velocity	7.3	m/s	-	-	-
Highest Gas Velocity	7.3	m/s	-	-	-
Ratio of Gas Velocities	1.0	: 1	< 3 : 1	Yes	BS EN 15259
Mean Velocity	7.3	m/s	-	-	-
Maximum angle of flow with regard to duct axis	<15	^{o}	< 15^{o}	Yes	BS EN 15259
No local negative flow	Yes	-	-	Yes	BS EN 15259

DUCT CHARACTERISTICS		
	Value	**Units**
Shape	Circular	-
Depth	0.34	m
Width	-	m
Area	0.09	m^2
Port Depth	90	mm

SAMPLING LINES & POINTS		
	Isokinetic	**Non-Iso & Gases**
Sample port size	4 Inch BSP	4 Inch BSP
Number of lines used	1	1
Number of points / line	1	1
Duct orientation	Vertical	Vertical
Filtration	In Stack	Out Stack
Filtration for TPM	In Stack	Out Stack

SAMPLING PLATFORM	
General Platform Information	
Permanent / Temporary Platform / Ground level / Floor Level / Roof	Permanent
Inside / Outside	Inside

M1 Platform requirements	
Is there a sufficient working area so work can be performed in a compliant manner	Yes
Platform has 2 levels of handrails (approximately 0.5 m & 1.0 m high)	Yes
Platform has vertical base boards (approximately 0.25 m high)	No
Platform has removable chains / self closing gates at the top of ladders	No
Handrail / obstructions do not hamper insertion of sampling equipment	Yes
Depth of Platform = >Stack depth / diameter + wall and port thickness + 1.5m	No

Sampling Platform Improvement Recommendations (if applicable)

The sampling platform needs a self closing gate and toe boards. The sampling platform does not meet the requirements of TGN M1, however, sampling can still be performed in a complaint manner.

EXECUTIVE SUMMARY

Sampling & Analytical Method Deviations

In this instance there were no deviations from the sampling and analytical methods employed.

APPENDICES

CONTENTS

APPENDIX 1 - Monitoring Schedule, Calibration Checklist & Monitoring Team

MONITORING SCHEDULE					
Species	**Method** Standard Reference Method / Alternative Method	**SOCOTEC Technical Procedure**	**UKAS Lab Number**	**MCERTS Accredited Method**	**Number of Samples**
Total Particulate Matter	SRM - BS EN 13284-1	AE 104	1015	MCERTS	3
Total Volatile Organic Compounds	SRM - BS EN 12619:2013	AE 102	1015	MCERTS	1
Oxides of Nitrogen	SRM - BS EN 14792:2017	AE 102	1015	MCERTS	1
Carbon Monoxide	SRM - BS EN 15058:2017	AE 102	1015	MCERTS	1
Oxygen	SRM - BS EN 14789:2017	AE 102	1015	MCERTS	1
Moisture	BS EN 14790	AE 105	1015	MCERTS	1
Velocity	SRM - EN ISO 16911-1	AE 154	1015	MCERTS	1

APPENDIX 1 - Monitoring Schedule, Calibration Checklist & Monitoring Team

CALIBRATEABLE EQUIPMENT CHECKLIST

Extractive Sampling		Instrumental Analyser/s		Miscellaneous	
Equipment	**Equipment I.D.**	**Equipment**	**Equipment I.D.**	**Equipment**	**Equipment I.D.**
Control Box DGM	LNO 13-29	Horiba PG - 350 Analyser	LNO 21-59	Laboratory Balance	LNO 00-13/33
Box Thermocouples	LNO 03-29	FT-IR	-	Tape Measure	LNO 24-MD
Meter In Thermocouple	LNO 03-29	FT-IR Oven Box	-	Stopwatch	LNO 17-MD
Meter Out Thermocouple	LNO 03-29	Bernath 3006 FID	-	Protractor	-
Control Box Timer	LNO 17-29	Signal 3030 FID	-	Barometer	LNO 08-MD
Oven Box	-	Servomex	-	Digital Micromanometer	LNO 01-MD
Probe	LNO 11-02	JCT Heated Head Filter	-	Digital Temperature Meter	LNO 03-MD
Probe Thermocouple	LNO 10-02	I FID	LNO 21-55	Stack Thermocouple	LNO 10-MD
Probe	-	Stackmaster	-	Mass Flow Controller	-
Probe Thermocouple	-	FTIR Heater Box for Heated Line	-	MFC Display module	-
S-Pitot	LNO 06-MD	Anemometer	-	1m Heated Line (1)	-
L-Pitot	-	Ecophysics NOx Analyser	-	1m Heated Line (2)	-
Site Balance	LNO 14-MD	Chiller (JCT/MAK 10)	LNO 21-105	1m Heated Line (3)	-
Last Impinger Arm	-	Heated Line Controller (1)	LNO 03-88	5m Heated Line (1)	-
Dioxins Cond. Thermocouple	-	Heated Line Controller (2)	-	10m Heated Line (1)	-
Callipers	LNO 31-MD	Site temperature Logger	-	10m Heated Line (2)	-
Small DGM	-			15m Heated Line (1)	-
Heater Controller	-			20m Heated Line (1)	LNO 18-82
Inclinometer (Swirl Device)	LNO 23-MD			20m Heated Line (2)	-

NOTE: If the equipment I.D is represented by a dash (-), then this piece of equipment has not been used for this test.

CALIBRATION GASES

Gas (traceable to ISO 17025)	Cylinder I.D Number	Supplier	ppm	%	Analytical Tolerance +/- %
Oxygen	HPC2302	BOC	-	20.96	2.0
Propane	HPC 2109	BOC	10	-	2.0
Nitric Oxide	HPC 2149	BOC	198.7	-	2.0
Carbon Monoxide	HPC 2149	BOC	80.1	-	2.0

STACK EMISSIONS MONITORING TEAM

MONITORING TEAM								
Personnel	**MCERTS Number**	**MCERTS**		**TE / H&S Qualifications and Expiry Date**				
		Level	**Expiry**	**TE1**	**TE2**	**TE3**	**TE4**	**H&S**
Mark Derbyshire	MM 07 824	MCERTS Level 2	Nov-26	Nov-26	Apr-27	May-28	Jul-27	Feb-25
Pete Watson	MM 08 953	MCERTS Level 1	Apr-24	-	-	-	-	Apr-24

APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

TOTAL PARTICULATE MATTER SUMMARY					
Parameter	**Sampling Times**	**Concentration mg/m³**	**Uncertainty mg/m³**	**ELV mg/m³**	**Emission Rate g/hr**
Run 1	11:40 - 12:20 23 October 2023	32	1.2	60	72
Run 2	13:28 - 14:08 23 October 2023	39	1.7	60	64
Run 3	14:15 - 14:55 23 October 2023	23	0.99	60	54
Blank	-	0.40	-	-	-

Reference conditions are 273K, 101.3kPa, dry gas 11% Oxygen.

