STACK EMISSIONS MONITORING REPORT

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Operator & Address:
Medite Smartply Redmonstown Clonmel Co. Tipperary Ireland

Permit Reference:
IE Licence: P0027-04

Release Point:
A2-23

Sampling Date(s):
03 - 05 May 2022

SOCOTEC Job Number:	LEK 13247 / Q2
Report Date:	07-Jun-22
Version:	1
Report By:	Aidan Whitney
MCERTS Number:	MM20 1603
MCERTS Level:	MCERTS Level 1 Technician
Technical Endorsements:	1
Report Approved By:	Brian Walsh
MCERTS Number:	MM 17 1414
Business Title:	MCERTS Level 2 - Team Leader
Technical Endorsements:	1, 2, 3 & 4
Signature:	Brian Walsh

UKAS TESTING 1015

mCERTS

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EXECUTIVE SUMMARY

MONITORING OBJECTIVES

Medite Smartply operates a wood fibre board press fan process at Clonmel which is subject to IE Licence P0027-04, under the EPA Act 1992.

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

Plant

A2-23

Operator

Medite Smartply
Redmonstown
Clonmel
Co. Tipperary
Ireland

IE Licence: P0027-04

Stack Emissions Monitoring Test House

SOCOTEC - East Kilbride Laboratory
2-4 Langlands Place
Kelvin South Business Park
East Kilbride
G75 0YF
UKAS and MCERTS Accreditation Number: 1015

EXECUTIVE SUMMARY

EMISSIONS SUMMARY					
Parameter	**Units**	**Result**	**Calculated Uncertainty +/-**	**Emission Limit Value (ELV)**	**Accreditation**
Total Particulate Matter Particulate Emission Rate	mg/m³ g/hr	0.22 10.48	0.44 20.95	15 -	MCERTS
Isocyanates Isocyanates Emission Rate	mg/m³ g/hr	0.0151 0.7123	0.0013 0.0620	0.06 -	MCERTS
Formaldehyde Formaldehyde Emission Rate	mg/m³ g/hr	0.04 2	0.04 1.8	6 -	MCERTS
Total Volatile Organic Compounds Total Volatile Organic Compounds Emission Rate	mg/m³ g/hr	6.91 307.01	1.31 58.02	100 -	MCERTS
Moisture	%	1.50	0.05	-	MCERTS
Stack Gas Temperature	°C	20	-	-	MCERTS
Stack Gas Velocity	m/s	17.2	0.42	-	
Gas Volumetric Flow Rate (Actual)	m³/hr	48642.5	2498.7	-	
Gas Volumetric Flow Rate (STP, Wet)	m³/hr	45077.6	2315.5	-	
Gas Volumetric Flow Rate (STP, Dry)	m³/hr	44402.3	2280.9	-	
Gas Volumetric Flow Rate at Reference Conditions	m³/hr	44402.3	2280.9	50000	

ND = None Detected,
Results at or below the limit of detection are highlighted by bold italic text.
The above volumetric flow rate is an average of the data collected during the isokinetic tests. Mass emissions for non isokinetic tests are also calculated using these 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	04 May 2022	12:14 - 12:44	28 minutes
Isocyanates Run 1	03 May 2022	13:35 - 14:05	32 minutes
Formaldehyde Run 1	04 May 2022	12:14 - 12:44	28 minutes
Total Volatile Organic Compounds Run 1	04 May 2022	13:40 - 14:40	60 minutes
Preliminary Stack Traverse	04 May 2022	12:00	-

EXECUTIVE SUMMARY

PROCESS DETAILS

Parameter	Process Details
Description of process	Wood Fibre Board Press Fan
Continuous or batch	Continuous
Product Details	Wood Fibre Board
Part of batch to be monitored (if applicable)	Normal Operation
Normal load, throughput or continuous rating	Normal Load
Fuel used during monitoring	N/A
Abatement	None
Plume Appearance	None

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 Environmental Protection Agency Technical Guidance Note (Monitoring) AG2.

