# STACK EMISSIONS MONITORING REPORT

2-4 Langlands Place
Kelvin South Business Park
East Kilbride
G75 0YF
Tel: 01355 246 730

| Your contact at SOCOTEC UK LTD |
|---|
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| Operator & Address: |
|---|
| Medite Europe Limited<br>Redmondstown<br>Clonmel<br>Co. Tipperary |

| Permit Reference: |
|---|
| IE Licence: P0027-04 |

| Release Point: |
|---|
| A2-21 |

| Sampling Date(s): |
|---|
| 30th September - 2nd October |

| | |
|---|---|
| SOCOTEC Job Number: | LIR 1328 / Q3 |
| Report Date: | 31-Oct-25 |
| Version: | 1 |
| Report By:<br>MCERTS Number:<br>MCERTS Level:<br>Technical Endorsements: | Barry Kehoe<br>MM 23 1818<br>MCERTS Level 1 Technician<br>1 & 4 |
| Report Approved By:<br>MCERTS Number:<br>Business Title:<br>Technical Endorsements:<br><br>Signature: | Brian Walsh<br>MM 17 1414<br>MCERTS Level 2 - Team Leader<br>1, 2, 3 & 4 |

UKAS TESTING 1015

mCERTS THE ENVIRONMENT AGENCY'S MONITORING CERTIFICATION SCHEME

# CONTENTS

# EXECUTIVE SUMMARY

## MONITORING OBJECTIVES

Medite Europe Limited operates a wood fibre drier process at Medite Europe Limited which is subject to IE Licence P0027-04, under the EPA Act 1992.

SOCOTEC UK LTD were commissioned by Medite Europe Limited 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 IE Licence, P0027-04.

**Plant**

A2-21

**Operator**

Medite Europe Limited
Redmondstown
Clonmel
Co. Tipperary

IE Licence: P0027-04

**Stack Emissions Monitoring Test House**

SOCOTEC UK LTD - East Kilbride Laboratory
2-4 Langlands Place
Kelvin South Business Park
East Kilbride
G75 0YF
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 A2-21 | | | | | |
|---|---|---|---|---|---|
| **Parameter** | **Units** | **Result** | **Calculated Uncertainty +/-** | **Emission Limit Value (ELV)** | **Accreditation** |
| Total Particulate Matter | mg/m³ | 5.7 | 0.23 | 20 | MCERTS |
| Particulate Emission Rate | g/hr | 1553 | 62 | - | |
| **Dioxins & Furans - UPPER Limits** | | | | | |
| Dioxins & Furans (NATO I-TEQ) | ng/m³ | 0.0008 | 0.0009 | - | MCERTS |
| Dioxins & Furans (NATO I-TEQ) Emission Rate | µg/hr | 0.1247 | 0.1365 | - | |
| Dioxins & Furans (WHO TEQ Humans / Mammals) | ng/m³ | 0.0008 | 0.0009 | - | MCERTS |
| Dioxins & Furans (WHO TEQ H / M) Emission Rate | µg/hr | 0.1276 | 0.1397 | - | |
| Dioxins & Furans (WHO TEQ Fish) | ng/m³ | 0.0008 | 0.0008 | - | MCERTS |
| Dioxins & Furans (WHO TEQ Fish) Emission Rate | µg/hr | 0.1195 | 0.1309 | - | |
| Dioxins & Furans (WHO TEQ Birds) | ng/m³ | 0.0026 | 0.0028 | - | MCERTS |
| Dioxins & Furans (WHO TEQ Birds) Emission Rate | µg/hr | 0.4042 | 0.4426 | - | |
| **Dioxins & Furans - LOWER Limits** | | | | | |
| Dioxins & Furans (NATO I-TEQ) | ng/m³ | 0.0006 | 0.0006 | - | MCERTS |
| Dioxins & Furans (NATO I-TEQ) Emission Rate | µg/hr | 0.0914 | 0.1001 | - | |
| Dioxins & Furans (WHO TEQ Humans / Mammals) | ng/m³ | 0.0005 | 0.0005 | - | MCERTS |
| Dioxins & Furans (WHO TEQ H / M) Emission Rate | µg/hr | 0.0769 | 0.0842 | - | |
| Dioxins & Furans (WHO TEQ Fish) | ng/m³ | 0.0004 | 0.0004 | - | MCERTS |
| Dioxins & Furans (WHO TEQ Fish) Emission Rate | µg/hr | 0.0640 | 0.0701 | - | |
| Dioxins & Furans (WHO TEQ Birds) | ng/m³ | 0.0022 | 0.0025 | - | MCERTS |
| Dioxins & Furans (WHO TEQ Birds) Emission Rate | µg/hr | 0.3557 | 0.3895 | - | |
| Formaldehyde | mg/m³ | 4.29 | 1.03 | 15 | MCERTS |
| Formaldehyde Emission Rate | g/hr | 1165.13 | 279.63 | - | |
| Total Volatile Organic Compounds | mg/m³ | 13.99 | 1.3 | 120 | MCERTS |
| Total Volatile Organic Compounds Emission Rate | g/hr | 2814.21 | 264.54 | - | |
| Oxides of Nitrogen (as $NO_2$) | mg/m³ | 102.17 | 4.2 | 110 | MCERTS |
| Oxides of Nitrogen (as $NO_2$) Emission Rate | g/hr | 20552 | 853 | - | |
| Carbon Monoxide | mg/m³ | 2.76 | 1.85 | 300 | MCERTS |
| Carbon Monoxide Emission Rate | g/hr | 555.24 | 372.56 | - | |
| Moisture | % | 7.19 | 0.19 | - | MCERTS |
| Stack Gas Temperature | °C | 58 | - | - | MCERTS |
| Stack Gas Velocity | m/s | 17.6 | 0.43 | - | |

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 .

# EXECUTIVE SUMMARY

| MONITORING TIMES | | | |
|---|---|---|---|
| **Parameter** | **Sampling Date(s)** | **Sampling Times** | **Sampling Duration** |
| Total Particulate Matter Run 1 | 30 September 2025 | 12:10 - 12:42 | 32 minutes |
| Dioxins & Furans Run 1 | 30 September 2025 | 12:50 - 18:50 | 360 minutes |
| Formaldehyde Run 1 | 30 September 2025 | 12:10 - 12:42 | 32 minutes |
| Total Volatile Organic Compounds Run 1 | 02 October 2025 | 11:43 - 12:15 | 32 minutes |
| Combustion Gases | 30 September 2025 | 13:29 - 14:28 | 59 minutes |
| Preliminary Stack Traverse | 30 September 2025 | 12:20 | - |

# EXECUTIVE SUMMARY

## PROCESS DETAILS

| Parameter | Process Details |
|---|---|
| Description of process | Wood Fibre Drier |
| Continuous or batch | Continuous |
| Product Details | MDF |
| Part of batch to be monitored (if applicable) | N/A |
| Normal load, throughput or continuous rating | Normal Load |
| Fuel used during monitoring | Wood |
| Abatement | Cyclone |
| Plume Appearance | Very Heavy Steam Plume |

# EXECUTIVE SUMMARY

## Monitoring Methods

Declaration: Unless otherwise stated as a deviation, work has been completed to conform to the specific requirements of the Irish EPA's monitoring guidance notes; AG1, AG2, and the index of preferred methods.

| 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 - EN 13284-1 | AE 104 | 1015 | MCERTS | 0.08 mg/m³ | 4% | 1.14% |
| Dioxins & Furans | SRM - EN 1948 - Part 1 | AE 109 | 1015 | MCERTS | 0.0003 ng/m³ | 109.5% | N/A - No ELV |
| Formaldehyde | CEN/TS 17638 | AE114 | 1015 | MCERTS | 0.022 mg/m³ | 24% | 6.86% |
| Total Volatile Organic Compounds | SRM - EN 12619:2013 | AE 102 | 1015 | MCERTS | 0.3 mg/m³ | 9.4% | 1.1% |
| Oxides of Nitrogen | SRM - EN 14792:2017 | AE 102 | 1015 | MCERTS | 0.51 mg/m³ | 4.1% | 3.85% |
| Carbon Monoxide | SRM - EN 15058:2017 | AE 102 | 1015 | MCERTS | 0.28 mg/m³ | 67.1% | 0.6% |
| Moisture | EN 14790 | AE 105 | 1015 | MCERTS | 0.02% | 2.7% | N/A - No ELV |
| Velocity | SRM - EN ISO 16911-1 | AE 154 | 1015 | MCERTS | 5 Pa | 2.4% | N/A - No ELV |
| Volumetric Flow Rate | SRM - EN ISO 16911-1 | AE 154 | 1015 | MCERTS | - | 5.1% | 5.94% |

# 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 (East Kilbride) | N/A | 8 Weeks |
| Dioxins and Furans | Gas Chromatography - High Resolution Mass Spectometry | 2002a | 1668 | MCERTS | Marchwood | 577586-577587 13 Oct 2025 | 8 Weeks |
| Formaldehyde | Spectrophotometric | M103 | 0605 | MCERTS | RPS | 25-08503-1 | 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 (East Kilbride) | SOCOTEC (East Kilbride) | 5 years |
| Oxides of Nitrogen | Chemiluminescence | AE 102 | 1015 | MCERTS | SOCOTEC (East Kilbride) | SOCOTEC (East Kilbride) | 5 years |
| Carbon Monoxide | Non Dispersive Infra Red | AE 102 | 1015 | MCERTS | SOCOTEC (East Kilbride) | SOCOTEC (East Kilbride) | 5 years |
| Moisture | Gravimetric | AE 105 | 1015 | MCERTS | SOCOTEC (East Kilbride) | - | - |

# EXECUTIVE SUMMARY

| SAMPLING LOCATION | | | | | |
|---|---|---|---|---|---|
| **Sampling Plane Validation Criteria** | **Value** | **Units** | **Requirement** | **Compliant** | **Method** |
| Lowest Differential Pressure | 39 | Pa | >= 5 Pa | Yes | EN 15259 |
| Lowest Gas Velocity | 8.9 | m/s | - | - | - |
| Highest Gas Velocity | 25.4 | m/s | - | - | - |
| Ratio of Gas Velocities | 2.8 | : 1 | < 3 : 1 | Yes | EN 15259 |
| Mean Velocity | 17.6 | m/s | - | - | - |
| Maximum angle of flow with regard to duct axis | <15 | ° | < 15° | Yes | EN 15259 |
| No local negative flow | Yes | - | - | Yes | EN 15259 |

| DUCT CHARACTERISTICS | | |
|---|---|---|
| | **Value** | **Units** |
| Shape | Circular | - |
| Depth | 2.30 | m |
| Width | - | m |
| Area | 4.16 | $m^2$ |
| Port Depth | 90 | mm |

| SAMPLING LINES & POINTS | | |
|---|---|---|
| | **Isokinetic** | **Non-Iso & Gases** |
| Sample port size | 4" BSP | 1" Port |
| Number of lines used | 2 | 1 |
| Number of points / line | 9 | 1 |
| Duct orientation | Vertical | Vertical |
| Filtration | Out Stack | Out Stack |
| Filtration for TPM | In Stack | - |

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

| AG1 Platform requirements | |
|---|---|
| Is there a sufficient working area so work can be performed in a compliant manner | No |
| 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) | Yes |
| Platform has removable chains / self closing gates at the top of ladders | Yes |
| Handrail / obstructions do not hamper insertion of sampling equipment | No |
| Depth of Platform = >Stack depth / diameter + wall and port thickness + 1.5m | No |

**Sampling Platform Improvement Recommendations (if applicable)**

-

# EXECUTIVE SUMMARY

## Sampling & Analytical Method Deviations

**Nozzle Size**

Due to the high velocities at the sampling point selected in the stack a 6mm nozzle was required to achieve isokinetic monitoring, this does not completely adhere to EN 13284-1.