Acetone Blank Value mg/l	Acceptable Value mg/l
0.3	10

FILTER INFORMATION

SAMPLES								
Test	Filter & Probe Rinse Number	Filter Start Weight g	Filter End Weight g	Mass Gained on Filter g	Probe Rinse Start Weight g	Probe Rinse End Weight g	Mass Gained on Probe g	Combined Total Mass Gained g
Run 1	G5334	0.10884	0.12560	0.01676	65.44490	65.44790	0.00300	0.01976
Run 2	G5335	0.10652	0.12108	0.01456	69.99370	69.99600	0.00230	0.01686
Run 3	G5336	0.10687	0.12001	0.01314	65.30490	65.30630	0.00140	0.01454

If total mass gained is less than the LOD then the LOD is reported

BLANKS								
Test	Filter & Probe Number	Filter Start Weight g	Filter End Weight g	Mass Gained Filter g	Probe Start Weight g	Probe End Weight g	Mass Gained Probe g	Combined Total Mass Gained g
Run 1	G5333	0.10904	0.10890	-0.00014	60.48740	60.48750	0.00010	0.00020

If total mass gained is less than the LOD then the LOD is reported

APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

ISOKINETIC SAMPLING EQUATIONS - RUN 1 — TPM

Absolute pressure of stack gas, P_S		
Barometric pressure, P_b	Kpa	100.2
Stack static pressure, P_{static}	pa	50.0
$P_s = P_b + P_{static}$	Kpa	100.3
Vol. of water vapour collected, V_{wstd}		
Moisture trap weight increase,Vlc	g	8.8
$V_{wstd} = (0.001246)(V_{lc})$	m^3	0.0109648
Volume of gas metered dry, V_{mstd}		
Volume of gas sample through gas meter, V_m		0.553
Gas meter correction factor, Y_d		0.989
Mean dry gas meter temperature, T_m		293
Mean pressure drop across orifice, DH	mmH_2O	20.230
$V_{mstd} = \frac{(0.3592)(V_m)(P_b+(DH/13.6))(Y_d)}{T_m}$	m^3	0.505
Volume of gas metered wet, V_{mstw}		
$V_{mstw} = V_{mstd} + V_{wstd}$	m^3	0.5156
Vol. of gas metered at O_2 Ref. Cond., $V_{mstd@X\%O2}$		
Is the process burning hazardous waste? *(If yes, no favourable oxygen correction)*		No
% oxygen measured in gas stream, act%O_2		8.6
% oxygen reference condition		11
O_2 Reference Factor $O_2\ Ref = \frac{21.0 - act\%O_2}{21.0 - ref\%O_2}$		1.24
$V_{mstd@X\%oxygen} = (V_{mstd})(O_{2\ Ref})$	m^3	0.6258
Moisture content, B_{wo}		
$B_{wo} = \frac{V_{wstd}}{V_{mstd} + V_{wstd}}$		0.0213
	%	2.13
Moisture by FTIR	%	-
Velocity of stack gas, V_s		
Velocity pressure coefficient, C_p		0.84
Mean of velocity heads, DP_{avg}	Pa	38.34
Mean stack gas temperature, T_s	K	338
Gas density (wet, ambient), p		
p=(Ms*Ps)/(8.314*Ts)	kg/m^3	1.055
Stack Velocity, Vs $V_s = \frac{\sum_{i=1}^{n} V_i}{n}$	m/s	7.18

Molecular weight of dry gas, M_d		
CO_2	%	9.23
O_2	%	8.60
Total	%	17.83
N_2 (100 -Total)	%	82.17
$M_d = 0.44(\%CO_2)+0.32(\%O_2)+0.28(\%N_2)$		29.82
Molecular weight of wet gas, M_s		
$M_s = M_d(1 - B_{wo}) + 18(B_{wo})$	g/gmol	29.57
Actual flow of stack gas, Q_a		
Area of stack, A_s	m^2	0.09
$Q_a = (60)(A_s)(V_s)$	m^3/min	39.1
Total flow of stack gas, Q		
Conversion factor (K/mm.Hg)		0.3592
$Q_{std} = \frac{(Q_a)P_s(0.3592)(1-B_{wo})}{(T_s)}$	Dry	30.6
$Q_{stdO2} = \frac{(Q_a)P_s(0.3592)(1-B_{wo})(O_2REF)}{(T_s)}$	@O_2ref	37.93
$Q_{stw} = \frac{(Q_a)P_s(0.3592)}{(T_s)}$	Wet	31.25
Percent isokinetic, %I		
Nozzle diameter, D_n	mm	6.90
Nozzle area, A_n	mm^2	37.36
Total sampling time, q	min	40
$\%I = \frac{(4.6398E6)(T_s)(V_{mst}}{(P_s)(V_s)(A_n)(q)(1-B_{wo})}$	%	100.3
Acceptable isokinetic range 95% to 115%		Yes
Particulate Concentration, C		
Mass collected on filter, M_f	g	0.01676
Mass collected in probe, M_p	g	0.00300
Total mass collected, M_n	g	0.01976
$C_{wet} = \frac{M_n}{V_{mstw}}$	mg/m^3	38.322
$C_{dry} = \frac{M_n}{V_{mstd}}$	mg/m^3	39.154
$C_{dry@X\%O2} = \frac{M_n}{V_{mstd@X\%oxygen}}$	mg/m^3	31.576
Particulate Emission Rates, E		
$E = [(C_{wet})(Q_{stw})(60)] / 1000$		71.85

APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

ISOKINETIC SAMPLING EQUATIONS - RUN 2 — TPM

Absolute pressure of stack gas, P_S			**Molecular weight of dry gas, M_d**		
Barometric pressure, P_b	Kpa	100.2	CO_2	%	9.23
Stack static pressure, P_{static}	pa	50.0	O_2	%	12.00
$P_s = P_b + P_{static}$	Kpa	100.3	Total	%	21.23
			N_2 (100 -Total)	%	78.77
Vol. of water vapour collected, V_{wstd}			$M_d = 0.44(\%CO_2)+0.32(\%O_2)+0.28(\%N_2)$		29.96
Moisture trap weight increase,Vlc	g	-	**Molecular weight of wet gas, M_s**		
$V_{wstd} = (0.001246)(V_{lc})$	m^3	-	$M_s = M_d(1 - B_{wo}) + 18(B_{wo})$	g/gmol	29.70
Volume of gas metered dry, V_{mstd}			**Actual flow of stack gas, Q_a**		
Volume of gas sample through gas meter, V_m		0.525	Area of stack, A_s	m^2	0.09
Gas meter correction factor, Y_d		0.989	$Q_a = (60)(A_s)(V_s)$	m^3/min	39.9
Mean dry gas meter temperature, T_m		295	**Total flow of stack gas, Q**		
Mean pressure drop across orifice, DH	mmH_2O	20.091	Conversion factor (K/mm.Hg)		0.3592
$V_{mstd} = \frac{(0.3592)(V_m)(P_b+(DH/13.6))(Y_d)}{T_m}$	m^3	0.476	$Q_{std} = \frac{(Q_a)P_s(0.3592)(1-B_{wo})}{(T_s)}$	Dry	30.3
Volume of gas metered wet, V_{mstw}			$Q_{stdO2} = \frac{(Q_a)P_s(0.3592)(1-B_{wo})(O_2REF)}{(T_s)}$	@O_2ref	27.28
$V_{mstw} = V_{mstd} + V_{wstd}$	m^3	0.4864	$Q_{stw} = \frac{(Q_a)P_s(0.3592)}{(T_s)}$	Wet	30.98
Vol. of gas metered at O_2 Ref. Cond., $V_{mstd@X\%O2}$					
Is the process burning hazardous waste? *(If yes, no favourable oxygen correction)*		No	**Percent isokinetic, %I**		
			Nozzle diameter, D_n	mm	6.90
% oxygen measured in gas stream, act%O_2		12.0	Nozzle area, A_n	mm^2	37.36
% oxygen reference condition		11	Total sampling time, q	min	40
O_2 Reference Factor O_2 Ref = $\frac{21.0 - act\%O_2}{21.0 - ref\%O_2}$		0.90	$\%I = \frac{(4.6398E6)(T_s)(V_{mstd})}{(P_s)(V_s)(A_n)(q)(1-B_{wo})}$	%	95.4
$V_{mstd@X\%oxygen} = (V_{mstd})(O_{2\ Ref})$	m^3	0.4285	Acceptable isokinetic range 95% to 115%		Yes
Moisture content, B_{wo}			**Particulate Concentration, C**		
$B_{wo} = \frac{V_{wstd}}{V_{mstd} + V_{wstd}}$		0.0213	Mass collected on filter, M_f	g	0.01456
	%	2.13	Mass collected in probe, M_p	g	0.00230
Moisture by FTIR	%	-	Total mass collected, M_n	g	0.01686
Velocity of stack gas, V_s			$C_{wet} = \frac{M_n}{V_{mstw}}$	mg/m^3	34.662
Velocity pressure coefficient, C_p		0.84	$C_{dry} = \frac{M_n}{V_{mstd}}$	mg/m^3	35.415
Mean of velocity heads, DP_{avg}	Pa	38.96	$C_{dry@X\%O2} = \frac{M_n}{V_{mstd@X\%oxygen}}$	mg/m^3	39.351
Mean stack gas temperature, T_s	K	348			
Gas density $_{(wet,\ ambient)}$, p			**Particulate Emission Rates, E**		
p=(Ms*Ps)/(8.314*Ts)	kg/m^3	1.029			
Stack Velocity, Vs $V_s = \frac{\sum_{i=1}^{n} V_i}{n}$	m/s	7.33	E = [(C_{wet})(Q_{stw})(60)] / 1000		64.42

APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

ISOKINETIC SAMPLING EQUATIONS - RUN 3 — TPM

Absolute pressure of stack gas, P_S			**Molecular weight of dry gas, M_d**		
Barometric pressure, P_b	Kpa	100.2	CO_2	%	9.23
Stack static pressure, P_{static}	pa	50.0	O_2	%	8.00
$P_s = P_b + P_{static}$	Kpa	100.3	Total	%	17.23
			N_2 (100 -Total)	%	82.77
Vol. of water vapour collected, V_{wstd}			$M_d = 0.44(\%CO_2)+0.32(\%O_2)+0.28(\%N_2)$		29.80
Moisture trap weight increase,Vlc	g	-	**Molecular weight of wet gas, M_s**		
$V_{wstd} = (0.001246)(V_{lc})$	m^3	-	$M_s = M_d(1 - B_{wo}) + 18(B_{wo})$	g/gmol	29.55
Volume of gas metered dry, V_{mstd}			**Actual flow of stack gas, Q_a**		
Volume of gas sample through gas meter, V_m		0.524	Area of stack, A_s	m^2	0.09
Gas meter correction factor, Y_d		0.989	$Q_a = (60)(A_s)(V_s)$	m^3/min	39.1
Mean dry gas meter temperature, T_m		293	**Total flow of stack gas, Q**		
Mean pressure drop across orifice, DH	mmH_2O	19.084	Conversion factor (K/mm.Hg)		0.3592
$V_{mstd} = \frac{(0.3592)(V_m)(P_b+(DH/13.6))(Y_d)}{T_m}$	m^3	0.478	$Q_{std} = \frac{(Q_a)P_s(0.3592)(1-B_{wo})}{(T_s)}$	Dry	29.7
Volume of gas metered wet, V_{mstw}			$Q_{stdO2} = \frac{(Q_a)P_s(0.3592)(1-B_{wo})(O_2REF)}{(T_s)}$	@O_2ref	38.64
$V_{mstw} = V_{mstd} + V_{wstd}$	m^3	0.4885			
Vol. of gas metered at O_2 Ref. Cond., $V_{mstd@X\%O2}$			$Q_{stw} = \frac{(Q_a)P_s(0.3592)}{(T_s)}$	Wet	30.37
Is the process burning hazardous waste? *(If yes, no favourable oxygen correction)*		No	**Percent isokinetic, %I**		
			Nozzle diameter, D_n	mm	6.90
% oxygen measured in gas stream, act%O_2		8.0	Nozzle area, A_n	mm^2	37.36
% oxygen reference condition		11	Total sampling time, q	min	40
O_2 Reference Factor O_2 Ref = $\frac{21.0 - act\%O_2}{21.0 - ref\%O_2}$		1.30	$\%I = \frac{(4.6398E6)(T_s)(V_{mstd})}{(P_s)(V_s)(A_n)(q)(1-B_{wo})}$	%	97.7
$V_{mstd@X\%oxygen} = (V_{mstd})(O_{2\ Ref})$	m^3	0.6216	Acceptable isokinetic range 95% to 115%		Yes
Moisture content, B_{wo}			**Particulate Concentration, C**		
$B_{wo} = \frac{V_{wstd}}{V_{mstd} + V_{wstd}}$		0.0213	Mass collected on filter, M_f	g	0.01314
	%	2.13	Mass collected in probe, M_p	g	0.00140
Moisture by FTIR	%	-	Total mass collected, M_n	g	0.01454
Velocity of stack gas, V_s			$C_{wet} = \frac{M_n}{V_{mstw}}$	mg/m^3	29.762
Velocity pressure coefficient, C_p		0.84	$C_{dry} = \frac{M_n}{V_{mstd}}$	mg/m^3	30.409
Mean of velocity heads, DP_{avg}	Pa	37.24	$C_{dry@X\%O2} = \frac{M_n}{V_{mstd@X\%oxygen}}$	mg/m^3	23.391
Mean stack gas temperature, T_s	K	348			
Gas density $_{(wet, ambient)}$, p			**Particulate Emission Rates, E**		
p=(Ms*Ps)/(8.314*Ts)	kg/m^3	1.024			
Stack Velocity, Vs $V_s = \frac{\sum_{i=1}^{n} V_i}{n}$	m/s	7.18	E = $[(C_{wet})(Q_{stw})(60)] / 1000$		54.23

APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

TOTAL PARTICULATE MATTER QUALITY ASSURANCE CHECKLIST

LEAK RATE						
Run	Mean Sampling Rate litre/min	Pre-sampling Leak Rate litre/min	Post-sampling Leak Rate litre/min	Maximum Vacuum mm Hg	Acceptable Leak Rate litre/min	Leak Tests Acceptable?
Run 1	13.67	0.10	-	-457.2	0.27	Yes
Run 2	12.98	0.11	-	-482.6	0.26	Yes
Run 3	12.95	0.10	-	-457.2	0.26	Yes

In BS EN 13284-1:2017 a post sampling leak check is not required.

ISOKINETICITY		
Run	Isokinetic Variation %	Acceptable Isokineticity
Run 1	100.25	Yes
Run 2	95.41	Yes
Run 3	97.75	Yes

Acceptable isokinetic range 95% to 115%

WEIGHING BALANCE UNCERTAINTY			
Run	Result mg/m³	5% ELV mg/m³	LOD < 5% ELV
Run 1	0.32	3	Yes
Run 2	0.47	3	Yes
Run 3	0.32	3	Yes

The above is based on both the Filter and rinse uncertainty

BLANK VALUE				
Run	Overall Blank Value mg/m^3	Daily Emission Limit Value mg/m^3	Acceptable Blank Value mg/m^3	Overall Blank Acceptable mg/m^3
Blank 1	0.40	60	6.0	Yes

FILTERS					
Run	Filter Material	Filter Size mm	Max Filtration Temperature °C	Pre-use Filter Conditioning Temperature °C	Post-use Filter Conditioning Temperature °C
Run 1	Glass Fibre	47	65	180	160
Run 2	Glass Fibre	47	75	180	160
Run 3	Glass Fibre	47	75	180	160

APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

TOTAL VOLATILE ORGANIC COMPOUNDS SUMMARY

Test	Sampling Times	Concentration mg/m³	LOD mg/m³	ELV mg/m³	Emission Rate g/hr
Run 1	11:40 - 14:55 23 October 2023	9.1	0.40	20	11

Reference conditions are 273K, 101.3kPa, dry gas 11% Oxygen.

