STACK EMISSIONS MONITORING REPORT

Unit 20
The Falcon Business Centre
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Permit Reference:
EPR Permit: EPR B04/18

Release Point:
Nederman Exhaust

Sampling Date(s):
17th October 2019

SOCOTEC Job Number:	LRO1836
Report Date:	05-Nov-19
Version:	1
Report By: MCERTS Number: MCERTS Level: Technical Endorsements:	Carl Redgrove MM 03 173 MCERTS Level 2 - Team Leader 1, 2, 3 & 4
Report Approved By: MCERTS Number: Business Title: Technical Endorsements: Signature:	Nik Agopian MM 08 902 MCERTS Level 2 - Team Leader 1, 2, 3 & 4

UKAS TESTING
1015

CONTENTS

EXECUTIVE SUMMARY

MONITORING OBJECTIVES

IKO Insulations UK Ltd operates a six liquid chemicals mixed. foam forms as mix cools process at Huntingdon which is subject to EPR Permit EPR B04/18, under the Environmental Permitting Regulations 2010.

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

The results of these tests shall be used to demonstrate compliance with a set of emission limit values for prescribed pollutants as specified in the Plant's EPR Permit, EPR B04/18.

Plant

Nederman Exhaust

Operator

IKO Insulations UK Ltd
Founders House
Pierson Road
The Enterprise Campus
Alconbury Weald
Huntingdon
Cambridgeshire

EPR Permit: EPR B04/18

Stack Emissions Monitoring Test House

SOCOTEC - Romford Laboratory
Unit 20
The Falcon Business Centre
Romford
RM3 8UR
UKAS and MCERTS Accreditation Number: 1015

Opinions and interpretations expressed herein are outside the scope of UKAS accreditation.
MCERTS accredited results will only be claimed where both the sampling and analytical stages are UKAS accredited.

EXECUTIVE SUMMARY

EMISSIONS SUMMARY					
Parameter	**Units**	**Result**	**Calculated Uncertainty +/-**	**Emission Limit Value (ELV)**	**MCERTS accredited result**
Isocyanates	mg/m³	0.0002	0.001	0.1	✓
Isocyanates Emission Rate	g/hr	0.002	0.011	-	
Moisture	%	0.82	0.48	-	✓
Stack Gas Temperature	°C	40	-	-	✓
Stack Gas Velocity	m/s	14.0	0.33	-	
Gas Volumetric Flow Rate (Actual)	m³/hr	12418	635	-	
Gas Volumetric Flow Rate (STP, Wet)	m³/hr	10628	544	-	
Gas Volumetric Flow Rate (STP, Dry)	m³/hr	10540	539	-	
Gas Volumetric Flow Rate at Reference Conditions	m³/hr	10628	544	-	

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 without correction for water vapour

EXECUTIVE SUMMARY

MONITORING TIMES			
Parameter	**Sampling Date(s)**	**Sampling Times**	**Sampling Duration**
Isocyanates Run 1	16 October 2019	14:13 - 16:14	120 minutes
Preliminary Stack Traverse	16 October 2019	13:55	-

EXECUTIVE SUMMARY

PROCESS DETAILS

Parameter	Process Details
Description of process	Six liquid chemicals mixed. Foam forms as mix cools
Continuous or batch	Continuous
Product Details	Foam
Part of batch to be monitored (if applicable)	N/A
Normal load, throughput or continuous rating	Normal
Fuel used during monitoring	n/a
Abatement	None
Plume Appearance	None visible

EXECUTIVE SUMMARY

Monitoring Methods

The selection of standard reference / alternative methods employed by SOCOTEC is determined, wherever possible by the hierarchy of method selection outlined in Environment Agency Technical Guidance Note (Monitoring) M2.