**Sampling lines**

It was only possible to sample from one representative sampling point for all isokinetic monitoring due to a number of factors i.e. flow being excessively high, swirl being greater than 15° & negative flow experienced throughout sample point locations. This sampling location does not therefore comply with all the requirements of AG1 & IS EN 16911-1.

**Velocity traverse**

As this sampling location shows high levels of turbulence throughout the results from the standard flow traverse are only indicative. In the past, reports detailing the volumetric flow rate according to fan rating have been used to calculate mass emission rates for this stack.

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 - EN 13284-1 | AE 104 | 1015 | MCERTS | 1 |
| Dioxins & Furans | SRM - EN 1948 - Part 1 | AE 109 | 1015 | MCERTS | 1 |
| Formaldehyde | CEN/TS 17638 | AE114 | 1015 | MCERTS | 1 |
| Total Volatile Organic Compounds | SRM - EN 12619:2013 | AE 102 | 1015 | MCERTS | 1 |
| Oxides of Nitrogen | SRM - EN 14792:2017 | AE 102 | 1015 | MCERTS | 1 |
| Carbon Monoxide | SRM - EN 15058:2017 | AE 102 | 1015 | MCERTS | 1 |
| Moisture | 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

| CALIBRATABLE EQUIPMENT CHECKLIST | | | | | |
|---|---|---|---|---|---|
| Extractive Sampling | | Instrumental Analyser/s | | Miscellaneous | |
| Equipment | Equipment I.D. | Equipment | Equipment I.D. | Equipment | Equipment I.D. |
| Control Box DGM | LIR 9.49 | Horiba PG - 350E Analyser | LIR 12.2 | Laboratory Balance | LIR 15.21 |
| Box Thermocouples | LIR 9.50 | FT-IR | - | Tape Measure | LIR 20.2 |
| Meter In Thermocouple | LIR 9.50 | FT-IR Oven Box | - | Stopwatch | - |
| Meter Out Thermocouple | LIR 9.50 | Bernath 3006 FID | LIR 8.4 | Protractor | - |
| Control Box Timer | LIR 17.27 | Signal 3030 FID | - | Barometer | LIR 16.13 |
| Oven Box | LIR 13.25 | Servomex | - | Digital Micromanometer | LIR 15.AF1 |
| Probe | LIR 6.22 | JCT Heated Head Filter | LIR 13.32a | Digital Temperature Meter | LIR 2.11 |
| Probe Thermocouple | - | Thermo FID | LIR 8.27 | Stack Thermocouple | - |
| Probe | LIR 6.17 | Stackmaster | - | Mass Flow Controller | - |
| Probe Thermocouple | - | FTIR Heater Box for Heated Line | - | MFC Display module | - |
| S-Pitot | LIR 6.17 | Anemometer | - | 1m Heated Line (1) | - |
| L-Pitot | - | Ecophysics NOx Analyser | - | 1m Heated Line (2) | - |
| Site Balance | LIR 23.24 | Chiller (JCT/MAK 10) | LIR 12.12 | 1m Heated Line (3) | - |
| Last Impinger Arm | LIR 3.109 | Heated Line Controller (1) | LIR 8.49 | 5m Heated Line (1) | - |
| Dioxins Cond. Thermocouple | LIR 3.209 | Heated Line Controller (2) | - | 10m Heated Line (1) | - |
| Callipers | LIR 15.1X | Site temperature Logger | - | 10m Heated Line (2) | - |
| Small DGM | - | Gas Divider (1) | - | 15m Heated Line (1) | - |
| Heater Controller | - | Gas Divider (2) | - | 20m Heated Line (1) | LIR 8.49 |
| Inclinometer (Swirl Device) | LIR 24.15 | | | 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 +/- % |
| Propane | LEK 232 | BOC | 82.8 | - | 2.0 |
| Nitric Oxide | LEK 345 | BOC | 201 | - | 2.0 |
| Carbon Monoxide | LEK 345 | BOC | 164.3 | - | 2.0 |

Note: Span gases may be diluted to an appropriate range with a gas divider.

## 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 |
| Brian Walsh | MM 17 1414 | MCERTS Level 2 | May-27 | Jan-28 | Mar-29 | Nov-28 | May-28 | May-27 |
| Stuart Gordon | MM 22 1745 | MCERTS Level 1 | Sep-27 | Apr-29 | - | Mar-30 | May-30 | Sep-27 |

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 | 12:10 - 12:42 30 September 2025 | 5.72 | 0.23 | 20 | 1553.0 |
| Blank | - | 0.08 | - | - | - |

Reference conditions are 273K, 101.3kPa, dry gas .

| Acetone Blank Value mg/l | Acceptable Value mg/l |
|---|---|
| 0.3 | 1.0 |

## 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 | IAQ 200 | 0.15015 | 0.15261 | 0.00246 | 56.00982 | 56.01142 | 0.00160 | 0.00406 |

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 | IAQ 199 | 0.15330 | 0.15337 | 0.00007 | 54.56067 | 54.56064 | -0.00003 | 0.00006 |

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 | 101.0 |
| Stack static pressure, $P_{static}$ | pa | 81.0 |
| $P_s = P_b + P_{static}$ | Kpa | 101.1 |
| **Vol. of water vapour collected, $V_{wstd}$** | | |
| Moisture trap weight increase,Vlc | g | 44.1 |
| $V_{wstd} = (0.001246)(V_{lc})$ | $m^3$ | 0.0549486 |
| **Volume of gas metered dry, $V_{mstd}$** | | |
| Volume of gas sample through gas meter, $V_m$ | | 0.775 |
| Gas meter correction factor, $Y_d$ | | 0.993 |
| Mean dry gas meter temperature, $T_m$ | | 297 |
| Mean pressure drop across orifice, DH | $mmH_2O$ | 51.379 |
| $V_{mstd} = \frac{(0.3592)(V_m)(P_b+(DH/13.6))(Y_d)}{T_m}$ | $m^3$ | 0.709 |
| **Volume of gas metered wet, $V_{mstw}$** | | |
| $V_{mstw} = V_{mstd} + V_{wstd}$ | $m^3$ | 0.7642 |
| **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%$O_2$ | | 19.1 |
| % oxygen reference condition | | 21 |
| $O_2$ Reference Factor $O_2$ Ref $= \frac{21.0 - act\%O_2}{21.0 - ref\%O_2}$ | | No O2 Ref |
| $V_{mstd@X\%oxygen} = (V_{mstd})(O_{2\,Ref})$ | $m^3$ | No O2 Ref |
| **Moisture content, $B_{wo}$** | | |
| $B_{wo} = \frac{V_{wstd}}{V_{mstd} + V_{wstd}}$ | | 0.0719 |
| | % | 7.19 |
| **Moisture by FTIR** | % | - |
| **Velocity of stack gas, $V_s$** | | |
| Velocity pressure coefficient, $C_p$ | | 0.84 |
| Mean of velocity heads, $DP_{avg}$ | Pa | 414.05 |
| Mean stack gas temperature, $T_s$ | K | 330 |
| Gas density $_{(wet,\ ambient)}$, ρ | | |
| p=(Ms*Ps)/(8.314*Ts) | $kg/m^3$ | 1.041 |
| Stack Velocity, Vs $V_s = \frac{\sum_{i=1}^{n} V_i}{n}$ | m/s | 23.68 |

| | | |
|---|---|---|
| **Molecular weight of dry gas, $M_d$** | | |
| $CO_2$ | % | 1.79 |
| $O_2$ | % | 19.09 |
| Total | % | 20.88 |
| $N_2$ (100 -Total) | % | 79.12 |
| $M_d = 0.44(\%CO_2)+0.32(\%O_2)+0.28(\%N_2)$ | | 29.05 |
| **Molecular weight of wet gas, $M_s$** | | |
| $M_s = M_d(1 - B_{wo}) + 18(B_{wo})$ | g/gmol | 28.26 |
| **Actual flow of stack gas, $Q_a$** | | |
| Area of stack, $A_s$ | $m^2$ | 4.16 |
| $Q_a = (60)(A_s)(V_s)$ | $m^3$/min | 5904.2 |
| **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 | 4521.8 |
| $Q_{stdO2} = \frac{(Q_a)P_s(0.3592)(1-B_{wo})(O_2REF)}{(T_s)}$ | @$O_2$ref | No O2 Ref |
| $Q_{stw} = \frac{(Q_a)P_s(0.3592)}{(T_s)}$ | Wet | 4872.12 |
| **Percent isokinetic, %I** | | |
| Nozzle diameter, $D_n$ | mm | 4.99 |
| Nozzle area, $A_n$ | $mm^2$ | 19.59 |
| Total sampling time, q | min | 32 |
| $\%I = \frac{(4.6398E6)(T_s)(V_{mstd})}{(P_s)(V_s)(A_n)(q)(1-B_{wo})}$ | % | 104.0 |
| Acceptable isokinetic range 95% to 115% | | Yes |
| **Particulate Concentration, C** | | |
| Mass collected on filter, $M_f$ | g | 0.00246 |
| Mass collected in probe, $M_p$ | g | 0.00160 |
| Total mass collected, $M_n$ | g | 0.00406 |
| $C_{wet} = \frac{M_n}{V_{mstw}}$ | $mg/m^3$ | 5.313 |
| $C_{dry} = \frac{M_n}{V_{mstd}}$ | $mg/m^3$ | 5.724 |
| $C_{dry@X\%O2} = \frac{M_n}{V_{mstd@X\%oxygen}}$ | $mg/m^3$ | No O2 Ref |
| **Particulate Emission Rates, E** | | |
| $E = [(C_{wet})(Q_{stw})(60)] / 1000$ | | 1553.05 |

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 | 24.06 | 0.13 | - | -381 | 0.48 | Yes |