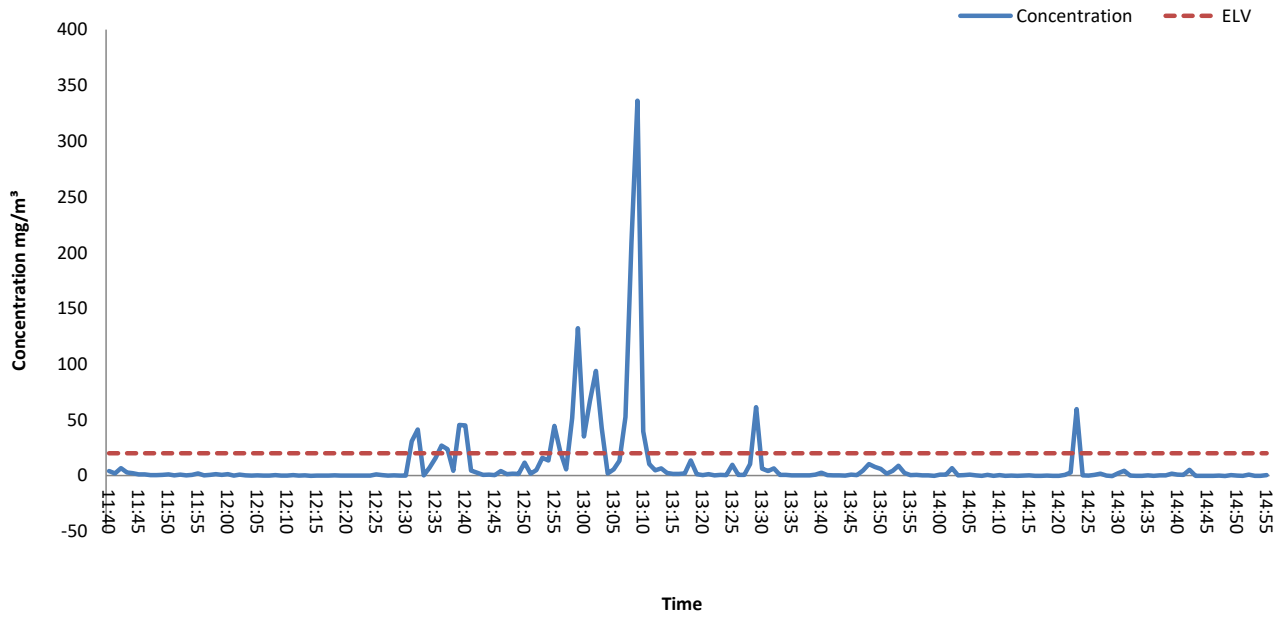
INSTRUMENTAL SPAN & ZERO CHECKS

PRE-SAMPLING CALIBRATION CHECKS								
Date	23 October 2023							
Start Time	10:02							
End Time	10:10							
Gas	Gas Conc (ppm)	Range	Instrument Zero Reading	Instrument Span Reading	Instrument Zero Reading	Zero Down line reading	Span down line reading	Leak Rate (%)
Propane	10.0	100	0.00	10.0	0.00	0.10	10.0	0.00

Zero and Span gas contained 10% Oxygen

POST-SAMPLING CALIBRATION CHECKS								
Date	23 October 2023							
Start Time	15:05							
End Time	15:14							
Gas	Mean Raw Value ppm	Zero down line reading	Span down line reading	Zero Drift (%)	Span Drift (%)	Corrected for Zero Drift	Corrected for Span Drift	Corrected Values ppm / %
Propane	4.06	0.40	9.8	3.00	-4.80	✓	✓	0.00

TOTAL VOLATILE ORGANIC COMPOUNDS EMISSIONS CHART



Reference conditions are 273K, 101.3kPa, dry gas 11% Oxygen.

APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

COMBUSTION GASES SUMMARY

Test	Sampling Time and Date	Concentration mg/m³	LOD mg/m³	ELV mg/m³	Emission Rate g/hr
Oxides of Nitrogen	11:40 - 14:55 23 October 2023	101	1.2	400	187
Carbon Monoxide	11:40 - 14:55 23 October 2023	175	0.63	250	289

Test	Sampling Time and Date	Concentration %	LOD %
Oxygen	11:40 - 14:55 23 October 2023	11.2	0.01

Reference conditions are 273K, 101.3kPa, dry gas 11% Oxygen.

PRE-SAMPLING CALIBRATION DATA

Date	23 October 2023
Start Time	10:10
End Time	10:25

Chiller Temperature (°C)	2.1
Requirement	< 4°C
Compliant	Yes

Gas	Range (ppm / %)	Zero Reading at analyser	Span Reading at analyser	Zero Check at analyser	Zero Check down line	Span Check down line	Response Time (Secs)	Leak Rate %
Nitric Oxide	250	0.00	198.7	0.40	0.50	198.5	20	0.10
Carbon Monoxide	200	0.00	80.1	0.60	0.70	79.9	20	0.25
Oxygen	25	0.00	20.96	0.03	0.08	20.93	20	0.14

POST-SAMPLING CALIBRATION DATA

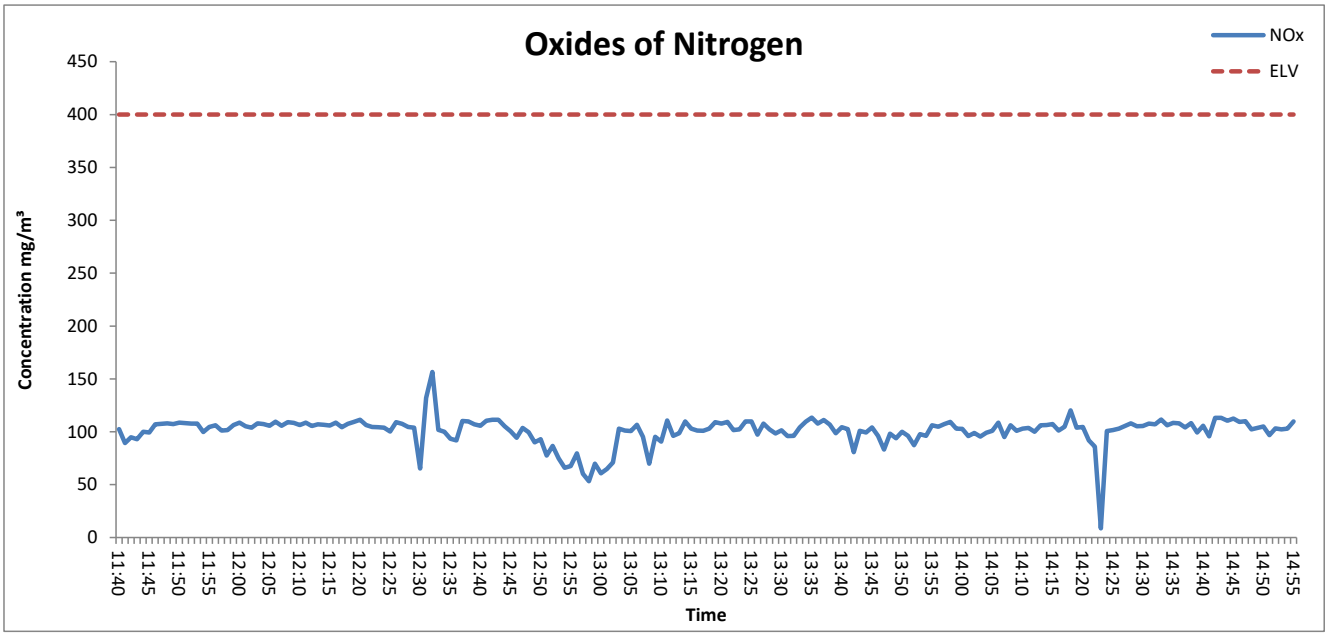
Date	29 September 2023
Start Time	15:05
End Time	15:20

