

EMISSIONS MONITORING SURVEY

Prepared for:

Morgan Composite & Defence Systems - NP .
473 Foleshill Road
Coventry
West Midlands
CV6 5AQ

Permit Number	: 189
Variation Number	: n/a
Installation	: Site 3
Visit Details	: Annual Compliance
Job Number	: P1830
Report Number	: R001
Report Issue Date	: 14 th August 2013
Survey Dates	: 18 th July 2013

This report supersedes and replaces P1830/R001

Prepared by:

Environmental Compliance Limited
 Unit G1
 Main Avenue
 Treforest Industrial Estate
 Pontypridd
 CF37 5BF.

Tel: 01443 841760

Fax: 01443 841761

Report Issue:		FINAL	
Report Prepared by:		Report Reviewed & Approved by MCERTS Level Two Technical Endorsements TE1, TE2, TE3 & TE4	
Name:	Jon Litterick	Name:	Andy Barnes
		MCERTS No:	MM 03 235
		Signature:	
Date:	06/08/13	Date:	21/08/13

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MCERTS requirements mean that comparison of results with emissions limit values is not permitted within this report.

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PART 1 - EXECUTIVE SUMMARY

1 Monitoring Objectives

Environmental Compliance Ltd (ECL) was commissioned by **Morgan Composite & Defence Systems - NP** to undertake an emission monitoring survey at their **Coventry – Site 3** factory. This report presents the findings of the study.

The monitoring at this installation was carried out in accordance with our quotation reference **PC/P1830/Q001**, for compliance check monitoring of emissions to air. The substances requested for monitoring at each emissions point are listed below:

Substances to be monitored	Emission Point Identification	
	Abrading / Degreasing Booth	Linex Booth
	A1	A2
Particulates		● U
Isocyanates (MDI)		●
Total Organic Carbon (TVOC)	● U	● U

●
U

Denotes the substances to be monitored.

Denotes UKAS accreditation is held for monitoring that substance, but does not mean that it has been claimed which will depend on whether the testing could be completed in accordance with the Standard Reference Method.

Special Requirements: *“None.”*

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1.1 Monitoring Results

Emission Point Reference	Substance to be Monitored	Emission Limit Value	Periodic Monitoring Result	Units	Uncertainty %	Reference Conditions 273 K, 101.3 kPa	Date of Sampling	Start and End Times	Monitoring Method Reference	Accreditation for use of Method	Tick if non-conforming test (see Sections 2 & 5)	Operating Status
Linex Booth (A2)	Particulates §	50	1.50	mg/m ³	40	& Wet Gas	18/07/2013	10:50 – 11:31	BS EN 13284-1	NU	✓	Normal
			0.68		100	& Wet Gas		11:36 – 12:17		NU	✓	
	TVOC as Carbon	75	6.8	4	& Wet Gas	11:00 – 12:00		BS EN 12619:2013	UKAS / MCERTS			
	Isocyanates (MDI)	0.1	<0.002	100	& Wet Gas	11:00 – 12:00		MDHS 25/3	NA			
Abrading / Degreasing Booth (A1)	TVOC as Carbon	75	17.6	mgC/m ³	2	& Wet Gas	18/07/2013	13:00 – 14:00	BS EN 12619:2013	UKAS / MCERTS		Normal

Notes

The uncertainty figures presented in Table 1.1 for TVOC are “measurement uncertainty” figures, which do not take into account the variability of the measured sample values. The “uncertainty of measurement results” figures, which do include this contribution, are presented in the appendices of the report for these determinands.

Emission Limit Value The emission limit value is that stated in the permit and will be expressed as a concentration or a mass emission.
 Periodic Monitoring Result The result given is expressed in the same terms and units as the emission limit value.
 Uncertainty The uncertainty associated with the quoted result is at the 95% confidence interval. The Uncertainty results **DO NOT** take into account the effect of the sample location limitations.
 Reference Conditions All results are expressed at 273 K and 101.3kPa. The oxygen and moisture corrections are stated.
 Monitoring Method Reference The method stated is in accordance with the Environment Agency Technical Guidance Note M2, or other method approved by the Environment Agency.
Accreditation for use of Method **The details indicate the accreditation for the use of the complete monitoring method, e.g. MCERTs, UKAS. If use of the method is not accredited " NA" is stated.**
 Operating Status § The details indicate the feedstock and the loading rate of the plant during monitoring.
 § Chemical Analysis on sample reagents was performed by an External Laboratory as detailed in Section 4
 NU UKAS Accreditation Held but UKAS Accreditation cannot be claimed for the test as sampling did not comply with the Standard Reference Method (SRM), see section 2 & 5
 NA **Method is NOT UKAS Accredited.**

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1.2 Operating Information

Emission Point Reference	Process Type	Process Duration	Fuel	Feedstock	Abatement	Load	Comparison of Operator CEMS and Periodic Monitoring Results					
							Parameter	Date	Time	CEMS Results	Periodic Monitoring Results	Units
A1	Batch	Various	n/a	n/a	Dry Filter	Normal	...	...	...	NP	...	...
A2	Batch	Various	n/a	n/a	Dry Filter	Normal	...	...	...	NP	...	...