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	0.22 mg/m³	200%	2.96%
Isocyanates	SRM - US EPA CTM 036	AE 116	1015	MCERTS	0.0008 mg/m³	8.7%	2.19%
Formaldehyde	US EPA Method 316	AE114	1015	MCERTS	0.012 mg/m³	100.5%	0.64%
Total Volatile Organic Compounds	SRM - EN 12619:2013	AE 102	1015	MCERTS	0.36 mg/m³	18.9%	1.3%
Moisture	EN 14790	AE 105	1015	MCERTS	0.02%	3.6%	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%	4.56%

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 number	Archive Period
Total Particulate Matter	Gravimetric	AE 106	1015	MCERTS	SOCOTEC (East Kilbride)	N/A	8 Weeks
Isocyanates	High performance Liquid Chromatography - Ultra Violet	HPLC-UV	0605	MCERTS	RPS	22-05666-1	8 Weeks
Formaldehyde	Ion Chromatography	M103(U)	0605	MCERTS	RPS	22-05665-1	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
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	199	Pa	>= 5 Pa	Yes	EN 15259
Lowest Gas Velocity	15.6	m/s	-	-	-
Highest Gas Velocity	19.0	m/s	-	-	-
Ratio of Gas Velocities	1.2	: 1	< 3 : 1	Yes	EN 15259
Mean Velocity	17.2	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	1.00	m
Width	-	m
Area	0.79	m^2
Port Depth	90	mm

SAMPLING LINES & POINTS		
	Isokinetic	**Non-Iso & Gases**
Sample port size	4" BSP	4" BSP
Number of lines used	2	1
Number of points / line	2	1
Duct orientation	Vertical	Vertical
Filtration	In 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	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)	Yes
Platform has removable chains / self closing gates at the top of ladders	Yes
Handrail / obstructions do not hamper insertion of sampling equipment	Yes
Depth of Platform = >Stack depth / diameter + wall and port thickness + 1.5m	Yes

Sampling Platform Improvement Recommendations (if applicable)

The sampling location meets all the requirements as specified in EPA Guidance Note AG1

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 - EN 13284-1	AE 104	1015	MCERTS	1
Isocyanates	SRM - US EPA CTM 036	AE 116	1015	MCERTS	1
Formaldehyde	US EPA Method 316	AE114	1015	MCERTS	1
Total Volatile Organic Compounds	SRM - EN 12619:2013	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

CALIBRATEABLE EQUIPMENT CHECKLIST

Extractive Sampling		Instrumental Analyser/s		Miscellaneous	
Equipment	**Equipment I.D.**	**Equipment**	**Equipment I.D.**	**Equipment**	**Equipment I.D.**
Control Box DGM	LEK 9.44	Horiba PG-250 Analyser	LEK 12.18	Laboratory Balance	LEK 15.21
Box Thermocouples	LEK 9.46	FT-IR Gasmet	-	Tape Measure	LEK 20.2
Meter In Thermocouple	LEK 9.46	FT-IR Oven Box	-	Stopwatch	-
Meter Out Thermocouple	LEK 9.46	Bernath 3006 FID	-	Protractor	-
Control Box Timer	LEK 17.25	Signal 3030 FID	-	Barometer	LEK 16.8
Oven Box	-	Servomex	-	Digital Micromanometer	LEK 1.20
Probe	LEK 6.53	JCT Heated Head Filter	LEK 13.32a	Digital Temperature Meter	LEK 2.11
Probe Thermocouple	LEK 3.187	Thermo FID	-	Stack Thermocouple	-
Probe	LEK 6.17	Stackmaster	-	Mass Flow Controller	-
Probe Thermocouple	LEK 6.17	FTIR Heater Box for Heated Line	-	MFC Display module	-
S-Pitot	LEK 6.77	Anemometer	-	1m Heated Line (1)	-
L-Pitot	-	Ecophysics NOx Analyser	-	1m Heated Line (2)	-
Site Balance	LEK 23.16	Chiller (JCT/MAK 10)	LEK 12.12	1m Heated Line (3)	-
Last Impinger Arm	LEK 3.109	Heated Line Controller (1)	LEK 8.49	5m Heated Line (1)	-
Dioxins Cond. Thermocouple	LEK 10.93	Heated Line Controller (2)	-	10m Heated Line (1)	-
Callipers	LEK 15.1X	Site temperature Logger	-	10m Heated Line (2)	-
Small DGM	-			15m Heated Line (1)	-
Heater Controller	-			20m Heated Line (1)	LEK 8.49
Inclinometer (Swirl Device)	LEK 24.10			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 262	BOC	202	-	2.0
Carbon Monoxide	LEK 262	BOC	167	-	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**
Brian Walsh	MM 17 1414	MCERTS Level 2	Jan-23	Jan-23	Nov-23	Nov-23	May-23	Sep-23
Aidan Whitney	MM20 1603	MCERTS Level 1	Sep-25	Nov-26	-	-	-	Sep-25