Chiller Temperature (°C)	2.1
Requirement	< 4°C
Compliant	Yes

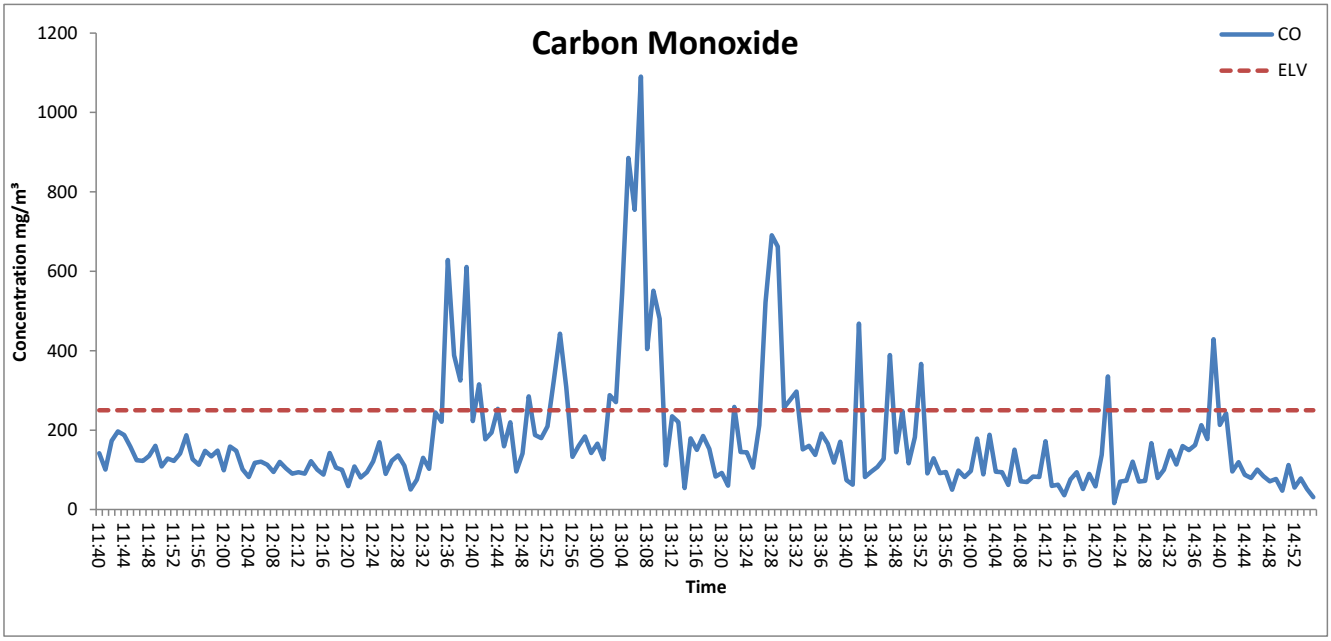
Gas	Zero Check at Analyser	Span Check at Analyser	Zero Drift (%)	Span Drift (%)	Corrected for Zero Drift	Corrected for Span Drift	Corrected Values ppm / %
Nitric Oxide	1.10	198.2	0.36	-0.60	×	×	N/A - not corrected
Carbon Monoxide	0.90	79.7	0.39	-0.87	×	×	N/A - not corrected
Oxygen	0.07	20.93	0.19	-0.33	×	×	N/A - not corrected

APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

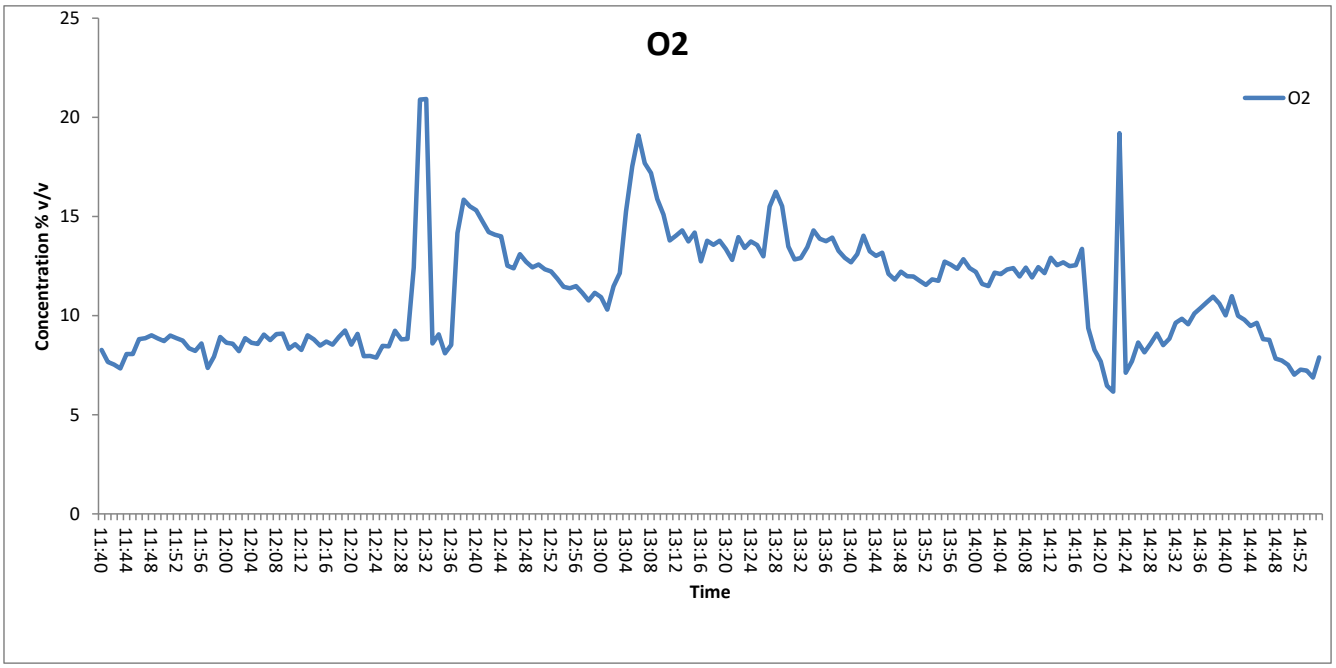
OXIDES OF NITROGEN (as NO_2) EMISSIONS CHART



CARBON MONOXIDE EMISSIONS CHART



OXYGEN EMISSIONS CHART



APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

MOISTURE CALCULATIONS

Moisture Determination - Isokinetic							
Test Number	Sampling Time and Date	Start Weight kg	End Weight kg	Total gain kg	Concentration %	LOD %	Uncertainty %
Run 1	11:40 - 12:20 23 October 2023	3.3268	3.3356	0.0088	2.1	0.02	4.1

Moisture Quality Assurance							
Test Number	Sampling Duration mins	Total Volume Sampled l	Sampling Rate l/min	Start Leak Rate l/min	End Leak Rate l/min	Acceptable Leak Rate l/min	Leak Tests Acceptable?
Run 1	40	516	13.7	0.10	-	0.27	Yes

PRELIMINARY STACK SURVEY

Stack Characteristics		
Stack Diameter / Depth, D	0.34	m
Stack Width, W	-	m
Stack Area, A	0.09	m^2
Average stack gas temperature	60	^oC
Stack static pressure	0.05	kPa
Barometric Pressure	100.1	kPa

Stack Gas Composition & Molecular Weights								
Component	Molar Mass M	Density kg/m^3 p	Conc Dry % Vol	Dry Volume Fraction r	Dry Conc kg/m^3 pi	Conc Wet % Vol	Wet Volume Fraction r	Wet Conc kg/m^3 pi
CO_2	44	1.963059	9.227827	0.092278	0.181148	9.031600	0.090316	0.177296
O_2	32	1.427679	10.619931	0.106199	0.151619	10.394102	0.103941	0.148394
N_2	28	1.249219	80.152242	0.801522	1.001277	78.447828	0.784478	0.979985
H_2O	18	0.803070	-	-	-	2.126471	0.021265	0.017077

Where: p = M / 22.41 p*i* = r x p

Calculation of Stack Gas Densities		
Determinand	Result	Units
Dry Density (STP), P_{STD}	1.3340	kg/m^3
Wet Density (STP), P_{STW}	1.3228	kg/m^3
Dry Density (Actual), P_{Actual}	1.0813	kg/m^3
Average Wet Density (Actual), $P_{ActualW}$	1.072	kg/m^3

Where:

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

$P_{STW} = (P_{STD} + pi \text{ of } H_2O) / (1 + (pi \text{ of } H_2O / 0.8036))$

$P_{Actual} = P_{STD}$ x (Ts / Ps) x (Pa / Ta)

$P_{ActualW} = P_{STW}$ x (Ts / Ps) x (Pa / Ta)

APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

PRELIMINARY STACK SURVEY

TRAVERSE 1

Date of Survey	23 October 2023
Time of Survey	11:10
Velocity Measurement Device:	S-Type Pitot