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

| ISOKINETICITY | | |
|---|---|---|
| Run | Isokinetic Variation % | Acceptable Isokineticity |
| Run 1 | 103.99 | Yes |

Acceptable isokinetic range 95% to 115%

| WEIGHING BALANCE UNCERTAINTY | | | |
|---|---|---|---|
| Run | Result mg/m³ | 5% ELV mg/m³ | LOD < 5% ELV |
| Run 1 | 0.08 | 1.0 | Yes |

The above is based on both the Filter and rinse uncertainty

| BLANK VALUE | | | | |
|---|---|---|---|---|
| Run | Overall Blank Value $mg/m^3$ | Daily Limit Value $mg/m^3$ | Acceptable Blank Value $mg/m^3$ | Overall Blank Acceptable |
| Blank 1 | 0.08 | 20 | 2.0 | 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 | Quartz Fibre | 47 | 57 | 180 | 160 |

APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

## DIOXINS & FURANS SUMMARY - UPPER LIMIT

| NATO I-TEQ | | | | | |
|---|---|---|---|---|---|
| Test | Sampling Times | Concentration ng/m³ | LOD ng/m³ | ELV ng/m³ | Emission Rate µg/hr |
| Run 1 | 12:50 - 18:50 30 September 2025 | 0.0008 | 0.0003 | - | 0.12 |
| Field Blanks Run 1 | - | 0.000984 | 0.00037 | - | - |

| WHO TEQ (Humans / Mammals) | | | | | |
|---|---|---|---|---|---|
| Test | Sampling Times | Concentration ng/m³ | LOD ng/m³ | ELV ng/m³ | Emission Rate µg/hr |
| Run 1 | 12:50 - 18:50 30 September 2025 | 0.0008 | 0.0004 | - | 0.13 |
| Field Blanks Run 1 | - | 0.00107 | 0.00046 | - | - |

| WHO TEQ (Fish) | | | | | |
|---|---|---|---|---|---|
| Test | Sampling Times | Concentration ng/m³ | LOD ng/m³ | ELV ng/m³ | Emission Rate µg/hr |
| Run 1 | 12:50 - 18:50 30 September 2025 | 0.0008 | 0.0004 | - | 0.12 |
| Field Blanks Run 1 | - | 0.00113 | 0.00050 | - | - |

| WHO TEQ (Birds) | | | | | |
|---|---|---|---|---|---|
| Test | Sampling Times | Concentration ng/m³ | LOD ng/m³ | ELV ng/m³ | Emission Rate µg/hr |
| Run 1 | 12:50 - 18:50 30 September 2025 | 0.0026 | 0.0006 | - | 0.40 |
| Field Blanks Run 1 | - | 0.00293 | 0.00064 | - | - |

Reference conditions are 273K, 101.3kPa, dry gas .

APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

## DIOXINS & FURANS SUMMARY - LOWER LIMIT

| NATO I-TEQ | | | | | |
|---|---|---|---|---|---|
| Test | Sampling Times | Concentration ng/m³ | LOD ng/m³ | ELV ng/m³ | Emission Rate µg/hr |
| Run 1 | 12:50 - 18:50 30 September 2025 | 0.0006 | - | - | 0.09 |
| Field Blanks Run 1 | - | 0.0008348 | - | - | - |

| WHO TEQ (Humans / Mammals) | | | | | |
|---|---|---|---|---|---|
| Test | Sampling Times | Concentration ng/m³ | LOD ng/m³ | ELV ng/m³ | Emission Rate µg/hr |
| Run 1 | 12:50 - 18:50 30 September 2025 | 0.0005 | - | - | 0.08 |
| Field Blanks Run 1 | - | 0.00092619 | - | - | - |

| WHO TEQ (Fish) | | | | | |
|---|---|---|---|---|---|
| Test | Sampling Times | Concentration ng/m³ | LOD ng/m³ | ELV ng/m³ | Emission Rate µg/hr |
| Run 1 | 12:50 - 18:50 30 September 2025 | 0.0004 | - | - | 0.06 |
| Field Blanks Run 1 | - | 0.000948687 | - | - | - |

| WHO TEQ (Birds) | | | | | |
|---|---|---|---|---|---|
| Test | Sampling Times | Concentration ng/m³ | LOD ng/m³ | ELV ng/m³ | Emission Rate µg/hr |
| Run 1 | 12:50 - 18:50 30 September 2025 | 0.0022 | - | - | 0.36 |
| Field Blanks Run 1 | - | 0.00281297 | - | - | - |

Reference conditions are 273K, 101.3kPa, dry gas .

APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

## DIOXINS & FURANS ANALYSIS SUMMARY - RUN 1

| NATO I-TEQ & WHO TEQ (Humans / Mammals) | | | | | | | |
|---|---|---|---|---|---|---|---|
| Congener | Result | NATO I-TEQ | WHO TEQ Humans / Mammals | Extraction Recovery | | Sampling Recovery | |
| | | | | Actual | Permitted | Actual | Permitted |
| | ng | ng | ng | % | % | % | % |
| **Dioxins** | | | | | | | |
| 2,3,7,8 Tetra CDD | < 0.00032 | 0.0003 | 0.0003 | 92 | 50% - 130% | | |
| 1,2,3,7,8 Penta CDD | < 0.00099 | 0.0005 | 0.0010 | 72 | 50% - 130% | | |
| 1,2,3,4,7,8 Hexa CDD | < 0.00045 | 0.0000 | 0.0000 | 86 | 50% - 130% | | |
| 1,2,3,6,7,8 Hexa CDD | 0.00236 | 0.0002 | 0.0002 | 88 | 50% - 130% | | |
| 1,2,3,7,8,9 Hexa CDD | < 0.00045 | 0.0000 | 0.0000 | | - | | |
| 1,2,3,4,6,7,8 Hepta CDD | 0.0134 | 0.0001 | 0.0001 | 71 | 40% - 130% | | |
| OCDD Octa CDD | 0.0449 | 0.0000 | 0.00001 | 74 | 40% - 130% | | |
| **Total -Dioxins** | **0.06286** | **0.0013** | **0.0018** | | | | |
| **Furans** | | | | | | | |
| 2,3,7,8 Tetra CDF | 0.0079 | 0.0008 | 0.0008 | 80 | 50% - 130% | | |
| 1,2,3,7,8 Penta CDF | 0.00162 | 0.0001 | 0.0000 | | - | 86 | >=50 |
| 2,3,4,7,8 Penta CDF | 0.00172 | 0.0009 | 0.0005 | 72 | 50% - 130% | | |
| 1,2,3,4,7,8 Hexa CDF | 0.00125 | 0.0001 | 0.0001 | 84 | 50% - 130% | | |
| 1,2,3,6,7,8 Hexa CDF | 0.00123 | 0.0001 | 0.0001 | 81 | 50% - 130% | | |
| 2,3,4,6,7,8 Hexa CDF | 0.00146 | 0.0001 | 0.0001 | 85 | 50% - 130% | | |
| 1,2,3,7,8,9 Hexa CDF | < 0.00044 | 0.0000 | 0.0000 | | - | 84 | >=50 |
| 1,2,3,4,6,7,8 Hepta CDF | 0.00398 | 0.0000 | 0.0000 | 67 | 40% - 130% | | |
| 1,2,3,4,7,8,9 Hepta CDF | 0.00136 | 0.00001 | 0.00001 | | - | 88 | >=50 |
| OCDF Octa CDF | 0.00699 | 0.00001 | 0.00000 | 69 | 40% - 130% | | |
| **Total -Furans** | **0.027951** | **0.0022** | **0.0018** | | | | |
| **Mean Recoveries (%)** | | | | **79** | | **86** | |
| **Total Isomers** | **0.090811** | **0.0035** | **0.0036** | | | | |
| **Total ITEQ (<LOD = 0)** | | **0.0026** | **0.0022** | | | | |

NOTE: The Total Isomers result includes all isomers below the limit of detection. This gives a "worst case" Dioxins & Furans result.

APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

## DIOXINS & FURANS ANALYSIS SUMMARY - RUN 1

| WHO TEQ (Fish) & WHO TEQ (Birds) | | | | | | | |
|---|---|---|---|---|---|---|---|
| Congener | Result | WHO TEQ Fish | WHO TEQ Birds | Extraction Recovery | | Sampling Recovery | |
| | | | | Actual | Permitted | Actual | Permitted |
| | ng | ng | ng | % | % | % | % |
| **Dioxins** | | | | | | | |
| 2,3,7,8 Tetra CDD | < 0.00032 | 0.0003 | 0.0003 | 92 | 50% - 130% | | |
| 1,2,3,7,8 Penta CDD | < 0.00099 | 0.0010 | 0.0010 | 72 | 50% - 130% | | |
| 1,2,3,4,7,8 Hexa CDD | < 0.00045 | 0.0002 | 0.0000 | 86 | 50% - 130% | | |
| 1,2,3,6,7,8 Hexa CDD | 0.00236 | 0.0000 | 0.0000 | 88 | 50% - 130% | | |
| 1,2,3,7,8,9 Hexa CDD | < 0.00045 | 0.0000 | 0.0000 | | - | | |
| 1,2,3,4,6,7,8 Hepta CDD | 0.0134 | 0.00001 | 0.00001 | 71 | 40% - 130% | | |
| OCDD Octa CDD | 0.0449 | - | - | 74 | 40% - 130% | | |
| **Total -Dioxins** | **0.06286** | **0.0016** | **0.0014** | | | | |
| **Furans** | | | | | | | |
| 2,3,7,8 Tetra CDF | 0.0079 | 0.0004 | 0.0079 | 80 | 50% - 130% | | |
| 1,2,3,7,8 Penta CDF | 0.00162 | 0.0001 | 0.0000 | | - | 86 | >=50 |
| 2,3,4,7,8 Penta CDF | 0.00172 | 0.0009 | 0.0017 | 72 | 50% - 130% | | |
| 1,2,3,4,7,8 Hexa CDF | 0.00125 | 0.0001 | 0.0001 | 84 | 50% - 130% | | |
| 1,2,3,6,7,8 Hexa CDF | 0.00123 | 0.0001 | 0.0001 | 81 | 50% - 130% | | |
| 2,3,4,6,7,8 Hexa CDF | 0.00146 | 0.0001 | 0.0001 | 85 | 50% - 130% | | |
| 1,2,3,7,8,9 Hexa CDF | < 0.00044 | 0.0000 | 0.0000 | | - | 84 | >=50 |
| 1,2,3,4,6,7,8 Hepta CDF | 0.00398 | 0.0000 | 0.0000 | 67 | 40% - 130% | | |
| 1,2,3,4,7,8,9 Hepta CDF | 0.00136 | 0.00001 | 0.00001 | | - | 88 | >=50 |
| OCDF Octa CDF | 0.00699 | 0.00000 | 0.00000 | 69 | 40% - 130% | | |
| **Total -Furans** | **0.027951** | **0.0018** | **0.0101** | | | | |
| **Mean Recoveries (%)** | | | | **79** | | **86** | |
| **Total Isomers** | **0.090811** | **0.0034** | **0.0115** | | | | |
| **Total ITEQ (<LOD = 0)** | | **0.0018** | **0.0101** | | | | |

NOTE: The Total Isomers result includes all isomers below the limit of detection. This gives a "worst case" Dioxins & Furans result.

APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

## DIOXINS & FURANS ANALYSIS SUMMARY - FIELD BLANK RUN 1

| NATO I-TEQ & WHO TEQ (Humans / Mammals) | | | | | | | |
|---|---|---|---|---|---|---|---|
| Congener | Result | NATO I-TEQ | WHO TEQ Humans / Mammals | Extraction Recovery | | Sampling Recovery | |
| | | | | Actual | Permitted | Actual | Permitted |
| | ng | ng | ng | % | % | % | % |
| **Dioxins** | | | | | | | |
| 2,3,7,8 Tetra CDD | < 0.00042 | 0.000423 | 0.000423 | 96 | 50% - 130% | | |
| 1,2,3,7,8 Penta CDD | 0.00203 | 0.001015 | 0.002030 | 73 | 50% - 130% | | |
| 1,2,3,4,7,8 Hexa CDD | < 0.00065 | 0.000065 | 0.000065 | 89 | 50% - 130% | | |
| 1,2,3,6,7,8 Hexa CDD | < 0.00066 | 0.000066 | 0.000066 | 88 | 50% - 130% | | |
| 1,2,3,7,8,9 Hexa CDD | < 0.00068 | 0.000068 | 0.000068 | | - | | |
| 1,2,3,4,6,7,8 Hepta CDD | 0.0088 | 0.000088 | 0.000088 | 73 | 40% - 130% | | |
| OCDD Octa CDD | 0.0405 | 0.000041 | 0.000012 | 75 | 40% - 130% | | |
| **TOTAL 2,3,7,8-Dioxins** | **0.053741** | **0.0018** | **0.0028** | | | | |
| **Furans** | | | | | | | |
| 2,3,7,8 Tetra CDF | 0.00753 | 0.000753 | 0.000753 | 90 | 50% - 130% | | |
| 1,2,3,7,8 Penta CDF | 0.00192 | 0.000096 | 0.000058 | | - | 85 | >=50 |
| 2,3,4,7,8 Penta CDF | 0.00266 | 0.001330 | 0.000798 | 78 | 50% - 130% | | |
| 1,2,3,4,7,8 Hexa CDF | 0.00118 | 0.000118 | 0.000118 | 87 | 50% - 130% | | |
| 1,2,3,6,7,8 Hexa CDF | 0.00144 | 0.000144 | 0.000144 | 86 | 50% - 130% | | |
| 2,3,4,6,7,8 Hexa CDF | 0.0014 | 0.000140 | 0.000140 | 88 | 50% - 130% | | |
| 1,2,3,7,8,9 Hexa CDF | < 0.00044 | 0.000044 | 0.000044 | | - | 82 | >=50 |
| 1,2,3,4,6,7,8 Hepta CDF | 0.00341 | 0.000034 | 0.000034 | 72 | 40% - 130% | | |
| 1,2,3,4,7,8,9 Hepta CDF | < 0.00054 | 0.000005 | 0.000005 | | - | 86 | >=50 |
| OCDF Octa CDF | 0.00558 | 0.000006 | 0.000002 | 69 | 40% - 130% | | |
| **TOTAL 2,3,7,8-Furans** | **0.026093** | **0.0027** | **0.0021** | | | | |
| **Mean Recoveries (%)** | | | | **82** | | **84** | |
| **Total Isomers** | **0.079834** | **0.0044** | **0.0048** | | | | |
| **Total ITEQ (<LOD = 0)** | | **0.0037642** | **0.0041765** | | | | |

NOTE: The Total Isomers result includes all isomers below the limit of detection. This gives a "worst case" Dioxins & Furans result.

APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

## DIOXINS & FURANS ANALYSIS SUMMARY - FIELD BLANK RUN 1

| WHO TEQ (Fish) & WHO TEQ (Birds) | | | | | | | |
|---|---|---|---|---|---|---|---|
| Congener | Result | WHO TEQ Fish | WHO TEQ Birds | Extraction Recovery | | Sampling Recovery | |
| | | | | Actual | Permitted | Actual | Permitted |
| | ng | ng | ng | % | % | % | % |
| **Dioxins** | | | | | | | |
| 2,3,7,8 Tetra CDD | < 0.00042 | 0.000423 | 0.000423 | 96 | 50% - 130% | | |
| 1,2,3,7,8 Penta CDD | 0.00203 | 0.002030 | 0.002030 | 73 | 50% - 130% | | |
| 1,2,3,4,7,8 Hexa CDD | < 0.00065 | 0.000327 | 0.000033 | 89 | 50% - 130% | | |
| 1,2,3,6,7,8 Hexa CDD | < 0.00066 | 0.000007 | 0.000007 | 88 | 50% - 130% | | |
| 1,2,3,7,8,9 Hexa CDD | < 0.00068 | 0.000007 | 0.000007 | | - | | |
| 1,2,3,4,6,7,8 Hepta CDD | 0.0088 | 0.000009 | 0.000009 | 73 | 40% - 130% | | |
| OCDD Octa CDD | 0.0405 | - | - | 75 | 40% - 130% | | |
| **TOTAL 2,3,7,8-Dioxins** | **0.053741** | **0.0028** | **0.0025** | | | | |
| **Furans** | | | | | | | |
| 2,3,7,8 Tetra CDF | 0.00753 | 0.000377 | 0.007530 | 90 | 50% - 130% | | |
| 1,2,3,7,8 Penta CDF | 0.00192 | 0.000096 | 0.000019 | | - | 85 | >=50 |
| 2,3,4,7,8 Penta CDF | 0.00266 | 0.001330 | 0.002660 | 78 | 50% - 130% | | |
| 1,2,3,4,7,8 Hexa CDF | 0.00118 | 0.000118 | 0.000118 | 87 | 50% - 130% | | |
| 1,2,3,6,7,8 Hexa CDF | 0.00144 | 0.000144 | 0.000144 | 86 | 50% - 130% | | |
| 2,3,4,6,7,8 Hexa CDF | 0.0014 | 0.000140 | 0.000140 | 88 | 50% - 130% | | |
| 1,2,3,7,8,9 Hexa CDF | < 0.00044 | 0.000044 | 0.000044 | | - | 82 | >=50 |
| 1,2,3,4,6,7,8 Hepta CDF | 0.00341 | 0.000034 | 0.000034 | 72 | 40% - 130% | | |
| 1,2,3,4,7,8,9 Hepta CDF | < 0.00054 | 0.000005 | 0.000005 | | - | 86 | >=50 |
| OCDF Octa CDF | 0.00558 | 0.000001 | 0.000001 | 69 | 40% - 130% | | |
| **TOTAL 2,3,7,8-Furans** | **0.026093** | **0.0023** | **0.0107** | | | | |
| **Mean Recoveries (%)** | | | | **82** | | **84** | |
| **Total Isomers** | **0.079834** | **0.0051** | **0.0132** | | | | |
| **Total ITEQ (<LOD = 0)** | | **0.0042780** | **0.0126847** | | | | |

NOTE: The Total Isomers result includes all isomers below the limit of detection. This gives a "worst case" Dioxins & Furans result.

APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

## ISOKINETIC SAMPLING EQUATIONS - RUN 1 — Dioxins & Furans

| | | |
|---|---|---|
| **Absolute pressure of stack gas, $P_s$** | | |
| Barometric pressure, $P_b$ | kPa | 101.00 |
| Stack static pressure, $P_{static}$ | Pa | 68.00 |
| $P_s = P_b + (P_{static})$ | kPa | 101.07 |
| **Vol. of water vapour collected, $V_{wstd}$** | | |
| Moisture trap weight increase,Vlc | g | 294.7 |
| $V_{wstd} = (0.001246)(V_{lc})$ | $m^3$ | 0.3672 |
| **Volume of gas metered dry, $V_{mstd}$** | | |
| Volume of gas sample through gas meter, $V_m$ | m | 4.95 |
| Gas meter correction factor, $Y_d$ | | 0.99 |
| Mean dry gas meter temperature, $T_m$ | | 297.00 |
| Mean pressure drop across orifice, DH | $mmH_2O$ | 17.61 |
| $V_{mstd} = \frac{(0.3592)(V_m)(P_b+(DH/13.6))(Y_d)}{T_m + 273}$ | $m^3$ | 4.51 |
| **Volume of gas metered wet, $V_{mstw}$** | | |
| $V_{mstw} = V_{mstd} + V_{wstd}$ | $m^3$ | 4.8765 |
| **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%$O_2$ | | 19.09 |
| % oxygen reference condition | | 21 |
| $O_2$ Reference Factor: $O2\ Ref = \frac{21.0 - act\%O2}{21.0 - ref\%O2}$ | | No O2 Ref |
| $V_{mstd@X\%oxygen} = (V_{mstd})\ (O_{2\ Ref})$ | $m^3$ | No O2 Ref |
| **Moisture content, $B_{wo}$** | | |
| $B_{wo} = \frac{V_{wstd}}{V_{mstd} + V_{wstd}}$ | | 0.0753 |
| | % | 7.53 |
| **Moisture by FTIR** | % | - |

| | | |
|---|---|---|
| **Molecular weight of dry gas, $M_d$** | | |
| $CO_2$ | % | 1.79 |
| $O_2$ | % | 19.09 |
| Total | % | 20.88 |
| $N_2$ (100 -Total) | % | 79.12 |
| $M_d = 0.44(\%CO_2)+0.32(\%O_2)+0.28(\%N_2)$ | | 29.05 |
| **Molecular weight of wet gas, $M_s$** | | |
| $M_s = M_d(1 - B_{wo}) + 18(B_{wo})$ | g/gmol | 28.22 |
| **Velocity of stack gas, $V_s$** | | |
| Velocity pressure coefficient, $C_p$ | | 0.84 |
| Mean of velocity heads, $DP_{avg}$ | Pa | 141.42 |
| Mean stack gas temperature, $T_s$ | K | 328.00 |
| Gas density $_{(wet,\ ambient)}$, p | | |
| p=(Ms*Ps)/(8.314*Ts) | $kg/m^3$ | 1.046 |
| Stack Velocity, Vs $V_s = \frac{\sum_{i=1}^{n} V_i}{n}$ | m/s | 13.80 |
| **Actual flow of stack gas, $Q_a$** | | |
| Area of stack, $A_s$ | $m^2$ | 4.16 |
| $Q_a = (60)(A_s)(V_s)$ | $m^3$/min | 3440.9 |
| **Total flow of stack gas, Q** | | |
| Conversion factor (K/mm.Hg) | | |
| $Q_{std} = \frac{(Q_a)P_s(0.3592)(1-B_{wo})}{(Ts)}$ | Dry | 2641.3 |
| $Q_{std02} = \frac{(Q_a)P_s(0.3592)(1-B_{wo})(O_2REF)}{(Ts)}$ | @O2ref | No O2 Ref |
| $Q_{stw} = \frac{(Q_a)P_s(0.3592)}{(Ts)}$ | Wet | 2856 |
| **Percent isokinetic, %I** | | |
| Nozzle diameter, $D_n$ | mm | 5.0 |
| Nozzle area, $A_n$ | $mm^2$ | 19.6 |
| Total sampling time, q | min | 360.0 |
| $\%I = \frac{(4.6398E6)(T_s)(V_{mstd})}{(P_s)(V_s)(A_n)(q)(1-B_{wo})}$ | % | 100.6 |
| Acceptable isokinetic range 95% to 115% | | Yes |

APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

## DIOXINS & FURANS QUALITY ASSURANCE CHECKLIST

| Leak Test Results | Mean Sampling litre/min | Pre-sampling Leak Rate litre/min | Post-sampling Leak Rate litre/min | Maximum Vacuum mm Hg | Leak Tests Acceptable litre/min | Acceptable Leak Rate litre/min | Leak Tests Acceptable litre/min |
|---|---|---|---|---|---|---|---|
| Run 1 | 13.65 | 0.19 | 0.19 | -381 | Yes | 0.68 | Yes |

| Isokinetic Criterion Compliance | Isokinetic Variation % | Acceptable Isokineticity % |
|---|---|---|
| Run 1 | 100.6 | Yes |

**Acceptable isokinetic range 95% to 115%**

| Filtration | Filter Material | Filter Size mm | Maximum Filtration Temperature °C |
|---|---|---|---|
| Run 1 | Quartz Fibre | 47 | 120 |

| Critical Sampling Requirement | Maximum Temperature at Condenser / Adsorber °C | Acceptable Temperature? | Temperature during storage / transit <25°C |
|---|---|---|---|
| Run 1 | 0 | Yes | Yes |
| Acceptance Criteria | < 20°C | - | < 25°C |

APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

| FORMALDEHYDE SUMMARY | | | | | |
|---|---|---|---|---|---|
| Test | Sampling Times | Concentration mg/m³ | LOD mg/m³ | ELV mg/m³ | Emission Rate g/hr |
| Run 1 | 12:10 - 12:42 30 September 2025 | 4.29 | 0.022 | 15 | 1165.1 |
| Field Blank | - | 0.053 | - | - | - |

Reference conditions are 273K, 101.3kPa, dry gas .

## FORMALDEHYDE QUALITY ASSURANCE CHECKLIST

| | Barometric Pressure Kpa | Average Oxygen Value for Referencing % | Total Sample Volume @ ref Conditions m³ | Mean Sampling Rate l/min | Pre Sampling Leak Rate l/min | Post Sampling Leak Rate l/min | Acceptable Leak Rate l/min | Leak Tests Acceptable? |
|---|---|---|---|---|---|---|---|---|
| Run 1 | 101.0 | - | 0.709 | 24.1 | 0.13 | - | 0.48 | Yes |

| | Filter Material | Filter Size mm | Max. Filtration Temp. °C | Temperature during storage / transit <25°C | Type of Absorbers | Absorption Solutions |
|---|---|---|---|---|---|---|
| Run 1 | Glass Fibre | 47 | 57 | 0 | PTFE | Analytical Grade Water |

## FORMALDEHYDE ABSORPTION EFFICIENCY

| Parameter | Total ug | IMP C ug | Absorption Efficiency % | Acceptable Absorption Efficiency % | Absorption Efficiency Acceptable ? |
|---|---|---|---|---|---|
| Run 1 | 3045.9 | 15.6 | 99 | 95 | Yes |

ND - None Detected

APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

## ISOKINETIC SAMPLING EQUATIONS 1 — Formaldehyde

| | | | | | |
|---|---|---|---|---|---|
| **Absolute pressure of stack gas, $P_s$** | | | **Velocity of stack gas, $V_s$** | | |
| Barometric pressure, $P_b$ | kPa | 101 | Velocity pressure coefficient, $C_p$ | | 0.84 |
| Stack static pressure, $P_{static}$ | Pa | 81 | Mean of velocity heads, $DP_{avg}$ | Pa | 414.05 |
| $P_s = P_b + (P_{static})$ | kPa | 101.08 | Mean stack gas temperature, $T_s$ | K | 330.00 |
| | | | Gas density $_{(wet, ambient)}$, p | | |
| **Vol. of water vapour collected, $V_{wstd}$** | | | p=(Ms*Ps)/(8.314*Ts) | $kg/m^3$ | 1.041 |
| Moisture trap weight increase,Vlc | g | - | Stack Velocity, Vs | | |
| $V_{wstd} = (0.001246)(V_{lc})$ | $m^3$ | - | $V_s = \frac{\sum_{i=1}^{n} V_i}{n}$ | m/s | 23.68 |
| **Volume of gas metered dry, $V_{mstd}$** | | | **Actual flow of stack gas, $Q_a$** | | |
| Volume of gas sample through gas meter, $V_m$ | $m^3$ | 0.7752 | Area of stack, $A_s$ | $m^2$ | 4.16 |
| Gas meter correction factor, $Y_d$ | | 0.9933 | $Q_a = (60)(A_s)(V_s)$ | $m^3/min$ | 5904 |
| Mean dry gas meter temperature, $T_m$ | K | 296.88 | **Dry total flow of stack gas, $Q_{std}$** | | |
| Mean pressure drop across orifice, DH | $mmH_2O$ | 51.38 | Conversion factor (K/mm.Hg) | | 0.3592 |
| $V_{mstd} = \frac{(0.3592)(V_m)(P_b+(DH/13.6))(Y_d)}{T_m}$ | $m^3$ | 0.71 | $Q_{std} = \frac{(Q_a)P_s(0.3592)(1-B_{wo})}{(T_s)}$ | $m^3/min$ | 4522 |
| **Volume of gas metered wet, $V_{mstw}$** | | | **Wet total flow of stack gas, $Q_{stw}$** | | |
| $V_{mstw} = V_{mstd} + V_{wstd}$ | $m^3$ | 0.7642 | $Q_{stw} = \frac{(Q_a)P_s(0.3592)}{(T_s)}$ | $m^3/min$ | 4872 |
| **Vol. of gas metered at $O_2$ Ref. Cond., $V_{mstd@X\%O2}$** | | | **Dry total flow of stack gas at X% $O_2$, $Q_{stdO2}$** | | |
| Is the process burning hazardous waste? *(If yes, no favourable oxygen correction)* | | No | $Q_{stdO2} = \frac{(Q_a)P_s(0.3592)(1-B_{wo})(O_2REF)}{(T_s)}$ | $m^3/min$ | No O2 Ref |
| % oxygen measured in gas stream, act%$O_2$ | | 19.09 | | | |
| % oxygen reference condition | | 21 | **Percent isokinetic, %I** | | |
| $O_2$ Reference Factor $\frac{O2\ Ref = 21.0 - act\%O2}{21.0 - ref\%O2}$ | | No O2 Ref | Nozzle diameter, $D_n$ | mm | 4.99 |
| | | | Nozzle area, $A_n$ | $mm^2$ | 19.59 |
| $V_{mstd@X\%oxygen} = (V_{mstd})\ (O_{2\ Ref})$ | $m^3$ | No O2 Ref | Total sampling time, q | min | 32 |
| **Moisture content, $B_{wo}$** | | | $\%I = \frac{(4.6398E6)(T_s)(V_{mstd})}{(P_s)(V_s)(A_n)(q)(1-B_{wo})}$ | % | 104 |
| $B_{wo} = \frac{V_{wstd}}{V_{mstd} + V_{wstd}}$ | % | 0.0719<br>7.19 | Acceptable isokinetic range 95% to 115% | | Yes |
| **Moisture by FTIR** | % | - | **Formaldehyde Concentration, C** | | |
| **Molecular weight of dry gas, $M_d$** | | | Mass collected , M | ug | 3046 |
| $CO_2$ | | 1.79 | $C_{wet} = \frac{M_n}{V_{mstw}}$ | $mg/m^3$ | 3.986 |
| $O_2$ | | 19.09 | | | |
| Total | | 20.88 | $C_{dry} = \frac{M_n}{V_{mstd}}$ | $mg/m^3$ | 4.294 |
| $N_2$ (100 -Total) | | 79.12 | $C_{dry@X\%O2} = \frac{M_n}{V_{mstd@X\%oxygen}}$ | $mg/m^3$ | No O2 Ref |
| $M_d = 0.44(\%CO_2)+0.32(\%O_2)+0.28(\%N_2)$ | | 29.05 | | | |
| **Molecular weight of wet gas, $M_s$** | | | **Formaldehyde Emission Rates, E** | | |
| $M_s = M_d(1 - B_{wo}) + 18(B_{wo})$ | g/gmol | 28.3 | $E = [(C_{wet})(Q_{stw})(60)] / 1000$ | g/hr | 1165.13 |

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 | 11:43 - 12:15<br>02 October 2025 | 13.99 | 0.30 | 120 | 2814.21 |

Reference conditions are 273K, 101.3kPa, dry gas .