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	12:14 - 12:44 04 May 2022	0.22	0.44	15	10.48
Blank	-	0.22	-	-	-

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

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	AC 3114	0.09613	0.09631	0.00018	188.59970	188.59850	-0.00120	0.00018

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	AC 3112	0.09685	0.09686	0.00001	188.59970	188.59850	-0.00120	0.00018

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	101.9
Stack static pressure, P_{static}	pa	-130.0
$P_s = P_b + P_{static}$	Kpa	101.8
Vol. of water vapour collected, V_{wstd}		
Moisture trap weight increase,Vlc	g	9.9
$V_{wstd} = (0.001246)(V_{lc})$	m^3	0.0123354
Volume of gas metered dry, V_{mstd}		
Volume of gas sample through gas meter, V_m		0.895
Gas meter correction factor, Y_d		0.959
Mean dry gas meter temperature, T_m		294
Mean pressure drop across orifice, DH	mmH_2O	113.640
$V_{mstd} = \frac{(0.3592)(V_m)(P_b+(DH/13.6))(Y_d)}{T_m}$	m^3	0.811
Volume of gas metered wet, V_{mstw}		
$V_{mstw} = V_{mstd} + V_{wstd}$	m^3	0.8234
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		20.9
% oxygen reference condition		21
O_2 Reference Factor $O_2 \text{ Ref} = \frac{21.0 - act\%O_2}{21.0 - ref\%O_2}$		No O2 Ref
$V_{mstd@X\%oxygen} = (V_{mstd})\ (O_{2\,Ref})$	m^3	No O2 Ref
Moisture content, B_{wo}		
$B_{wo} = \frac{V_{wstd}}{V_{mstd} + V_{wstd}}$		0.0150
	%	1.50
Moisture by FTIR	%	-
Velocity of stack gas, V_s		
Velocity pressure coefficient, C_p		0.84
Mean of velocity heads, DP_{avg}	Pa	289.10
Mean stack gas temperature, T_s	K	307
Gas density $_{(wet,\ ambient)}$, p p=(Ms*Ps)/(8.314*Ts)	kg/m^3	1.144
Stack Velocity, Vs $V_s = Cp\sqrt{\frac{\Delta DPavg}{p}}$	m/s	18.98

Molecular weight of dry gas, M_d		
CO_2	%	0.09
O_2	%	20.90
Total	%	20.99
N_2 (100 -Total)	%	79.01
$M_d = 0.44(\%CO_2)+0.32(\%O_2)+0.28(\%N_2)$		28.85
Molecular weight of wet gas, M_s		
$M_s = M_d(1 - B_{wo}) + 18(B_{wo})$	g/gmol	28.69
Actual flow of stack gas, Q_a		
Area of stack, A_s	m^2	0.79
$Q_a = (60)(A_s)(V_s)$	m^3/min	894.3
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	786.7
$Q_{std@O2} = \frac{(Q_a)P_s(0.3592)(1-B_{wo})(O_2REF)}{(T_s)}$	@O_2ref	No O2 Ref
$Q_{stw} = \frac{(Q_a)P_s(0.3592)}{(T_s)}$	Wet	798.68
Percent isokinetic, %I		
Nozzle diameter, D_n	mm	6.02
Nozzle area, A_n	mm^2	28.44
Total sampling time, q	min	28
$\%I = \frac{(4.6398E6)(T_s)(V_{mstd})}{(P_s)(V_s)(A_n)(q)(1-B_{wo})}$	%	101.7
Acceptable isokinetic range 95% to 115%		Yes
Particulate Concentration, C		
Mass collected on filter, M_f	g	0.00018
Mass collected in probe, M_p	g	-0.00120
Total mass collected, M_n	g	0.00018
$C_{wet} = \frac{M_n}{V_{mstw}}$	mg/m^3	0.219
$C_{dry} = \frac{M_n}{V_{mstd}}$	mg/m^3	0.222
$C_{dry@X\%O2} = \frac{M_n}{V_{mstd@X\%oxygen}}$	mg/m^3	No O2 Ref
Particulate Emission Rates, E		
$E = [(C_{wet})(Q_{stw})(60)] / 1000$		10.48

As the total mass gained was less than the LOD, the LOD has been reported

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	30.63	0.19	0.14	-482.6	0.61	Yes

ISOKINETICITY		
Run	Isokinetic Variation %	Acceptable Isokineticity
Run 1	101.71	Yes