MONITORING METHODS							
Species	**Method** Standard Reference Method / Alternative Method	**SOCOTEC Technical Procedure**	**UKAS Lab Number**	**MCERTS Accredited Method**	**Limit of Detection (LOD)**	**Calculated MU +/- % Result**	**Calculated MU +/- % ELV**
Isocyanates	SRM - US EPA CTM 036	AE 116	1015	Yes	0.0001 mg/m³	562.6%	1.1%
Moisture	SRM - BS EN 14790	AE 105	1015	Yes	0.21%	57.80%	N/A - No ELV
Velocity	SRM - BS EN ISO 16911-1	AE 154	1015	Yes	5 Pa	2.4%	N/A - No ELV
Volumetric Flow Rate	SRM - BS EN ISO 16911-1	AE 154	1015	Yes	-	5.1%	N/A - No ELV

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

EXECUTIVE SUMMARY

Analytical Methods

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

SAMPLING METHODS WITH SUBSEQUENT ANALYSIS							
Species	**Analytical Technique**	**Analytical Procedure**	**UKAS Lab Number**	**UKAS Accredited Lab Analysis**	**Analysis Lab**	**Analysis Report number**	**Archive Period**
Isocyanates	High performance Liquid Chromatography - Ultra Violet	M119	0605	Yes	RPS	WK19-9993	8 Weeks

ON-SITE TESTING							
Species	**Analytical Technique**	**Analytical Procedure**	**UKAS Lab Number**	**MCERTS Accredited Analysis**	**Laboratory**	**Data Archive Location**	**Archive Period**
Moisture	Gravimetric	AE 105	1015	Yes	SOCOTEC Romford	-	-

EXECUTIVE SUMMARY

SAMPLING LOCATION					
Sampling Plane Validation Criteria	**Value**	**Units**	**Requirement**	**Compliant**	**Method**
Lowest Differential Pressure	139	Pa	>= 5 Pa	Yes	BS EN 15259
Lowest Gas Velocity	13.8	m/s	-	-	-
Highest Gas Velocity	14.3	m/s	-	-	-
Ratio of Gas Velocities	1.0	: 1	< 3 : 1	Yes	BS EN 15259
Mean Velocity	14.0	m/s	-	-	-
Maximum angle of flow with regard to duct axis	<15	°	< 15°	Yes	BS EN 15259
No local negative flow	Yes	-	-	Yes	BS EN 15259

DUCT CHARACTERISTICS		
	Value	**Units**
Shape	Circular	-
Depth	0.56	m
Width	-	m
Area	0.25	m^2
Port Depth	70	mm

SAMPLING LINES & POINTS		
	Isokinetic	**Non-Iso & Gases**
Sample port size	4"BSP	-
Number of lines used	2	-
Number of points / line	4	-
Duct orientation	Vertical	-
Filtration	In	-

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

M1 Platform requirements	
Is there a sufficient working area so work can be performed in a compliant manner	Yes
Platform has 2 levels of handrails (approximately 0.5 m & 1.0 m high)	Yes
Platform has vertical base boards (approximately 0.25 m high)	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 EA Guidance Note M1.

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**
Isocyanates	SRM - US EPA CTM 036	AE 116	1015	Yes	1
Moisture	SRM - BS EN 14790	AE 105	1015	Yes	1
Velocity	SRM - BS EN ISO 16911-1	AE 154	1015	Yes	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	P1959	Horiba PG-250 Analyser	-	Laboratory Balance	-
Box Thermocouples	P1959	FT-IR Gasmet	-	Tape Measure	P2255
Meter In Thermocouple	P1959	FT-IR Oven Box	-	Stopwatch	-
Meter Out Thermocouple	P1959	Bernath 3006 FID	-	Protractor	-
Control Box Timer	P1959	Signal 3030 FID	-	Barometer	P2748
Oven Box	-	Servomex	-	Digital Micromanometer	-
Probe	-	JCT Heated Head Filter	-	Digital Temperature Meter	-
Probe Thermocouple	P2713	Thermo FID	-	Stack Thermocouple	P2714
Probe	-	Stackmaster	-	Mass Flow Controller	P2950
Probe Thermocouple	-	FTIR Heater Box for Heated Line	-	MFC Display module	P2950
S-Pitot	-	Anemometer	-	1m Heated Line (1)	-
L-Pitot	-	Ecophysics NOx Analyser	-	1m Heated Line (2)	-
Site Balance	P1774	Chiller (JCT/MAK 10)	-	1m Heated Line (3)	-
Last Impinger Arm	-	Heated Line Controller (1)	-	5m Heated Line (1)	-
Dioxins Cond. Thermocouple	-	Heated Line Controller (2)	-	10m Heated Line (1)	-
Callipers	-	Site temperature Logger	-	10m Heated Line (2)	-
Small DGM	-		-	15m Heated Line (1)	-
Heater Controller	-		-	20m Heated Line (1)	-
Inclinometer (Swirl Device)	P2094		-	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 +/- %
-	-	-	-	-	-