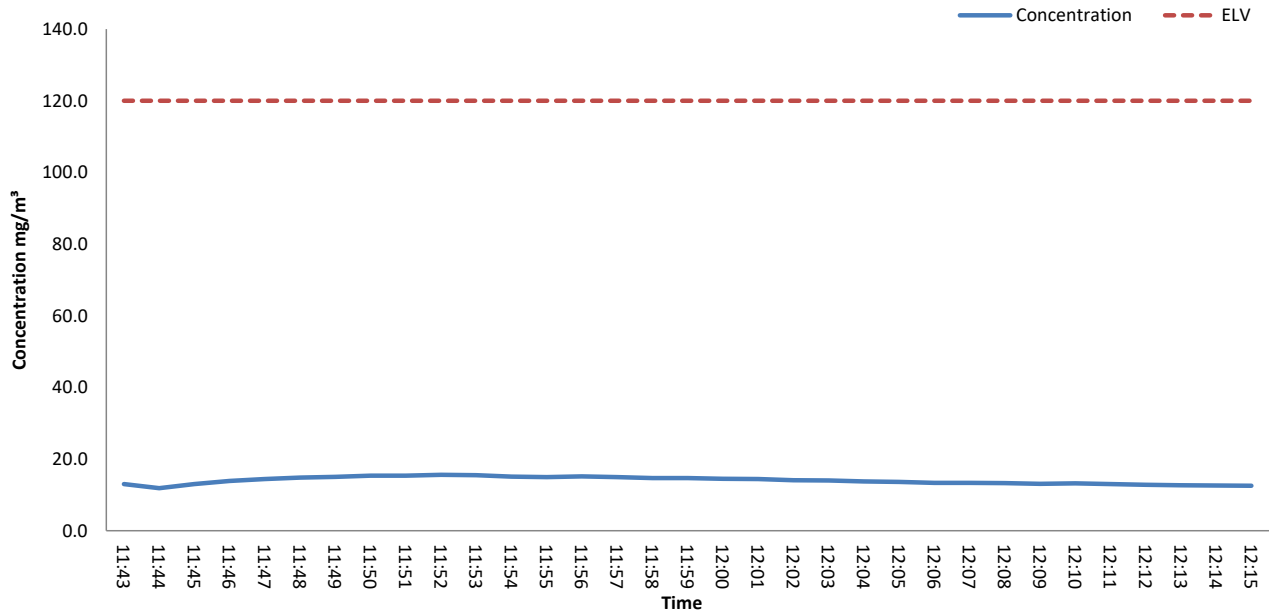
### INSTRUMENTAL SPAN & ZERO CHECKS

| PRE-SAMPLING CALIBRATION CHECKS | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Date | 02 October 2025 | | | | | | | |
| Start Time | 11:00 | | | | | | | |
| End Time | 11:40 | | | | | | | |
| Gas | Span Conc (ppm) | Analyser Range | Instrument Zero Reading | Instrument Span Reading | Instrument Zero Reading | Zero Down line reading | Span down line reading | Leak Rate (%) |
| Propane | 82.8 | 100 | 0.19 | 82.9 | 0.22 | 0.13 | 83.0 | -0.12 |

Zero and Span gas contained 20.27% Oxygen

| POST-SAMPLING CALIBRATION CHECKS | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Date | 02 October 2025 | | | | | | | |
| Start Time | 12:55 | | | | | | | |
| End Time | 13:10 | | | | | | | |
| 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 | 8.08 | 0.30 | 82.0 | 0.21 | -1.41 | × | × | N/A - not corrected |

## TOTAL VOLATILE ORGANIC COMPOUNDS EMISSIONS CHART




Reference conditions are 273K, 101.3kPa, dry gas .

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 | 13:29 - 14:28 30 September 2025 | 102.2 | 0.51 | 110 | 20552 |
| Carbon Monoxide | 13:29 - 14:28 30 September 2025 | 2.8 | 0.28 | 300 | 555.24 |

Reference conditions are 273K, 101.3kPa, dry gas .

### PRE-SAMPLING CALIBRATION DATA

| | |
|---|---|
| Date | 30 September 2025 |
| Start Time | 12:10 |
| End Time | 13:15 |

| | |
|---|---|
| Chiller Temperature (°C) | 2.3 |
| Requirement | < 4°C |
| Compliant | Yes |

| Gas | Analyser 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 | 200.9 | 0.10 | 0.20 | 200.8 | 23 | 0.05 |
| Carbon Monoxide | 200 | 0.10 | 164.1 | 0.20 | 0.10 | 163.9 | 22 | 0.12 |

### POST-SAMPLING CALIBRATION DATA

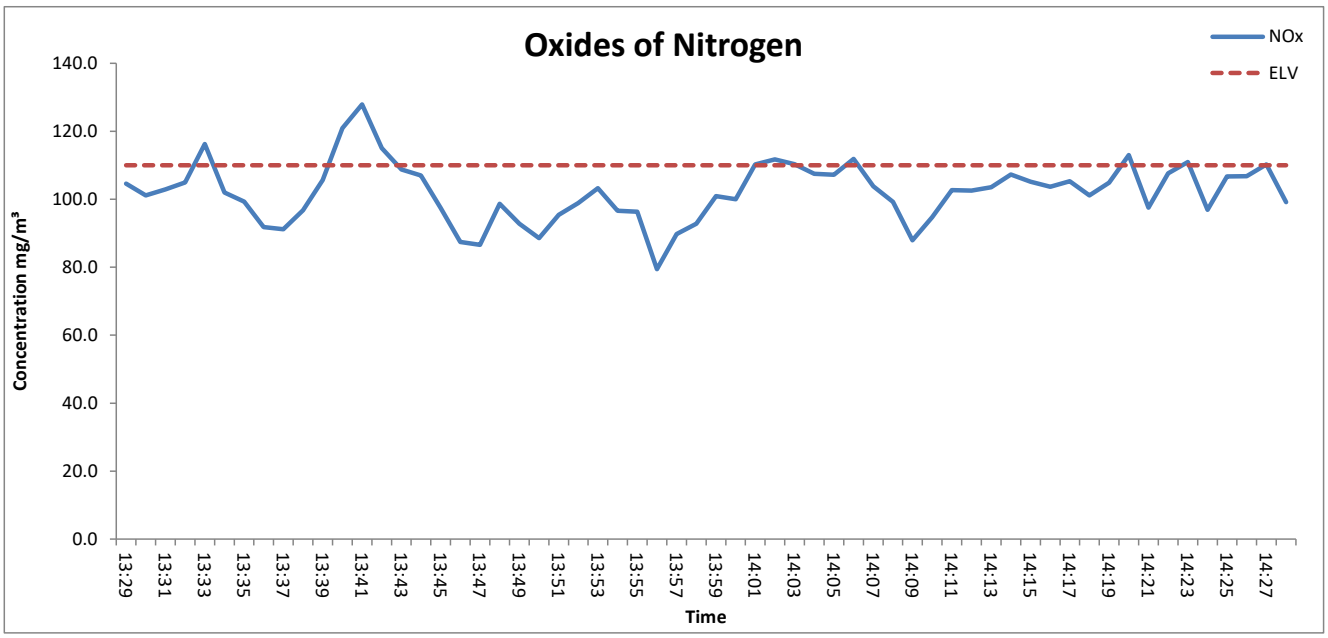
| | |
|---|---|
| Date | 30 September 2025 |
| Start Time | 15:10 |
| End Time | 15:20 |

| | |
|---|---|
| Chiller Temperature (°C) | 2.4 |
| Requirement | < 4°C |
| Compliant | Yes |

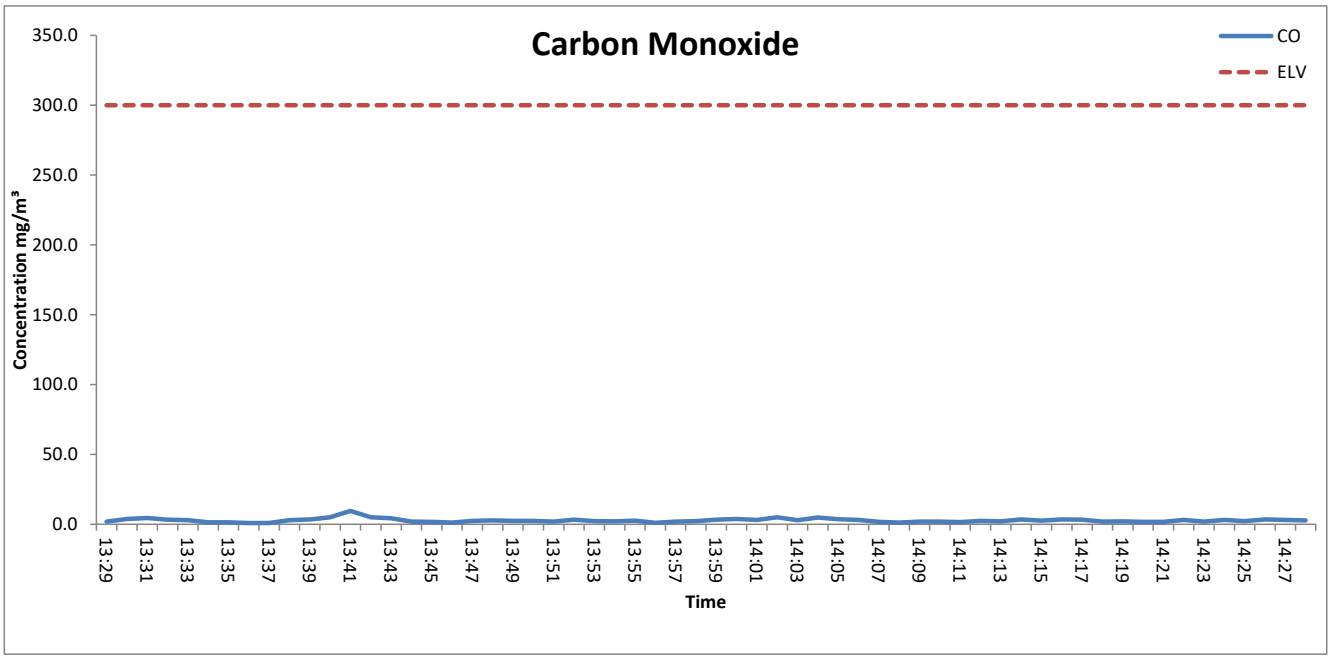
| Gas | Zero Check at Analyser | Span Check at Analyser | Zero Drift (% of Span Gas) | Span Drift (% of Span Gas) | Corrected for Zero Drift | Corrected for Span Drift | Corrected Values ppm / % |
|---|---|---|---|---|---|---|---|
| Nitric Oxide | 0.30 | 200.1 | 0.10 | -0.50 | × | × | N/A - not corrected |
| Carbon Monoxide | 0.10 | 161.9 | -0.06 | -1.28 | × | × | N/A - not corrected |

APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

## OXIDES OF NITROGEN (as $NO_2$) EMISSIONS CHART




## CARBON MONOXIDE 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 | 12:10 - 12:42 30 September 2025 | 1.6494 | 1.6935 | 0.0441 | 7.2 | 0.02 | 2.7 |

| 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 | 32 | 764 | 24.1 | 0.13 | - | 0.48 | Yes |

## PRELIMINARY STACK SURVEY

| Stack Characteristics | | |
|---|---|---|
| Stack Diameter / Depth, D | 2.30 | m |
| Stack Width, W | - | m |
| Stack Area, A | 4.16 | $m^2$ |
| Average stack gas temperature | 58 | $^oC$ |
| Stack static pressure | 0.083 | kPa |
| Barometric Pressure | 101 | 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 | 1.789517 | 0.017895 | 0.035129 | 1.660846 | 0.016608 | 0.032603 |
| $O_2$ | 32 | 1.427679 | 19.544295 | 0.195443 | 0.279030 | 18.139005 | 0.181390 | 0.258967 |
| $N_2$ | 28 | 1.249219 | 78.666188 | 0.786662 | 0.982713 | 73.009870 | 0.730099 | 0.912053 |
| $H_2O$ | 18 | 0.803070 | - | - | - | 7.190278 | 0.071903 | 0.057743 |