Acceptable isokinetic range 95% to 115%

WEIGHING BALANCE UNCERTAINTY			
Run	Result mg/m³	5% ELV mg/m³	LOD < 5% ELV
Run 1	0.22	0.8	Yes

The above is based on both the Filter and rinse uncertainty

BLANK VALUE				
Run	Overall Blank Value mg/m^3	Daily Emission mg/m^3	Acceptable Blank Value mg/m^3	Overall Blank Acceptable mg/m^3
Blank 1	0.22	15	1.5	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	34	180	160

APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

ISOCYANATES SUMMARY					
Test	Sampling Times	Concentration mg/m³	LOD mg/m³	ELV mg/m³	Emission Rate g/hr
Run 1	13:35 - 14:05 03 May 2022	0.0151	0.0008	0.06	0.71
Field Blank	-	0.0005	-	-	-

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

INDIVIDUAL ISOCYANATES SUMMARY					
Test		Lab Result ug	Concentration mg/m³	LOD mg/m³	Emission Rate g/hr
Run 1	MDI	13.40	0.01508	0.00079	0.71229
Blank 1	MDI	0.42	0.00047	0.00079	0.02233

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

APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

ISOKINETIC SAMPLING EQUATIONS 1 — ISOCYANATES

Absolute pressure of stack gas, P_s		
Barometric pressure, P_b	kPa	102
Stack static pressure, P_{static}	Pa	-130
$P_s = P_b + (P_{static})$ / 13.6	KPa	102
Vol. of water vapour collected, V_{wstd}		
Moisture trap weight increase,Vlc	g	-
$V_{wstd} = (0.001246)(V_{lc})$	m^3	-
Volume of gas metered dry, V_{mstd}		
Volume of gas sample through gas meter, V_m	m^3	0.9834
Gas meter correction factor, Y_d		0.9588
Mean dry gas meter temperature, T_m	K	295
Mean pressure drop across orifice, DH	mmH_2O	115.993
$V_{mstd} = \frac{(0.3592)(V_m)(P_b+(DH/13.6))(Y_d)}{T_m + 273}$		0.889
Volume of gas metered wet, V_{mstw}		
$V_{mstw} = V_{mstd} + V_{wstd}$	m^3	0.9022
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		20.9
% oxygen reference condition		21
O_2 Reference Factor: $\frac{O2\ Ref = 21.0 - act\%O2}{21.0 - ref\%O2}$		No O2 Ref
$V_{mstd@X\%oxygen} = (V_{mstd})\ (O_{2\ Ref})$	m^3	No O2 Ref
Moisture content, B_{wo}		
$B_{wo} = \frac{V_{wstd}}{V_{mstd} + V_{wstd}}$	%	0.0150
		1.50
Moisture by FTIR	%	-
Molecular weight of dry gas, M_d		
CO_2	%	0.09
O_2	%	20.90
Total	%	20.99
N_2 (100 -Total)	%	79.01
$M_d = 0.44(\%CO_2)+0.32(\%O_2)+0.28(\%N_2)$		28.85
Molecular weight of wet gas, M_s		
$M_s = M_d(1 - B_{wo}) + 18(B_{wo})$	g/gmol	28.7

Velocity of stack gas, V_s		
Velocity pressure coefficient, C_p		0.84
Mean of velocity heads, DP_{avg}	Pa	295
Mean stack gas temperature, T_s	K	313
Gas density $_{(wet,\ ambient)}$, p		
p=(Ms*Ps)/(8.314*Ts)	kg/m^3	1.122
Stack Velocity, Vs $V_s = Cp\sqrt{\frac{\Delta DPavg}{p}}$	m/s	19.36
Actual flow of stack gas, Q_a		
Area of stack, A_s		0.79
$Q_a = (60)(A_s)(V_s)$	m^3/min	913
Dry total flow of stack gas, Q_{std}		
Conversion factor (K/mm.Hg)		0.3592
$Q_{std} = \frac{(Q_a)P_s(0.3592)(1-B_{wo})}{(T_s) +273}$	m^3/min	787.35
Wet total flow of stack gas, Q_{stw}		
$Q_{stw} = \frac{(Q_a)P_s(0.3592)}{(T_s) +273}$	m^3/min	799.3
Dry total flow of stack gas at X% O_2, Q_{stdO2}		
$Q_{stdO2} = \frac{(Q_a)P_s(0.3592)(1-B_{wo})(O_2REF)}{(T_s) +273}$	m^3/min	No O2 Ref
Percent isokinetic, %I		
Nozzle diameter, D_n	mm	6.02
Nozzle area, A_n	mm^2	28.44
Total sampling time, q	min	32
$\%I = \frac{(4.6398E6)(T_s)(V_{mstw})}{(P_s)(V_s)(A_n)(q)(1-B_{wo})}$	%	99
Acceptable isokinetic range 95% to 115%		Yes
Isocyanates Concentration, C		
Mass of isocyanates collected ,	ug	13.4
$C_{wet} = \frac{M_n}{V_{mstw}}$	mg/m^3	0.01485
$C_{dry} = \frac{M_n}{V_{mstd}}$	mg/m^3	0.01508
$C_{dry@X\%O2} = \frac{M_n}{V_{mstd@X\%oxygen}}$	mg/m^3	No O2 Ref
Isocyanates Emission Rates, E		
$E = [(C_{wet})(Q_{stw})(60)] / 1000$	g/hr	0.71

APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

ISOCYANATES QUALITY ASSURANCE CHECKLIST

Leak Test Results	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	29.5	0.19	0.16	-381	0.59	Yes

Isokinetic Criterion Compliance	Isokinetic Variation %	Acceptable Isokineticity
Run 1	98.9	Yes

Filtration	Filter Material	Filter Size mm	Maximum Filtration Temperature °C	Filters Coated with
Run 1	GF	47	120	1-(2-pyridyl)piperazine

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	12:14 - 12:44 04 May 2022	***0.038***	0.012	6	2
Field Blank	-	0.077	-	-	-

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

FORMALDEHYDE QUALITY ASSURANCE CHECKLIST

	Barometric Pressure Kpa	Average Oxygen Value for %	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	101.9	-	0.811	30.6	0.19	0.14	0.61	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	34	Yes	Glass	HPLC Water

FORMALDEHYDE ABSORPTION EFFICIENCY

Parameter	**Total ug**	**IMP C ug**	**Absorption Efficiency %**	**Acceptable Absorption Efficiency %**	**Absorption Efficiency Acceptable ?**
Run 1	31	10	68	95	N/A- < 1mg/m³

ND - None Detected

APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

ISOKINETIC SAMPLING EQUATIONS 1 — Formaldehyde

Absolute pressure of stack gas, P_s		
Barometric pressure, P_b	kPa	102
Stack static pressure, P_{static}	Pa	-130
$P_s = P_b + (P_{static})$	kPa	101.77
Vol. of water vapour collected, V_{wstd}		
Moisture trap weight increase,Vlc	g	-
$V_{wstd} = (0.001246)(V_{lc})$	m^3	-
Volume of gas metered dry, V_{mstd}		
Volume of gas sample through gas meter, V_m	m^3	0.8946
Gas meter correction factor, Y_d		0.9588
Mean dry gas meter temperature, T_m	K	293.50
Mean pressure drop across orifice, DH	mmH_2O	113.64
$V_{mstd} = \frac{(0.3592)(V_m)(P_b+(DH/13.6))(Y_d)}{T_m}$	m^3	0.81
Volume of gas metered wet, V_{mstw}		
$V_{mstw} = V_{mstd} + V_{wstd}$	m^3	0.8234
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		20.90
% oxygen reference condition		21
O_2 Reference Factor: $\frac{21.0 - act\%O2}{21.0 - ref\%O2}$		No O2 Ref
$V_{mstd@X\%oxygen} = (V_{mstd})\ (O_{2\,Ref})$	m^3	No O2 Ref
Moisture content, B_{wo}		
$B_{wo} = \frac{V_{wstd}}{V_{mstd} + V_{wstd}}$	%	0.0150
		1.50
Moisture by FTIR	%	-
Molecular weight of dry gas, M_d		
CO_2		0.09
O_2		20.90
Total		20.99
N_2 (100 -Total)		79.01
$M_d = 0.44(\%CO_2)+0.32(\%O_2)+0.28(\%N_2)$		28.85
Molecular weight of wet gas, M_s		
$M_s = M_d(1 - B_{wo}) + 18(B_{wo})$	g/gmol	28.7