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
Carl Redgrove	MM 03 173	MCERTS Level 2	Mar-20	Oct-24	Mar-20	Mar-21	Jun-21	Apr-24
Allan Kigozi	MM 16 1368	MCERTS Level 1	May-21	-	-	-	-	May-21

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	14:13 - 16:14 16 October 2019	0.000	0.0001	0.1	0.0
Field Blank	-	0.0001	-	-	-

Reference conditions are 273K, 101.3kPa without correction for water vapour

INDIVIDUAL ISOCYANATES SUMMARY					
Test		Lab Result ug	Concentration mg/m³	LOD mg/m³	Emission Rate g/hr
Run 1	HDI	0.07	0.0000	0.0000	0.000
	MDI	0.20	0.0001	0.0000	0.001
	TDI	0.20	0.0001	0.0000	0.001
Blank 1	HDI	0.07	0.0000	0.0000	0.000
	MDI	0.07	0.0000	0.0000	0.000
	TDI	0.13	0.0001	0.0000	0.001

Reference conditions are 273K, 101.3kPa without correction for water vapour

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	101
Stack static pressure, P_{static}	Pa	-1700
$P_s = P_b + \frac{(P_{static})}{13.6}$	KPa	99
Vol. of water vapour collected, V_{wstd}		
Moisture trap weight increase,Vlc	g	H_20 by Non Iso
$V_{wstd} = (0.001246)(V_{lc})$	m^3	-
Volume of gas metered dry, V_{mstd}		
Volume of gas sample through gas meter, V_m	m^3	2.7260
Gas meter correction factor, Y_d		0.9939
Mean dry gas meter temperature, T_m	K	298
Mean pressure drop across orifice, DH	mmH_2O	48.423
$V_{mstd} = \frac{(0.3592)(V_m)(P_b+(DH/13.6))(Y_d)}{T_m + 273}$		2.488
Volume of gas metered wet, V_{mstw}		
$V_{mstw} = V_{mstd} + V_{wstd}$	m^3	2.5086
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}		
$B_{wo} = \frac{V_{wstd}}{V_{mstd} + V_{wstd}}$		0.0082
	%	0.82
Moisture by FTIR	%	-
Molecular weight of dry gas, M_d		
CO_2	%	0.03
O_2	%	20.90
Total	%	20.93
N_2 (100 -Total)	%	79.07
$M_d = 0.44(\%CO_2)+0.32(\%O_2)+0.28(\%N_2)$		28.84
Molecular weight of wet gas, M_s		
$M_s = M_d(1 - B_{wo}) + 18(B_{wo})$	g/gmol	28.8

Velocity of stack gas, V_s		
Velocity pressure coefficient, C_p		0.86
Mean of velocity heads, DP_{avg}	Pa	146
Mean stack gas temperature, T_s	K	298
Gas density $_{(wet, ambient)}$, p		
p=(Ms*Ps)/(8.314*Ts)	kg/m^3	1.153
Stack Velocity, Vs $V_s = Cp\sqrt{\frac{\Delta DPavg}{p}}$	m/s	13.67
Actual flow of stack gas, Q_a		
Area of stack, A_s		0.25
$Q_a = (60)(A_s)(V_s)$	m^3/min	202
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	180.07
Wet total flow of stack gas, Q_{stw}		
$Q_{stw} = \frac{(Q_a)P_s(0.3592)}{(T_s) +273}$	m^3/min	181.6
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	6.00
Nozzle area, A_n	mm^2	28.28
Total sampling time, q	min	120
$\%I = \frac{(4.6398E6)(T_s)(V_{mstw})}{(P_s)(V_s)(A_n)(q)(1-B_{wo})}$	%	101
Acceptable isokinetic range 95% to 115%		Yes
Isocyanates Concentration, C		
Mass of isocyanates collected , M	ug	0
$C_{wet} = \frac{M_n}{V_{mstw}}$	mg/m^3	0.000
$C_{dry} = \frac{M_n}{V_{mstd}}$	mg/m^3	0.000
$C_{dry@X\%O2} = \frac{M_n}{V_{mstd@X\%oxygen}}$	mg/m^3	No O2 Ref
Isocayanates Emission Rates, E		
$E = [(C_{wet})(Q_{stw})(60)] / 1000$	g/hr	0.00