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

| Calculation of Stack Gas Densities | | |
|---|---|---|
| Determinand | Result | Units |
| Dry Density (STP), $P_{STD}$ | 1.2969 | $kg/m^3$ |
| Wet Density (STP), $P_{STW}$ | 1.2614 | $kg/m^3$ |
| Dry Density (Actual), $P_{Actual}$ | 1.0689 | $kg/m^3$ |
| Average Wet Density (Actual), $P_{ActualW}$ | 1.040 | $kg/m^3$ |

**Where:**

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

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

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

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

APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

## PRELIMINARY STACK SURVEY

### TRAVERSE 1

| | |
|---|---|
| Date of Survey | 30 September 2025 |
| Time of Survey | 12:20 |
| 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 | 0.07 | 473.7 | 48.3 | 57 | 25.4 | 105.3 | - | <15 |
| 2 | 0.21 | 343.0 | 35.0 | 57 | 21.6 | 89.6 | - | <15 |
| 3 | 0.38 | 294.0 | 30.0 | 57 | 20.0 | 83.0 | - | <15 |
| 4 | 0.61 | 267.9 | 27.3 | 57 | 19.1 | 79.2 | - | <15 |
| 5 | 1.15 | 251.5 | 25.7 | 57 | 18.5 | 76.8 | - | <15 |
| 6 | 1.69 | 173.1 | 17.7 | 57 | 15.3 | 63.7 | - | <15 |
| 7 | 1.92 | 124.1 | 12.7 | 57 | 13.0 | 53.9 | - | <15 |
| 8 | 2.09 | 88.2 | 9.0 | 57 | 10.9 | 45.5 | - | <15 |
| 9 | 2.23 | 58.8 | 6.0 | 57 | 8.9 | 37.1 | - | <15 |
| - | - | - | - | - | - | - | - | - |
| Mean | - | 230.5 | 23.5 | 57 | 17.0 | 70.5 | - | - |

| 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 ° |
| 1 | 0.07 | 460.6 | 47.0 | 58 | 25.0 | 103.9 | - | <15 |
| 2 | 0.21 | 408.3 | 41.7 | 58 | 23.5 | 97.8 | - | <15 |
| 3 | 0.38 | 343.0 | 35.0 | 58 | 21.6 | 89.6 | - | <15 |
| 4 | 0.61 | 294.0 | 30.0 | 58 | 20.0 | 83.0 | - | <15 |
| 5 | 1.15 | 264.6 | 27.0 | 58 | 18.9 | 78.7 | - | <15 |
| 6 | 1.69 | 209.1 | 21.3 | 58 | 16.8 | 70.0 | - | <15 |
| 7 | 1.92 | 169.9 | 17.3 | 58 | 15.2 | 63.1 | - | <15 |
| 8 | 2.09 | 130.7 | 13.3 | 58 | 13.3 | 55.3 | - | <15 |
| 9 | 2.23 | 65.3 | 6.7 | 58 | 9.4 | 39.1 | - | <15 |
| - | - | - | - | - | - | - | - | - |
| Mean | - | 260.6 | 26.6 | 58 | 18.2 | 75.6 | - | - |

## 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 | 147 | 147 | 0.0 | Pass | 129 | 129 | 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 15 seconds. 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 | 85 | 81 | 4.0 | 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 | 59 | Pa | >= 5 Pa | Yes |
| Lowest Gas Velocity | 8.9 | m/s | - | - |
| Highest Gas Velocity | 25.4 | m/s | - | - |
| Ratio of Gas Velocities | 2.8 | - | < 3 : 1 | Yes |
| Maximum angle of flow with regard to duct axis | <15 | ° | < 15° | 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 * D$P_{pt}$ / $P_{ActualW}$) | | |
| **Where:** | | |
| $K_{pt}$ = Pitot tube calibration coefficient | | |
| (1-e) = Compressibility correction factor, assumed at a constant 0.998 | | |
| Average Stack Gas Velocity, Va | **17.6** | m/s |

| Calculation of Stack Gas Volumetric Flowrate, Q | | | |
|---|---|---|---|
| Duct gas flow conditions | Actual | Reference | Units |
| Temperature | 58 | 0 | °C |
| Total Pressure | 101.083 | 101.3 | kPa |
| Oxygen | 19.1 | 21 | % |
| Moisture | 7.19 | 0.00 | % |
| Pitot tube calibration coefficient, $K_{pt}$ | 0.84 | | |

| Gas Volumetric Flowrate | Result | Units |
|---|---|---|
| Average Stack Gas Velocity (Va) | 17.58 | m/s |
| Stack Area (A) | 4.16 | $m^2$ |
| Gas Volumetric Flowrate (Actual), $Q_{Actual}$ | 262945.91 | $m^3$/hr |
| Gas Volumetric Flowrate (STP, Wet), $Q_{STP}$ | 216733.62 | $m^3$/hr |
| Gas Volumetric Flowrate (STP, Dry), $Q_{STP,Dry}$ | 201149.87 | $m^3$/hr |
| Gas Volumetric Flowrate (REF), $Q_{Ref}$ | 201149.87 | $m^3$/hr |

**Where:**

$Q_{Actual}$ = Va x A x 3600

$Q_{STP}$ = Q (Actual) x (Ts / Ta) x (Pa / Ps)

$Q_{STP,Dry}$ = Q (STP) / (100 - (100 / Ma))

$Q_{Ref}$ = Q (STP) x ((100 - Ma) / (100 - Ms)) x ((21 - $O_2$a) / (21 - $O_2$s))

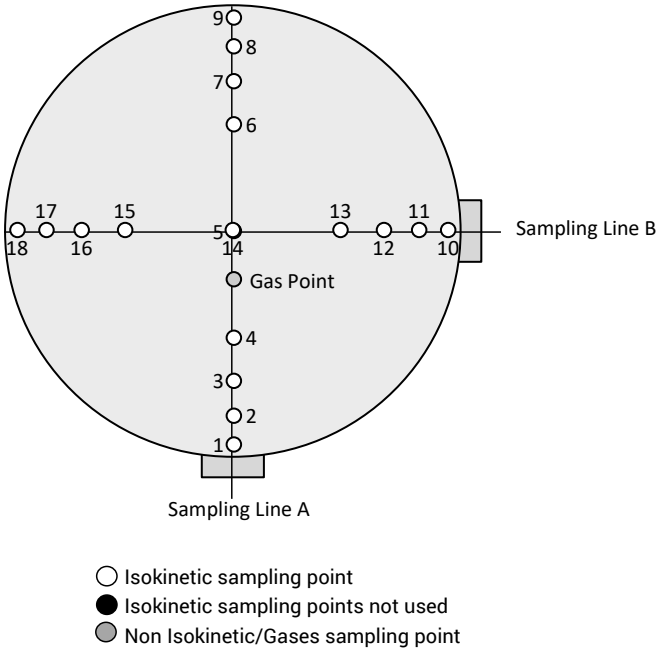
**Nomenclature:**

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
$O_2$a = Oxygen, Actual Conditions, % Vol
$O_2$s = Oxygen, Reference Conditions, % Vol

APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

## STACK DIAGRAM

| | Value | Units |
|---|---|---|
| Stack Depth | 2.30 | m |
| Stack Width | - | m |
| Area | 4.16 | $m^2$ |




| Non-Isokinetic/Gases Sampling | | | |
|---|---|---|---|
| Sampling Point | Distance (% of Depth) | Distance into Stack | Units |
| A | 30 | 0.69 | m |

| Isokinetic Sampling | | | |
|---|---|---|---|
| Sampling Point | Distance (% of Depth) | Distance into Stack (m) | Swirl ° |
| 1 | 2.9 | 0.07 | < 15 |
| 2 | 9.2 | 0.21 | < 15 |
| 3 | 16.7 | 0.38 | < 15 |
| 4 | 26.4 | 0.61 | < 15 |
| 5 | 50.0 | 1.15 | < 15 |
| 6 | 73.6 | 1.69 | < 15 |
| 7 | 83.3 | 1.92 | < 15 |
| 8 | 90.8 | 2.09 | < 15 |
| 9 | 97.1 | 2.23 | < 15 |
| 10 | 2.9 | 0.07 | < 15 |
| 11 | 9.2 | 0.21 | < 15 |
| 12 | 16.7 | 0.38 | < 15 |
| 13 | 26.4 | 0.61 | < 15 |
| 14 | 50.0 | 1.15 | < 15 |
| 15 | 73.6 | 1.69 | < 15 |
| 16 | 83.3 | 1.92 | < 15 |
| 17 | 90.8 | 2.09 | < 15 |
| 18 | 97.1 | 2.23 | < 15 |
| - | - | - | - |
| - | - | - | - |

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 | N/A | 0.06 | - | - |
| as a % | 0.20 | 0.61 | 0.50 | 1.0 | N/A | 0.42 | 0.54 | 0.000 |
| **compliant?** | **Yes** | **Yes** | **Yes** | **Yes** | **N/A** | **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 | 0.59 | 4.0600 | 1.0 | 0.0179 | 0.0000 | - |
| MU as $mg/m^3$ | 0.0740 | 0.0846 | - | 0.0179 | 0.0000 | **0.11** |
| MU as % | 1.29 | 1.4778 | - | 0.312 | 0.0009 | - |

| | | | | | |
|---|---|---|---|---|---|
| **R1 - Uncertainty expressed at a 95% confidence level (where k = 2)** | **0.23** | **$mg/m^3$** | **3.98** | **% Result** | **1.14** | **% 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 - DIOXINS & FURANS

| Run | Sampled Volume<br>$m^3$ | Sampled Gas Temp<br>K | Sampled Gas Pressure<br>kPa | Sampled Gas Humidity<br>% by volume | Oxygen Content<br>% by volume | Leak<br>% | Uncollected Mass<br>$ng/m^3$ |
|---|---|---|---|---|---|---|---|
| **MU required** | **≤ 2%** | **≤ 2%** | **≤ 1%** | **≤ 1%** | **≤ 10%** | **≤ 5%** | **≤ 10% ELV** |
| Run 1 | 0.009 | 2.0 | 0.50 | 1.0 | N/A | - | 0.00098 |
| as a % | 0.20 | 0.7 | 0.50 | 1.0 | N/A | 1.39 | N/A |
| **compliant?** | **Yes** | **Yes** | **Yes** | **Yes** | **N/A** | **Yes** | **N/A** |

| Run | Volume (STP)<br>$m^3$ | O2 Correction<br>- | Mass of Dioxin & Furan<br>ng | Leak<br>$ng/m^3$ | Uncollected Mass<br>$ng/m^3$ | Laboratory analysis<br>- | Combined uncertainty |
|---|---|---|---|---|---|---|---|
| Run 1 | 4.1327 | 1.0 | 0.0908 | 0.00001 | 0.00057 | - | - |
| MU as $ng/m^3$ | 0.0000 | - | 0.0001 | 0.00001 | 0.0004099 | 0.0001 | **0.0004** |
| MU as % | 1.3214 | - | 14.2857 | 0.8037 | 52.1118 | 8.60 | - |