Sampling Line A								
Traverse Point	Distance into duct (m)	DP pt Pa (average of 3 readings)	DP pt mmH_2O (average of 3 readings)	Temp °C	Velocity m/s	Volumetric Flow Rate (actual) m^3/s	O_2 % Vol	Angle of Swirl °
1	0.17	39.9	4.1	60	7.3	0.7	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
Mean	-	39.9	4.1	60	7.3	0.7	-	-

Sampling Line B								
Traverse Point	Distance into duct (m)	DP pt Pa (average of 3 readings)	DP pt mmH_2O (average of 3 readings)	Temp °C	Velocity m/s	Volumetric Flow Rate (actual) m^3/s	O_2 % Vol	Angle of Swirl °
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
Mean	-	-	-	-	-	-	-	-

PRELIMINARY STACK SURVEY QUALITY ASSURANCE CHECKLIST

PITOT LEAK CHECK								
Run	Pre Traverse Leak Rate				Post Traverse Leak Rate			
	Start Value mmH2O	End Value mmH2O	Difference %	Outcome	Start Value mmH2O	End Value mmH2O	Difference %	Outcome
Run 1	133	132	0.8	Pass	137	137	0.0	Pass

To complete a compliant pitot leak check a pressure of over 80 mmH_2O (or 800 Pa) is applied and the pressure drop monitored over 5 mins. A drop of less than 5% must be observed.

S-Type Pitot Stagnation Check				
Run	Stagnation (Pa)	Reference (Pa)	Difference (Pa)	Outcome (Permitted +/- 10 Pa)
Run 1	50	50	0.0	Pass

APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

PRELIMINARY STACK SURVEY (CONTINUED)

Sampling Plane Validation Criteria				
EA Technical Guidance Note (Monitoring) M1	Result	Units	Requirement	Compliant
Lowest Average Differential Pressure	40	Pa	>= 5 Pa	Yes
Lowest Gas Velocity	7.3	m/s	-	-
Highest Gas Velocity	7.3	m/s	-	-
Ratio of Gas Velocities	1.0	-	< 3 : 1	Yes
Maximum angle of flow with regard to duct axis	<15	^{o}	< 15^{o}	Yes
No local negative flow	Yes	-	-	Yes

Calculation of Stack Gas Velocity, V		
Velocity at Traverse Point, V = K_{pt} x (1-e) * Ö(2 * DP_{pt} / $P_{ActualW}$)		
Where: K_{pt} = Pitot tube calibration coefficient (1-e) = Compressibility correction factor, assumed at a constant 0.998		
Average Stack Gas Velocity, Va	**7.3**	m/s

Calculation of Stack Gas Volumetric Flowrate, Q			
Duct gas flow conditions	Actual	Reference	Units
Temperature	60	0	^{o}C
Total Pressure	100.15	101.3	kPa
Oxygen	10.6	11	%
Moisture	2.13	0.00	%
Pitot tube calibration coefficient, K_{pt}	0.84		

Gas Volumetric Flowrate	Result	Units
Average Stack Gas Velocity (Va)	7.26	m/s
Stack Area (A)	0.09	m^2
Gas Volumetric Flowrate (Actual), Q_{Actual}	2372.84	m^3/hr
Gas Volumetric Flowrate (STP, Wet), Q_{STP}	1923.22	m^3/hr
Gas Volumetric Flowrate (STP, Dry), $Q_{STP,Dry}$	1882.32	m^3/hr
Gas Volumetric Flowrate (REF), Q_{Ref}	1953.86	m^3/hr

Where:
Q_{Actual} = Va x A x 3600
Q_{STP} = Q (Actual) x (Ts / Ta) x (Pa / Ps) x 3600
$Q_{STP,Dry}$ = Q (STP) / (100 - (100 / Ma)) x 3600
Q_{Ref} = Q (STP) x ((100 - Ma) / (100 - Ms)) x ((21 - O_2a) / (21 - O_2s))

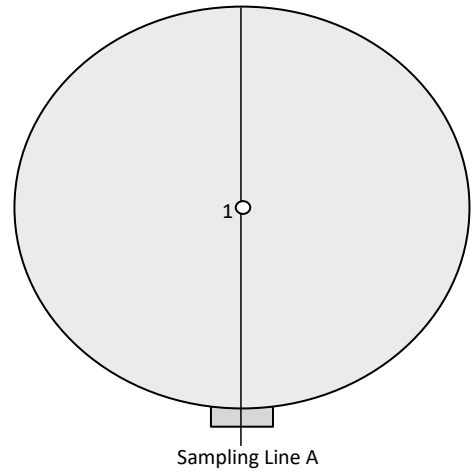
Nomenclature:
Ts = Absolute Temperature, Standard Conditions, 273 K
Ps = Absolute Pressure, Standard Conditions, 101.3 kPa
Ta = Absolute Temperature, Actual Conditions, K
Pa = Absolute Pressure, Actual Conditions, kPa
Ma = Water vapour, Actual Conditions, % Vol
Ms = Water vapour, Reference Conditions, % Vol
O_2a = Oxygen, Actual Conditions, % Vol
O_2s = Oxygen, Reference Conditions, % Vol

APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

STACK DIAGRAM

	Value	Units
Stack Depth	0.34	m
Stack Width	-	m
Area	0.09	m^2

Non-Isokinetic/Gases Sampling			
Sampling Point	Distance (% of Depth)	Distance into Stack	Units
A	50	0.17	m



○ Isokinetic sampling point
● Isokinetic sampling points not used
● Non Isokinetic/Gases sampling point

Isokinetic Sampling			
Sampling Point	Distance (% of Depth)	Distance into Stack (m)	Swirl °
1	50.0	0.17	< 15
-	-	-	-
-	-	-	-
-	-	-	-
-	-	-	-
-	-	-	-
-	-	-	-
-	-	-	-
-	-	-	-
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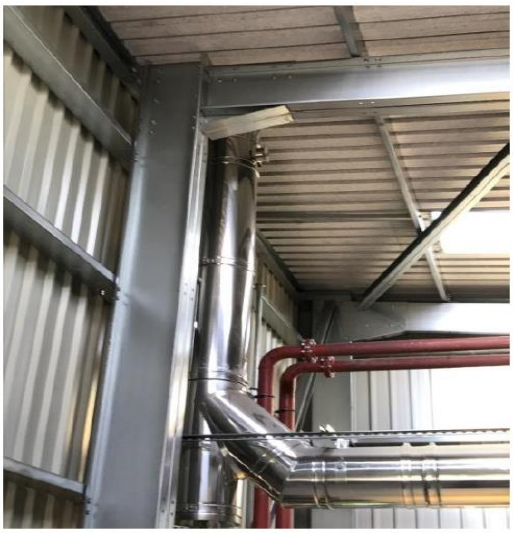
-	-	-	-

SAMPLING LOCATION



APPENDIX 3 - Measurement Uncertainty Budget Calculations

MEASUREMENT UNCERTAINTY BUDGET - TOTAL PARTICULATE MATTER

Run	Sampled Volume	Sampled Gas Temp	Sampled Gas Pressure	Sampled Gas Humidity	Oxygen Content	Limit of Detection	Leak	Uncollected Mass
	m^3	K	kPa	% by volume	% by volume	% by mass	%	mg
MU required	**≤ 2%**	**≤ 2%**	**≤ 1%**	**≤ 1%**	**≤ 10%**	**≤ 5% of ELV**	**≤ 2%**	**≤ 10% of ELV**
Run 1	0.001	2.0	0.50	1.0	0.1	0.2000	-	-
as a %	0.20	0.59	0.50	1.0	1.16	0.53266	0.73	0.0003
compliant?	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
Run 2	0.001	2.0	0.50	1.0	0.1	0.200	-	-
as a %	0.20	0.68	0.50	1.0	0.83	0.778	0.85	0.0003
compliant?	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
Run 3	0.001	2.0	0.50	1.0	0.1	0.2000	-	-
as a %	0.20	0.68	0.50	1.0	1.25	0.53625	0.77	0.0003
compliant?	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**