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	22.6	0.14	0.11	-254	0.45	Yes

Isokinetic Criterion Compliance	Isokinetic Variation %	Acceptable Isokineticity
Run 1	101.1	Yes

Filtration	Filter Material	Filter Size mm	Maximum Filtration Temperature °C	Filters Coated with
Run 1	Quartz Fibre	47	0	1-(2-pyridyl)piperazine

APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

MOISTURE CALCULATIONS

Moisture Determination - Non Isokinetic							
Test Number	Sampling Time and Date	Start Weight kg	End Weight kg	Total gain kg	Concentration %	LOD %	Uncertainty %
Run 1	14:42 - 15:42 17 October 2019	3.4414	3.4418	0.0004	0.8	0.21	57.8

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	60	60	1.0	0.01	0.01	0.02	Yes

PRELIMINARY STACK SURVEY

Stack Characteristics		
Stack Diameter / Depth, D	0.56	m
Stack Width, W	-	m
Stack Area, A	0.25	m^2
Average stack gas temperature	40	^oC
Stack static pressure	-1.7	kPa
Barometric Pressure	101.1	kPa

Stack Gas Composition & Molecular Weights								
Component	Molar Mass M	Density kg/m^3 p	Conc Dry % Vol	Dry Volume Fraction r	Dry Conc kg/m^3 pi	Conc Wet % Vol	Wet Volume Fraction r	Wet Conc kg/m^3 pi
CO_2	44	1.963059	0.028571	0.000286	0.000561	0.028336	0.000283	0.000556
O_2	32	1.427679	20.900000	0.209000	0.298385	20.727821	0.207278	0.295927
N_2	28	1.249219	79.071429	0.790714	0.987775	78.420020	0.784200	0.979638
H_2O	18	0.803070	-	-	-	0.823823	0.008238	0.006616

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

Calculation of Stack Gas Densities		
Determinand	Result	Units
Dry Density (STP), P_{STD}	1.2867	kg/m^3
Wet Density (STP), P_{STW}	1.2827	kg/m^3
Dry Density (Actual), P_{Actual}	1.1012	kg/m^3
Average Wet Density (Actual), $P_{ActualW}$	1.098	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	16 October 2019
Time of Survey	13:55
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	0.08	147.0	15.0	40	14.1	3.5	-	<15
2	0.48	151.6	15.5	40	14.3	3.5	-	<15
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
Mean	-	149.3	15.2	40	14.2	3.5	-	-

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	0.08	143.4	14.6	40	13.9	3.4	-	<15
2	0.48	140.5	14.3	40	13.8	3.4	-	<15
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
Mean	-	141.9	14.5	40	13.8	3.4	-	-

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	88	84	4.5	Pass	101	98	3.0	Pass

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

S-Type Pitot Stagnation Check				
Run	Stagnation (Pa)	Reference (Pa)	Difference (Pa)	Outcome (Permitted +/- 10 Pa)
Run 1	-1700	-1700	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 Differential Pressure	140	Pa	>= 5 Pa	Yes
Lowest Gas Velocity	13.8	m/s	-	-
Highest Gas Velocity	14.3	m/s	-	-
Ratio of Gas Velocities	1.0	-	< 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) * O(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	**14.0**	m/s

Calculation of Stack Gas Volumetric Flowrate, Q			
Duct gas flow conditions	Actual	Reference	Units
Temperature	40	0	°C
Total Pressure	99.4	101.3	kPa
Oxygen	20.9	21	%
Moisture	0.82	0.82	%
Pitot tube calibration coefficient, K_{pt}	0.86		

Gas Volumetric Flowrate	Result	Units
Average Stack Gas Velocity (Va)	14.00	m/s
Stack Area (A)	0.25	m^2
Gas Volumetric Flowrate (Actual), Q_{Actual}	12418	m^3/hr
Gas Volumetric Flowrate (STP, Wet), Q_{STP}	10628	m^3/hr
Gas Volumetric Flowrate (STP, Dry), $Q_{STP,Dry}$	10540	m^3/hr
Gas Volumetric Flowrate (REF), Q_{Ref}	10628	m^3/hr

Where:

Q_{Actual} = Va x A x 3600

Q_{STP} = Q (Actual) x (Ts / Ta) x (Pa / Ps) x 3600

$Q_{STP,Dry}$ = Q (STP) / (100 - (100 / Ma)) x 3600

Q_{Ref} = Q (STP) x ((100 - Ma) / (100 - Ms)) x ((21 - O_2a) / (21 - O_2s))

Nomenclature:

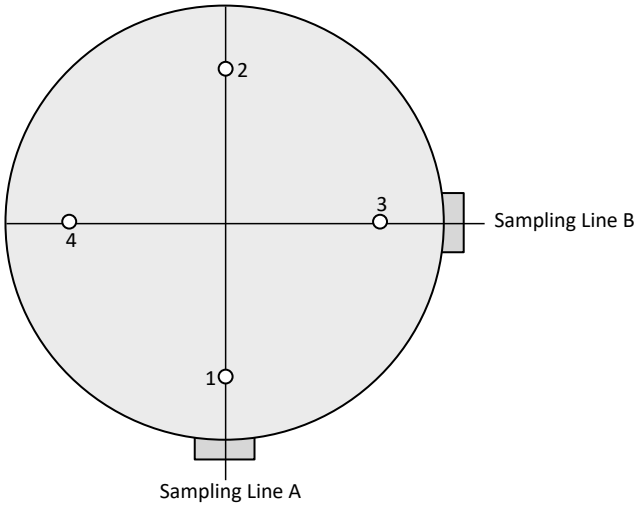
Ts = Absolute Temperature, Standard Conditions, 273 K
Ps = Absolute Pressure, Standard Conditions, 101.3 kPa
Ta = Absolute Temperature, Actual Conditions, K
Pa = Absolute Pressure, Actual Conditions, kPa
Ma = Water vapour, Actual Conditions, % Vol
Ms = Water vapour, Reference Conditions, % Vol
O_2a =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

APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

STACK DIAGRAM

	Value	Units
Stack Depth	0.56	m
Stack Width	-	m
Area	0.25	m^2

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



Isokinetic Sampling			
Sampling Point	Distance (% of Depth)	Distance into Stack (m)	Swirl °
1	14.6	0.08	< 15
2	85.4	0.48	< 15
3	14.6	0.08	< 15
4	85.4	0.48	< 15
-	-	-	-
-	-	-	-
-	-	-	-
-	-	-	-
-	-	-	-
-	-	-	-
-	-	-	-
-	-	-	-
-	-	-	-
-	-	-	-
-	-	-	-
-	-	-	-
-	-	-	-
-	-	-	-
-	-	-	-
-	-	-	-

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

SAMPLING LOCATION

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	0.001	2	0.5	1	N/A	-	-
as a %	0.04	0.66	0.50	1.00	N/A	0.49	0.07
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	2.23	0.0005	1.00	0.000	0.0000	-
MU as mg/m³	0.00	0.0005	-	0.000	0.0000	**8.70**
MU as %	1.30	0.0281	-	0.281	8.60	-

R1 - Uncertainty expressed at a 95% confidence level (where k = 2)	**0.001**	**mg/m³**	**562.63**	**% Result**	**1.05**	**% 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 m³	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	0.000	2.0	0.50	1.0	N/A	-
as a %	0.03	0.64	0.50	1.0	N/A	1.00
compliant?	**Yes**	**Yes**	**Yes**	**Yes**	**N/A**	**Yes**

Run	Volume (STP) m³	Mass Gained mg	O2 Correction -	Leak mg/m³	Uncollected Mass mg	Combined uncertainty
Run 1	0.1	400	1.0	38.5	58	-
MU as % v/v	0.01	0.21	-	0.00	0.12	**0.24**
MU as %	1.3	25.0	-	0.6	14.4	-

R1 - Uncertainty expressed at a 95% confidence level (where k = 2)	**0.48**	**% v/v**	**57.80**	**%**

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	14.0	m/s
Measured Volumetric Flow rate at Actual Conditions	12418	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	-	1.21		
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	22.94	<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	1.60	<1% of value	Yes
Uncertainty of absolute pressure in the duct	pa	507		
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	-	0.0001		

Measurement Uncertainty - Velocity	m/s
Combined uncertainty	0.17
Expanded uncertainty at a 95% Confidence Interval	0.33

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	324
Expanded uncertainty at a 95% Confidence Interval	635

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