Velocity of stack gas, V_s		
Velocity pressure coefficient, C_p		0.844
Mean of velocity heads, DP_{avg}	Pa	289.10
Mean stack gas temperature, T_s	K	307.00
Gas density $_{(wet,\ ambient)}$, p		
p=(Ms*Ps)/(8.314*Ts)	kg/m^3	1.144
Stack Velocity, Vs $V_s = Cp\sqrt{\frac{\Delta DPavg}{p}}$	m/s	18.98
Actual flow of stack gas, Q_a		
Area of stack, A_s	m^2	0.79
$Q_a = (60)(A_s)(V_s)$	m^3/min	894
Dry total flow of stack gas, Q_{std}		
Conversion factor (K/mm.Hg)		0.3592
$Q_{std} = \frac{(Q_a)P_s(0.3592)(1-B_{wo})}{(T_s)}$	m^3/min	787
Wet total flow of stack gas, Q_{stw}		
$Q_{stw} = \frac{(Q_a)P_s(0.3592)}{(T_s)}$	m^3/min	799
Dry total flow of stack gas at X% O_2, Q_{stdO2}		
$Q_{stdO2} = \frac{(Q_a)P_s(0.3592)(1-B_{wo})(O_2REF)}{(T_s)}$	m^3/min	No O2 Ref
Percent isokinetic, %I		
Nozzle diameter, D_n	mm	6.02
Nozzle area, A_n	mm^2	28.44
Total sampling time, q	min	28
$\%I = \frac{(4.6398E6)(T_s)(V_{mstd})}{(P_s)(V_s)(A_n)(q)(1-B_{wo})}$	%	102
Acceptable isokinetic range 95% to 115%		Yes
Formaldehyde Concentration, C		
Mass collected , M	ug	31
$C_{wet} = \frac{M_n}{V_{mstw}}$	mg/m^3	0.038
$C_{dry} = \frac{M_n}{V_{mstd}}$	mg/m^3	0.038
$C_{dry@X\%O2} = \frac{M_n}{V_{mstd@X\%oxygen}}$	mg/m^3	No O2 Ref
Formaldehyde Emission Rates, E		
$E = [(C_{wet})(Q_{stw})(60)] / 1000$	g/hr	1.80

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	13:40 - 14:40 04 May 2022	6.9	0.22	100	307.01

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

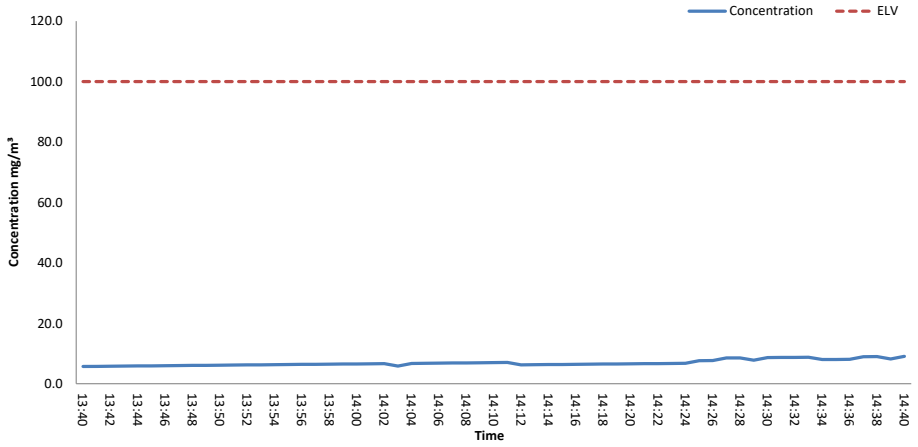
INSTRUMENTAL SPAN & ZERO CHECKS

PRE-SAMPLING CALIBRATION CHECKS								
Date	04 May 2022							
Start Time	11:45							
End Time	12:10							
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	82.8	100	0.10	82.8	0.10	0.20	83.0	-0.24

Zero and Span gas contained 20.27% Oxygen

POST-SAMPLING CALIBRATION CHECKS								
Date	04 May 2022							
Start Time	14:45							
End Time	15:15							
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	3.46	0.20	80.9	0.00	2.54	×	✓	4.24

TOTAL VOLATILE ORGANIC COMPOUNDS EMISSIONS CHART



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

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	12:14 - 12:44 04 May 2022	2.0931	2.1030	0.0099	1.5	0.02	3.6

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	28	823	30.6	0.19	0.14	0.61	Yes

PRELIMINARY STACK SURVEY

Stack Characteristics		
Stack Diameter / Depth, D	1.00	m
Stack Width, W	-	m
Stack Area, A	0.79	m^2
Average stack gas temperature	20	°C
Stack static pressure	-0.1465	kPa
Barometric Pressure	100.9	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	0.093810	0.000938	0.001842	0.092404	0.000924	0.001814
O_2	32	1.427679	20.900000	0.209000	0.298385	20.586890	0.205869	0.293915
N_2	28	1.249219	79.006190	0.790062	0.986961	77.822573	0.778226	0.972175
H_2O	18	0.803070	-	-	-	1.498133	0.014981	0.012031