Notes:

Process Type	State whether the process is a continuous or batch process.
Process Duration	If a batch process, state the duration, frequency and details of the portion of the batch sampled. If continuous state "NA"
Fuel	If applicable, state the fuel type If not applicable state "NA"
Feedstock	State the feedstock type
Abatement	State the type and whether operational during monitoring. If not applicable state "NA"
Load	State the normal load, throughput or rating of the plant
CEMS Data	Enter this data for each CEM installed if it is has been provided by operator otherwise state "NP" (NOT PROVIDED)

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2 Monitoring Deviations

The objective of the survey was to measure the concentrations of pollutants from the processes / locations as detailed in Section 1. This survey meets the requirements of the site's **PPC Permit Number: 189** where UKAS and MCERTS accreditation has and could be claimed for the testing in the monitoring results table.

There were no modifications to the sampling procedures (TPDs) listed in Section 4.

There were no substance deviations from the original and agreed emissions monitoring schedule.

Non-conforming tests are as follows:-

- **A1:** Flow profile does not conform to the requirements of the SRM. This is because swirl was measured at greater than 15° at a number of points on the sample plane.
- **A1 & A2:** Flow profiles do not conform to the requirements of the SRM. This is because the ratio of highest to lowest pitot readings was greater than 9:1.
- **A2:** Particulate samples were taken at a reduced number of sample positions, as sampling cannot take place at the points where the velocity pressure is <5Pa. (A4, A5, B1 & B2).
- **Due to the flow traverse issues, the particulates tests on A2 cannot be UKAS / MCERTS accredited.**

The Uncertainty of the reported concentrations for these pollutant results DOES NOT take into account the effect of these non-conformities or sample location limitations.

Homogeneity tests have not been completed for pollutants at any of the sampling locations. Tests are not applicable to these locations (area <1m²) and were not requested by client.

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PART 2 – SUPPORTING INFORMATION

3 SAMPLING STAFF DETAILS

Site Sampling Team

Names of Site Team	Dates on Site	MCERTS No.	LEVEL	Technical Endorsements
Paul Calland	18/07/2013	MM 03 212	2	TE1, TE2, TE3, TE4
Jonathan Litterick	18/07/2013	MM 03 236	2	TE1, TE2, TE3, TE4

Report Reviewer

Name	MCERTS No.	LEVEL	Technical Endorsements
Andy Barnes	MM 03 235	2	TE1, TE2, TE3, TE4

Technical Endorsement Key:-

TE1 – Isokinetic Particulates, Temperature & Velocity Profiles, Oxygen.
TE2 – Isokinetic Extractive Pollutants:- Metals, Dioxin & Furans, PAHs, PCBs, HCl, HF.
TE3 – Non-Isokinetic Extractive Pollutants:- Speciated VOCs, HF, HCl, Cyanide.
TE4 – Continuous Analysers (Combustion Gases):- TVOC, CO, NOx, SO2.

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4 SAMPLING PROTOCOLS / METHODOLOGIES

Any required modifications to the Technical Procedure Documents (TPDs) specified below will be detailed in section 2 of this report.

Pressure, Temperature and Velocity

Testing was carried out using a sampling system in accordance with **BS EN 13284-1 & MID** and In-house technical procedure **ECL/TPD/022**.

Temperature was recorded using a thermocouple and digital temperature reader.

Velocity and pressure were recorded using an "L" type pitot and digital manometer, data being recorded in Pascals.

Particulates

Testing was carried out using a Manual Stack Sampling system in accordance with **BS EN 13284-1 & MID** and In-house technical procedure **ECL/TPD/027a**.

Isokinetic particulate sampling is achieved when the velocity of gas entering the sampling nozzle is exactly equal to the velocity of the approaching gas stream within the stack.

A measured volume of sample gas is withdrawn from the stack isokinetically through a sampling nozzle and through 37mm pre-weighed and pre-blown GFA filter positioned in an unheated housing inserted into the stack.

Particulate matter is collected on the filter. Following testing the front half of the filter housing, probe (out-stack sampling only) and the sample nozzle are rinsed to remove any particulate matter which, may have impacted on the surfaces during testing. The dry residue of the Acetone used for rinses is <5mg/l. The filters and rinses are subsequently analysed to determine the amount of particulate matter captured.