Run	Volume (STP)	Mass of particulate	O_2 Correction	Leak	Uncollected Mass	Combined uncertainty
	m^3	mg	-	mg/m^3	mg	
Run 1	0.40	19.7600	0.8	0.1334	0.0001	-
MU as mg/m^3	0.41	0.3196	0.25	0.1334	0.0002	**0.59**
MU as %	1.29	1.0121	-	0.422	0.0006	-
Run 2	0.39	16.8600	1.1	0.1926	0.0001	-
MU as mg/m^3	0.52	0.4668	0.44	0.1926	0.0003	**0.85**
MU as %	1.3	1.1862	-	0.489	0.0007	-
Run 3	0.57	14.5400	0.8	0.1043	0.0001	-
MU as mg/m^3	0.31	0.3218	0.18	0.1043	0.0002	**0.49**
MU as %	1.33	1.3755	-	0.446	0.0008	-

R1 - Uncertainty expressed at a 95% confidence level (where k = 2)	**1.2**	**mg/m^3**	**3.7**	**% Result**	**2.0**	**% ELV**
R2 - Uncertainty expressed at a 95% confidence level (where k = 2)	**1.7**	**mg/m^3**	**4.3**	**% Result**	**2.8**	**% ELV**
R3 - Uncertainty expressed at a 95% confidence level (where k = 2)	**0.99**	**mg/m^3**	**4.2**	**% Result**	**1.6**	**% ELV**

(k is a coverage factor which gives a 95% confidence in the quoted figures)

Reference – SOCOTEC Technical Procedure AE150 Estimation of Uncertainty of Measurement

APPENDIX 3 - Measurement Uncertainty Budget Calculations

MEASUREMENT UNCERTAINTY BUDGET - MOISTURE

Run	Sampled Volume	Sampled Gas Temp	Sampled Gas Pressure	Sampled Gas Humidity	Oxygen Content	Leak
	m^3	K	kPa	% by volume	% by volume	%
MU required	**≤ 2%**	**≤ 2%**	**≤ 1%**	**≤ 1%**	**≤ 10%**	**≤ 2%**
Run 1	0.001	2.0	0.50	1.0	0.1	-
as a %	0.20	0.59	0.50	1.0	1.16	0.73
compliant?	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**

Run	Volume (STP)	Mass Gained	O_2 Correction	Leak	Uncollected Mass	Combined uncertainty
	m^3	mg	-	mg/m^3	mg	
Run 1	0.40	8800	0.8	73.66	58	-
MU as % v/v	0.03	0.02	0.02	0.01	0.014	**0.05**
MU as %	1.29	1.14	0.81	0.42	0.66	-

R1 - Uncertainty expressed at a 95% confidence level (where k = 2)	**0.09**	**% v/v**	**4.1**	**%**

APPENDIX 3 - Measurement Uncertainty Budget Calculations

MEASUREMENT UNCERTAINTY BUDGET - VOLATILE ORGANIC COMPOUNDS RUN 1

Measured Concentration	9.1	mg/m^3
Limit	20	mg/m^3
Calibration Gas Concentration	16	mg/m^3
Range	160	mg/m^3

Performance characteristics	Value	Units	specification	MU Met?
Response time	20	seconds	<180	Yes
Logger sampling interval	60	seconds	-	-
Measurement period	195	minutes	-	-
Number of readings in measurement	195	-	-	-
Repeatability at zero	0.25	% full scale	<1 % range	Yes
Repeatability at span level	0.15	% full scale	<2 % range	Yes
Deviation from linearity	0.70	% of value	<2 % range	Yes
Zero drift	3.00	% full scale	<5% range / 24hr	Yes
Span drift	-4.80	% full scale	<5% range / 24hr	Yes
volume or pressure flow dependence	0.02	% of full scale/3 kPa	<2 % / 3 kPa	Yes
atmospheric pressure dependence	0.80	% of full scale/2 kPa	<3% / 2 kPa	Yes
ambient temperature dependence	0.01	% full scale/10K	<3% range / 10 K	Yes
dependence on voltage	0.10	% full scale/10V	< 0.1%vol /10 volt	Yes
losses in the line (leak)	0.0000	% of value	< 2% of span gas value	Yes
Uncertainty of calibration gas	1.0	% of value	< 2% of value	Yes

Performance characteristic	Uncertainty	Value of uncertainty quantity
Standard deviation of repeatability at zero	ur0	0.01
Standard deviation of repeatability at span level	urs	0.01
Lack of fit	ufit	0.65
Drift	u0dr	0.16
volume or pressure flow dependence	uspres	0.0006
atmopsheric pressure dependence	uapres	0.04
ambient temperature dependence	utemp	0.000005
Dependence on voltage	uvolt	0.14
losses in the line (leak)	uleak	0.000000
Uncertainty of calibration gas	ucalib	0.05
Uncertainty in factor	uf	0.03

Measurement uncertainty Measured Concentration	9.06	mg/m^3
Combined uncertainty	0.68	mg/m^3
Expanded uncertainty	1.34	mg/m^3

Expanded uncertainty expressed with a level of confidence of 95%	**6.7**	**% ELV**
Expanded uncertainty expressed with a level of confidence of 95%	**1.3**	**mg/m^3**
Expanded uncertainty expressed with a level of confidence of 95%	**15**	**% value**

Reference – SOCOTEC Technical Procedure AE150 Estimation of Uncertainty of Measurement

APPENDIX 3 - Measurement Uncertainty Budget Calculations

MEASUREMENT UNCERTAINTY BUDGET - OXIDES OF NITROGEN

Limit value	400	mg/m^3
Concentration @ Ref conditions	100.9	mg/m^3
Cal gas conc	407	mg/m^3
Analyser Full Scale	513	mg/m^3

	Value	Units	specification	MU Met?
Response time	20	seconds	180	Yes
Logger sampling interval	60	seconds	-	-
Measurement period	195	minutes	-	-
Number of readings in measurement	195	-	-	-
Repeatability at zero	0.11	% full scale	<1 % range	Yes
Repeatability at span level	0.1	% full scale	<2 % range	Yes
Deviation from linearity	-0.40	% of value	<2 % range	Yes
Zero drift	0.36	% full scale	<5% range / 24hr	Yes
Span drift	-0.60	% full scale	<5% range / 24hr	Yes
volume or pressure flow dependence	0.25	% of full scale/3 kPa	<2 % / 3 kPa	Yes
atmospheric pressure dependence	0.25	% of full scale/2 kPa	<3% / 2 kPa	Yes
ambient temperature dependence zero / span	0.0000	% full scale/10K	<3% range / 10 K	Yes
Combined interference	-0.01	% range	<4% of Range	Yes
dependence on voltage	0.04	% full scale/10V	< 0.1%vol /10 volt	Yes
Influence of Vibration	N/A	% of upper limit of Cal range	<2%	-
losses in the line (leak)	0.04	% of value	< 2% of value	Yes

Performance characteristic	Uncertainty	Value of uncertainty quantity
repeatability	$U_r = S_r$	0.0037
lack of fit	U_{lof}	-0.2309
short term zero drift	$U_{d,z}$	0.2058
short term span drift	$U_{d,s}$	-0.3487
influence of Ambient Temp at Zero	$U_{t,z}$	0.0000
influence of Ambient Temp at Span	$U_{t,s}$	0.4500
influence of sample gas pressure	U_p	0.000000
influence of sample gas flow	U_{fit}	0.1732
influence of supply voltage	U_v	0.1071
Combined Interfence	U_i	-0.0018
Uncertainty of Cal gas	U_{adj}	1.9870

Measurement uncertainty (Concentration Measured)	100.92	mg/m^3
Combined uncertainty	2.10	mg/m^3
Expanded at a 95% confidence interval	4.12	mg/m^3

Expanded uncertainty expressed with a level of confidence of 95%	**1.0**	**% ELV**
Expanded uncertainty expressed with a level of confidence of 95%	**4.1**	**mg/m^3**
Expanded uncertainty expressed with a level of confidence of 95%	**4.1**	**% value**