Where: p = M / 22.41 pi = r x p

Calculation of Stack Gas Densities		
Determinand	Result	Units
Dry Density (STP), P_{STD}	1.2872	kg/m^3
Wet Density (STP), P_{STW}	1.2799	kg/m^3
Dry Density (Actual), P_{Actual}	1.1929	kg/m^3
Average Wet Density (Actual), $P_{ActualW}$	1.186	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	04 May 2022
Time of Survey	12:00
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	0.15	218.5	22.3	20	16.2	12.7	20.9	<15
2	0.85	201.6	20.6	20	15.6	12.2	-	<15
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
Mean	-	210.0	21.4	20	15.9	12.5	20.9	-

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	0.15	272.4	27.8	20	18.1	14.2	20.9	<15
2	0.85	299.6	30.6	20	19.0	14.9	-	<15
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
Mean	-	286.0	29.2	20	18.5	14.6	20.9	-

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	149	148	0.7	Pass	139	138	0.7	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	-80	-80	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	202	Pa	>= 5 Pa	Yes
Lowest Gas Velocity	15.6	m/s	-	-
Highest Gas Velocity	19.0	m/s	-	-
Ratio of Gas Velocities	1.2	-	< 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 * 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	**17.2**	m/s

Calculation of Stack Gas Volumetric Flowrate, Q			
Duct gas flow conditions	Actual	Reference	Units
Temperature	20	0	°C
Total Pressure	100.7535	101.3	kPa
Oxygen	20.9	21	%
Moisture	1.50	0.00	%
Pitot tube calibration coefficient, K_{pt}	0.84		

Gas Volumetric Flowrate	Result	Units
Average Stack Gas Velocity (Va)	17.20	m/s
Stack Area (A)	0.79	m^2
Gas Volumetric Flowrate (Actual), Q_{Actual}	48642.5	m^3/hr
Gas Volumetric Flowrate (STP, Wet), Q_{STP}	45077.6	m^3/hr
Gas Volumetric Flowrate (STP, Dry), $Q_{STP,Dry}$	44402.3	m^3/hr
Gas Volumetric Flowrate (REF), Q_{Ref}	44402.3	m^3/hr

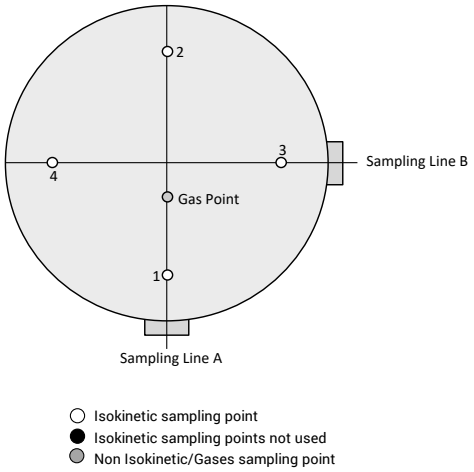
Where:
Q_{Actual} = Va x A x 3600
Q_{STP} = Q (Actual) x (Ts / Ta) x (Pa / Ps) x 3600
$Q_{STP,Dry}$ = Q (STP) / (100 - (100 / Ma)) x 3600
Q_{Ref} = Q (STP) x ((100 - Ma) / (100 - Ms)) x ((21 - O_2a) / (21 - O_2s))

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	1.00	m
Stack Width	-	m
Area	0.79	m^2



Non-Isokinetic/Gases Sampling			
Sampling Point	Distance (% of Depth)	Distance into Stack	Units
A	30	0.30	m

Isokinetic Sampling			
Sampling Point	Distance (% of Depth)	Distance into Stack (m)	Swirl °
1	14.6	0.15	< 15
2	85.4	0.85	< 15
3	14.6	0.15	< 15
4	85.4	0.85	< 15
-	-	-	-
-	-	-	-
-	-	-	-
-	-	-	-
-	-	-	-
-	-	-	-
-	-	-	-
-	-	-	-
-	-	-	-
-	-	-	-
-	-	-	-
-	-	-	-
-	-	-	-
-	-	-	-
-	-	-	-
-	-	-	-