| | | | | | | |
|---|---|---|---|---|---|---|
| **R1 - Uncertainty expressed at a 95% confidence level (where k = 2)** | **0.0009** | **$ng/m^3$** | **109.5** | **% Result** | **N/A** | **% 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 - ISOKINETIC FORMALDEHYDE

| Run | Sampled Volume<br>m³ | Sampled Gas Temp<br>K | Sampled Gas Pressure<br>kPa | Sampled Gas Humidity<br>% by volume | Oxygen Content<br>% by volume | Limit of Detection<br>% by mass | Leak<br>% |
|---|---|---|---|---|---|---|---|
| **MU required** | **<=2%** | **<2.5 k** | **<=1%** | **<=1%** | **<=10%** | **≤ 5% of ELV** | **<=2%** |
| Run 1 | 0.709 | 297 | 101.81 | 1.0 | - | 4.5 | - |
| as a % | 0.14 | 0.67 | 0.49 | 1.0 | - | 0.32 | 0.54 |
| **compliant?** | **Yes** | **Yes** | **Yes** | **Yes** | **N/A** | **Yes** | **Yes** |

| Run | Volume (STP)<br>m³ | Mass of Formaldehyde<br>mg | O2 Correction<br>- | Leak<br>mg/m³ | Lab Uncertainty<br>mg | Combined uncertainty |
|---|---|---|---|---|---|---|
| Run 1 | 0.6555 | 4.4988 | - | 0.0134 | - | - |
| MU as mg/m³ | 0.0563 | 0.0475 | - | 0.0134 | 0.5089 | **0.5144** |
| MU as % | 1.3108 | 1.1060 | - | 0.3119 | 11.9 | - |

| | | | | | | |
|---|---|---|---|---|---|---|
| **R1 - Uncertainty expressed at a 95% confidence level (where k = 2)** | **1.03** | **mg/m³** | **23.96** | **% Result** | **6.86** | **% 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 $m^3$ | Sampled Gas Temp K | Sampled Gas Pressure kPa | Sampled Gas Humidity % by volume | Oxygen Content % by volume | Leak % |
|---|---|---|---|---|---|---|
| **MU required** | **≤ 2%** | **≤ 2%** | **≤ 1%** | **≤ 1%** | **≤ 10%** | **≤ 2%** |
| Run 1 | 0.0014 | 2.0 | 0.50 | 1.0 | N/A | - |
| as a % | 0.20 | 0.61 | 0.50 | 1.0 | N/A | 0.54 |
| **compliant?** | **Yes** | **Yes** | **Yes** | **Yes** | **N/A** | **Yes** |

| Run | Volume (STP) $m^3$ | Mass Gained mg | $O_2$ Correction - | Leak $mg/m^3$ | Uncollected Mass mg | Combined uncertainty |
|---|---|---|---|---|---|---|
| Run 1 | 0.59 | 44100 | 1.0 | 193.94 | 58 | - |
| MU as % v/v | 0.101 | 0.018 | - | 0.024 | 0.010 | **0.106** |
| MU as % | 1.29 | 0.23 | - | 0.31 | 0.13 | - |

| | | | | |
|---|---|---|---|---|
| **R1 - Uncertainty expressed at a 95% confidence level (where k = 2)** | **0.21** | **% v/v** | **2.71** | **%** |

APPENDIX 3 - Measurement Uncertainty Budget Calculations

**MEASUREMENT UNCERTAINTY BUDGET - VOLATILE ORGANIC COMPOUNDS RUN 1**

| | | |
|---|---|---|
| Measured Concentration | 14.0 | $mg/m^3$ |
| Limit | 120 | $mg/m^3$ |
| Calibration Gas Concentration | 132.48 | $mg/m^3$ |
| Range | 160 | $mg/m^3$ |

| Performance characteristics | Value | Units | specification | MU Met? |
|---|---|---|---|---|
| Response time | 31 | seconds | <180 | Yes |
| Logger sampling interval | 60 | seconds | - | - |
| Measurement period | 32 | minutes | - | - |
| Number of readings in measurement | 32 | - | - | - |
| 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 | 0.21 | % full scale | <5% range / 24hr | Yes |
| Span drift | -1.41 | % 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) | -0.12 | % 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 | 0.03 |
| Standard deviation of repeatability at span level | urs | 0.03 |
| Lack of fit | ufit | 0.65 |
| Drift | u0dr | 0.03 |
| volume or pressure flow dependence | uspres | 0.00 |
| atmopsheric pressure dependence | uapres | 0.04 |
| ambient temperature dependence | utemp | 0.00 |
| Dependence on voltage | uvolt | 0.14 |
| losses in the line (leak) | uleak | -0.01 |
| Uncertainty of calibration gas | ucalib | 0.08 |
| Uncertainty in factor | uf | 0.03 |

| | | |
|---|---|---|
| Measurement uncertainty Measured Concentration | 13.99 | $mg/m^3$ |
| Combined uncertainty | 0.67 | $mg/m^3$ |
| Expanded uncertainty | 1.31 | $mg/m^3$ |

| | | |
|---|---|---|
| **Expanded uncertainty expressed with a level of confidence of 95%** | **1.09** | **% ELV** |
| **Expanded uncertainty expressed with a level of confidence of 95%** | **1.31** | **$mg/m^3$** |
| **Expanded uncertainty expressed with a level of confidence of 95%** | **9.38** | **% 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 | 110 | $mg/m^3$ |
| Concentration @ Ref conditions | 102.2 | $mg/m^3$ |
| Cal gas conc | 412 | $mg/m^3$ |
| Analyser Full Scale | 513 | $mg/m^3$ |

| | Value | Units | specification | MU Met? |
|---|---|---|---|---|
| Response time | 23 | seconds | 180 | Yes |
| Logger sampling interval | 60 | seconds | - | - |
| Measurement period | 59 | minutes | - | - |
| Number of readings in measurement | 59 | - | - | - |
| 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 | 0.10 | % full scale | <5% range / 24hr | Yes |
| Span drift | -0.50 | % 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 | 0.00 | % 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 | $U_{d,z}$ | 0.0579 |
| short term span drift | $U_{d,s}$ | -0.2872 |
| influence of Ambient Temp at Zero | $U_{t,z}$ | 0.0000 |
| influence of Ambient Temp at Span | $U_{t,s}$ | 0.6750 |
| influence of sample gas pressure | $U_p$ | 0.0000 |
| influence of sample gas flow | $U_{fit}$ | 0.1732 |
| influence of supply voltage | $U_v$ | 0.1099 |
| Combined Interfence | $U_i$ | -0.0018 |
| Uncertainty of Cal gas | $U_{adj}$ | 2.0100 |

| | | |
|---|---|---|
| Measurement uncertainty (Concentration Measured) | 102.17 | $mg/m^3$ |
| Combined uncertainty | 2.16 | $mg/m^3$ |
| Expanded at a 95% confidence interval | 4.24 | $mg/m^3$ |

| | | |
|---|---|---|
| **Expanded uncertainty expressed with a level of confidence of 95%** | **3.85** | **% ELV** |
| **Expanded uncertainty expressed with a level of confidence of 95%** | **4.2** | **$mg/m^3$** |
| **Expanded uncertainty expressed with a level of confidence of 95%** | **4.1** | **% value** |

Reference – SOCOTEC Technical Procedure AE150 Estimation of Uncertainty of Measurement

APPENDIX 3 - Measurement Uncertainty Budget Calculations

**MEASUREMENT UNCERTAINTY BUDGET - CARBON MONOXIDE**

| | | |
|---|---|---|
| Limit value | 300 | $mg/m^3$ |
| Concentration @ Ref conditions | 2.8 | $mg/m^3$ |
| Cal gas conc | 205.4 | $mg/m^3$ |
| Analyser Full Scale | 250 | $mg/m^3$ |

| Performance characteristics | Value | Units | specification | MU Met? |
|---|---|---|---|---|
| Response time | 22 | seconds | 180 | Yes |
| Logger sampling interval | 60 | seconds | - | - |
| Measurement period | 59 | minutes | - | - |
| Number of readings in measurement | 59 | - | - | - |
| 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 | -0.06 | % full scale | <5% range / 24hr | Yes |
| Span drift | -1.28 | % 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) | 0.00 | % 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 | $U_{d,s}$ | -0.03 |
| influence of Ambient Temp zero | $U_{t,z}$ | -0.01 |
| influence of Ambient Temp span | $U_{t,s}$ | 0.05 |
| influence of sample gas pressure | $U_p$ | 0.00 |
| influence of sample gas flow | $U_{fit}$ | 0.14 |
| influence of supply voltage | $U_v$ | -0.09 |
| Combined Interfence | $U_i$ | -0.22 |
| Uncertainty of Cal gas | $U_{adj}$ | 0.82 |

| | | |
|---|---|---|
| Measurement uncertainty (Concentration Measured) | 2.8 | $mg/m^3$ |
| Combined uncertainty | 0.9 | $mg/m^3$ |
| Expanded uncertainty | 1.9 | $mg/m^3$ |

| | | |
|---|---|---|
| **Expanded uncertainty expressed with a level of confidence of 95%** | **0.6** | **% ELV** |
| **Expanded uncertainty expressed with a level of confidence of 95%** | **1.9** | **$mg/m^3$** |
| **Expanded uncertainty expressed with a level of confidence of 95%** | **67.1** | **% value** |

Reference – SOCOTEC Technical Procedure AE150 Estimation of Uncertainty of Measurement

APPENDIX 3 - Measurement Uncertainty Budget Calculations

**MEASUREMENT UNCERTAINTY BUDGET - VELOCITY & VOLUMETRIC FLOW RATE**

| | | |
|---|---|---|
| Measured Velocity at Actual Conditions | 17.6 | m/s |
| Measured Volumetric Flow rate at Actual Conditions | 262946 | 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 | - | 1.93 | | |
| 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 | 37.33 | <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 | 0.00002 | | |
| Uncertainty of temperature measurement | K | 1.69 | <1% of value | Yes |
| Uncertainty of absolute pressure in the duct | pa | 516 | | |
| Uncertainty associated with the calculation of density | kg/m3 | 0.008 | | |
| 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** | 0.22 |
| **Expanded uncertainty at a 95% Confidence Interval** | 0.43 |

*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** | 1.2 |
| **Expanded uncertainty at a 95% Confidence Interval** | 2.4 |

| Measurement Uncertainty Volumetric Flow Rate | m³/hr |
|---|---|
| **Combined uncertainty** | 6900 |
| **Expanded uncertainty at a 95% Confidence Interval** | 13523 |

*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** | 5.1 |

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