APPENDIX 3 - Measurement Uncertainty Budget Calculations

MEASUREMENT UNCERTAINTY BUDGET - CARBON MONOXIDE

Limit value	250	mg/m^3
Concentration @ Ref conditions	175.5	mg/m^3
Cal gas conc	100.1	mg/m^3
Analyser Full Scale	250	mg/m^3

Performance characteristics	Value	Units	specification	MU Met?
Response time	20	seconds	180	Yes
Logger sampling interval	60	seconds	-	-
Measurement period	195	minutes	-	-
Number of readings in measurement	195	-	-	-
Repeatability at zero	0.1	% full scale	<1 % range	Yes
Repeatability at span level	0.2	% full scale	<2 % range	Yes
Deviation from linearity	0.61	% of value	<2 % range	Yes
Zero drift	0.39	% full scale	<5% range / 24hr	Yes
Span drift	-0.87	% full scale	<5% range / 24hr	Yes
volume or pressure flow dependence	0.2	% of full scale/3 kPa	<2 % / 3 kPa	Yes
atmospheric pressure dependence	0.44	% of full scale/2 kPa	<3% / 2 kPa	Yes
ambient temperature dependence zero / span	-0.8	% full scale/10K	<3% range / 10 K	Yes
Combined interference	-0.01	% of Range	<4% of Range	Yes
dependence on voltage	-0.06	% full scale/10V	< 0.1%vol /10 volt	Yes
Influence of Vibration	N/A	% of upper limit of Cal range	<2%	N/A
losses in the line (leak)	0.002	% of value	< 2% of value	Yes
Uncertainty of calibration gas	1.00	% of value	< 2% of value	Yes

N/A - Horiba's are not effected by Vibration

Performance characteristic	Uncertainty	Value of uncertainty quantity
repeatability	$U_r = S_r$	0.003
lack of fit	U_{lof}	0.12
short term zero drift	$U_{d,z}$	0.35
short term span drift	$U_{d,s}$	0.22
influence of Ambient Temp zero	$U_{t,z}$	-0.07
influence of Ambient Temp span	$U_{t,s}$	0.04
influence of sample gas pressure	U_p	0.00000
influence of sample gas flow	U_{fit}	0.14
influence of supply voltage	U_v	-0.09
Combined Interfence	U_i	-0.20
Uncertainty of Cal gas	U_{adj}	0.40

Measurement uncertainty (Concentration Measured)	153.3	mg/m^3
Combined uncertainty	0.6	mg/m^3
Expanded uncertainty	1.3	mg/m^3

Expanded uncertainty expressed with a level of confidence of 95%	**0.51**	**% ELV**
Expanded uncertainty expressed with a level of confidence of 95%	**1.3**	**mg/m^3**
Expanded uncertainty expressed with a level of confidence of 95%	**0.83**	**% value**

Reference – SOCOTEC Technical Procedure AE150 Estimation of Uncertainty of Measurement

APPENDIX 3 - Measurement Uncertainty Budget Calculations

MEASUREMENT UNCERTAINTY BUDGET - OXYGEN

Reference	11	%vol
Reported Concentration	11.16	%vol
Calibration gas	20.96	%vol
Analyser Full Scale	25	%vol

	Value	Units	specification	MU Met?
Response time	20	seconds	180	Yes
Logger sampling interval	60	seconds	-	-
Measurement period	195	minutes	-	-
Number of readings in measurement	195	-	-	-
Repeatability at zero	0.25	% full scale	<1 % range	Yes
Repeatability at span level	0.15	% full scale	<2 % range	Yes
Deviation from linearity	0.13	% of value	<2 % range	Yes
Zero drift	0.19	% full scale	<5% range / 24hr	Yes
Span drift	-0.33	% full scale	<5% range / 24hr	Yes
volume or pressure flow dependence	0.03	% of full scale/3 kPa	<2 % / 3 kPa	Yes
atmospheric pressure dependence	0.05	% of full scale/2 kPa	<3% / 2 kPa	Yes
ambient temperature dependence	-0.05	% full scale/10K	<3% range / 10 K	Yes
Combined interference	0.01	% range	<4% of Range	Yes
dependence on voltage	0.0005	% full scale/10V	< 0.1%vol /10 volt	Yes
losses in the line (leak)	0.01	% of value	< 2% of value	Yes
Uncertainty of calibration gas	0.005	% of value	< 2% of value	Yes

Performance characteristic	Uncertainty	Value of uncertainty quantity
repeatability	$U_r = S_r$	0.0083
lack of fit	U_{lof}	0.0751
short term zero drift	$U_{d,z}$	0.1110
short term span drift	$U_{d,s}$	-0.1928
influence of Ambient Temp at Zero	$U_{t,z}$	-0.0001
influence of Ambient Temp at Span	$U_{t,s}$	0.000000
influence of sample gas pressure	U_p	0.000000
influence of sample gas flow	U_{fit}	0.0173
influence of supply voltage	U_v	0.0001
Combined Interfence	U_i	0.0017
Uncertainty of Cal gas	U_{adj}	0.1048

Measurement uncertainty (Concentration Measured)	11.16	%
Combined uncertainty	0.26	%
Expanded uncertainty	0.51	%

Expanded uncertainty expressed with a level of confidence of 95%	**0.5**	**%**
Expanded uncertainty expressed with a level of confidence of 95%	**4.53**	**% vol**

APPENDIX 3 - Measurement Uncertainty Budget Calculations

MEASUREMENT UNCERTAINTY BUDGET - VELOCITY & VOLUMETRIC FLOW RATE

Measured Velocity at Actual Conditions	7.3	m/s
Measured Volumetric Flow rate at Actual Conditions	2373	m³/hr

Performance Characteristics & Source of Value	Units	Values	Requirement	Compliant
Uncertainty of Local Gas Velocity Determination				
Uncertainty of pitot tube coefficient	-	0.010		
Uncertainty of mean local dynamic pressures	-	0.50		
Factor loading, function of the number of measurements.	3 readings	0.591	minimum 3	Yes
Range of measurment device	pa	1000		
Resolution	pa	1.00		
Calibration uncertainty	pa	7.70	<1% of Value or 20 Pa whichever is greater	Yes
Drift	% range	0.10		
Linearity	% range	0.06	<2% of value	Yes
Uncertainty of gas density determination				
Uncertainty of molar mass determination	kg/mol	0.00001		
Uncertainty of temperature measurement	K	1.70	<1% of value	Yes
Uncertainty of absolute pressure in the duct	pa	511		
Uncertainty associated with the calculation of density	kg/m3	0.007		
Uncertainty associated with the measurement of local velocity	-	0.0001		
Uncertainty associated with the measurement of mean velocity	-	0.0002		

Measurement Uncertainty - Velocity	m/s
Combined uncertainty	0.09
Expanded uncertainty at a 95% Confidence Interval	0.18

Note - The expanded uncertainty uses a coverage factor of k = 2.

Expanded Measurement Uncertainty of Velocity at a 95% Confidence Interval	%
Expressed as a % of the Measured Velocity	1.3
Expanded uncertainty at a 95% Confidence Interval	2.5

Measurement Uncertainty Volumetric Flow Rate	m³/hr
Combined uncertainty	63
Expanded uncertainty at a 95% Confidence Interval	123

Note - The expanded uncertainty uses a coverage factor of k = 2.

Expanded Measurement Uncertainty of Volumetric Flow Rate at a 95% Confidence Interval	%
Expressed as a % of the Measured Volumetric Flow Rate	2.6
Expanded uncertainty at a 95% Confidence Interval	5.2

Reference – SOCOTEC Technical Procedure AE150 Estimation of Uncertainty of Measurement

END OF REPORT

Thank you for choosing SOCOTEC for your environmental monitoring needs. We hope our services have met your requirements and that you are fully satisfied with your experience of working with us, we really do value your custom and would welcome your feedback. We would appreciate it if you could take a moment to complete a short online questionnaire so that we can improve our operations and address any areas that have not met with your expectations, by clicking on the following

https://www.surveymonkey.co.uk/r/CAE_customer_feedback_weblink