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	0.002	2.0	0.50	1.0	N/A	0.1800	-	-
as a %	0.20	0.65	0.49	1.0	N/A	1.47956	0.62	0.001
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	0.73	0.1800	1.0	0.0008	0.0001	-
MU as mg/m^3	0.00	0.2219	-	0.0008	0.0001	**0.22**
MU as %	1.31	100.0000	-	0.358	0.0577	-

R1 - Uncertainty expressed at a 95% confidence level (where k = 2)	**0.44**	**mg/m^3**	**200.02**	**% Result**	**2.96**	**% 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 - ISOCYANATES

Run	Sampled Volume m³	Sampled Gas Temp K	Sampled Gas Pressure kPa	Sampled Gas Humidity % by volume	Oxygen Content % by volume	Leak %	Uncollected Mass mg
MU required	**≤ 2%**	**≤ 2%**	**≤ 1%**	**≤ 1%**	**≤ 10%**	**≤ 2%**	**≤ 10% of ELV**
Run 1	0.002	2	0.5	1	N/A	-	-
as a %	0.20	0.68	0.49	1.00	N/A	0.64	0.00
compliant?	**Yes**	**Yes**	**Yes**	**Yes**	**N/A**	**Yes**	**Yes**

Run	Volume (STP) m³	Mass of Isocyanates mg	O2 Correction -	Leak mg/m³	Uncollected Mass mg	Combined uncertainty
Run 1	0.83	0.0134	1.00	0.000	0.0000	-
MU as mg/m³	0.00	0.0006	-	0.000	0.0001	**1.37**
MU as %	1.32	0.0004	-	0.372	0.00	-

R1 - Uncertainty expressed at a 95% confidence level (where k = 2)	**0.001**	**mg/m³**	**8.70**	**% Result**	**2.19**	**% 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	Sampled Gas Temp	Sampled Gas Pressure	Sampled Gas Humidity	Oxygen Content	Limit of Detection	Leak
	m^3	K	kPa	% by volume	% by volume	% by mass	%
MU required	**<=2%**	**<2.5 k**	**<=1%**	**<=1%**	**<=5%**	**≤ 5% of ELV**	**<=2%**
Run 1	0.811	294	100.6	1.0	-	0.1	-
as a %	0.12	0.68	0.50	1.0	-	0.32	0.62
compliant?	**Yes**	**Yes**	**Yes**	**Yes**	**N/A**	**Yes**	**Yes**

Run	Volume (STP)	Mass of Formaldehyde	O2 Correction	Leak	Lab Uncertainty	Combined uncertainty
	m^3	mg	-	mg/m^3	mg	
Run 1	0.7492	0.0620	-	0.0001	-	-
MU as mg/m^3	0.0005	0.0191	-	0.0001	0.0019	**0.0192**
MU as %	1.3150	50.0010	-	0.3581	5.0	-

R1 - Uncertainty expressed at a 95% confidence level (where k = 2)	**0.04**	**mg/m^3**	**100.54**	**% Result**	**0.64**	**% 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 - VOLATILE ORGANIC COMPOUNDS RUN 1

Measured Concentration	6.9	mg/m^3
Limit	100	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	28	seconds	<180	Yes
Logger sampling interval	60	seconds	-	-
Measurement period	60	minutes	-	-
Number of readings in measurement	60	-	-	-
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	0.00	% full scale	<2% range / 24hr	Yes
Span drift	2.54	% full scale	<2% 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)	-0.24	% 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	0.02
Standard deviation of repeatability at span level	urs	0.02
Lack of fit	ufit	0.65
Drift	u0dr	0.08
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	0.04
Uncertainty in factor	uf	0.00

Measurement uncertainty Measured Concentration	6.91	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%	**1.31**	**% 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%	**18.94**	**% value**

Reference – SOCOTEC Technical Procedure AE150 Estimation of Uncertainty of Measurement

APPENDIX 3 - Measurement Uncertainty Budget Calculations

APPENDIX 3 - Measurement Uncertainty Budget Calculations

MEASUREMENT UNCERTAINTY BUDGET - VELOCITY & VOLUMETRIC FLOW RATE

Measured Velocity at Actual Conditions	17.2	m/s
Measured Volumetric Flow rate at Actual Conditions	48642	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	-	1.95		
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	37.69	<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	0.00003		
Uncertainty of temperature measurement	K	1.49	<1% of value	Yes
Uncertainty of absolute pressure in the duct	pa	514		
Uncertainty associated with the estimate of density	-	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	0.21
Expanded uncertainty at a 95% Confidence Interval	0.42

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	1275
Expanded uncertainty at a 95% Confidence Interval	2499

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