The standard pre-sample conditioning temperature of the filters is 180°C and the standard post-sample conditioning temperature is 160°C. (Any modifications to this are noted in Section 2 of this report). Apparent weights are corrected, if required, based on the weights of three control filters and evaporating basins which are weighed (pre and post sampling) with each batch of filters & rinses.

Scientific Analysis Laboratories Ltd (SAL) who are situated in Manchester carried out the analysis of the samples. **SAL** are UKAS accredited for this analysis. In addition to the survey samples, appropriate field blanks are submitted as part of the technical procedure.

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TVOC as Carbon

Testing was carried out using an MCERTS Certified Signal 3030PM FID and heated gas sample line, with reference to the manufacturer's operation handbook, **BS EN 12619:2013** and in-house technical procedure **ECL/TPD/032**.

The analyser was calibrated on site using certified propane span gases, (made up in synthetic air) which are traceable to ISO 17025 standard (with uncertainty <2%).

Zero measurements were performed using synthetic air zero gas, with TVOC content less than 0.2 mg/m³ (or purity greater than 99.998%).

The analyser was calibrated directly into the sample inlet and then checked through the entire sampling system (including sampling probe, heated filter and heated gas transport lines). Data was corrected by molecular weight to TVOCs as total carbon.

Data was recorded as minute averages over each test period. The data is presented in the Figures Section and the minute averaged data is detailed in the Tables Section.

Isocyanates

Non-continuous sampling for Isocyanates was carried out non-isokinetically, in accordance with **MDHS 25/3**. In this method a volume of stack gases is removed from the duct and first passed through a filter, pre-treated with 1-2 MP in Toluene, then passed through a series of impingers containing 1-2 MP in Toluene. After sampling the filter is combined with the impinger solution for analysis.

ECL are not UKAS accredited for this sampling method.

Scientific Analysis Laboratories Ltd (SAL) who are situated in Manchester carried out the analysis of the samples. **SAL** are UKAS accredited for this analysis. In addition to the survey samples, appropriate field blanks are submitted as part of the technical procedure.

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5 SAMPLE POINT DESCRIPTIONS

The homogeneity test is applicable to combustion processes. This includes but is not restricted to, those regulated under the Waste Incineration Directive (**WID**) and the Large Combustion Plant Directive (**LCPD**).

Homogeneity testing has not been completed at these locations.

The test is not usually required for stacks with sampling plane areas of 1m^2 (below 1.13m in diameter for circular ducts).

The sample locations that were monitored are detailed below:-

Site 3 – Degreasing Booth (A1)

The sampling location does not meet the requirements detailed in *Technical Guidance Note (Monitoring) M1 "Sampling requirements for stack-emission monitoring" Environment Agency*, and BS EN 13284-1 due to the flow profile (Swirl of greater than 15° was measured in areas of the sample plane and ratio of highest to lowest pitot reading was greater than 9:1).

The stack diameter is 0.8m and the sample platform width back from the sample port is 1.0m. Two sample ports are located on the stack at 90 degrees to each other and are located on the same plane.

The sample location is non-conforming, due to the fact that the flow profile does not conform to the SRM. Swirl was measured at greater than 15° at a number of points on the sample plane, also the ratio of highest to lowest pitot readings exceeded 9:1.

The Uncertainty of the reported concentrations for these pollutant results DOES NOT take into account the effect of these non-conformities or sample location limitations.

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Site 3 – LineX Booth (A2)

The sampling location does not meet the requirements detailed in *Technical Guidance Note (Monitoring) M1 "Sampling requirements for stack-emission monitoring" Environment Agency*, and BS EN 13284-1 due to the flow profile. (Swirl of greater than 15° was measured in areas of the sample plane and ratio of highest to lowest pitot reading was greater than 9:1).

The stack diameter is 0.7m and the sample platform width back from the sample port is 2.0m. Two sample ports are located on the stack at 90 degrees to each other and are located on the same plane.

Sampling for Particulates was carried out using an in-stack filter system.

Samples for particulates are non-conforming, due to the fact that the swirl was measured at greater than 15° at a number of points on the sample plane, also the ratio of highest to lowest pitot readings exceeded 9:1. As a consequence of this deviation, UKAS/MCERTS accreditation cannot be claimed for the particulate samples.

The Uncertainty of the reported concentrations for these pollutant results DOES NOT take into account the effect of these non-conformities or sample location limitations.

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**EQUIPMENT IDs
(Pre site checklist from SSP)**

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FIGURES

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Figure 1

TVOC Data Recorded From Morgan Composite & Defence Systems - NP,
Linex Booth (A2), on 18/07/2013, Between 11:00 and 12:00.
Data expressed at reference conditions of 273K, 101.3kPa & Wet Gas

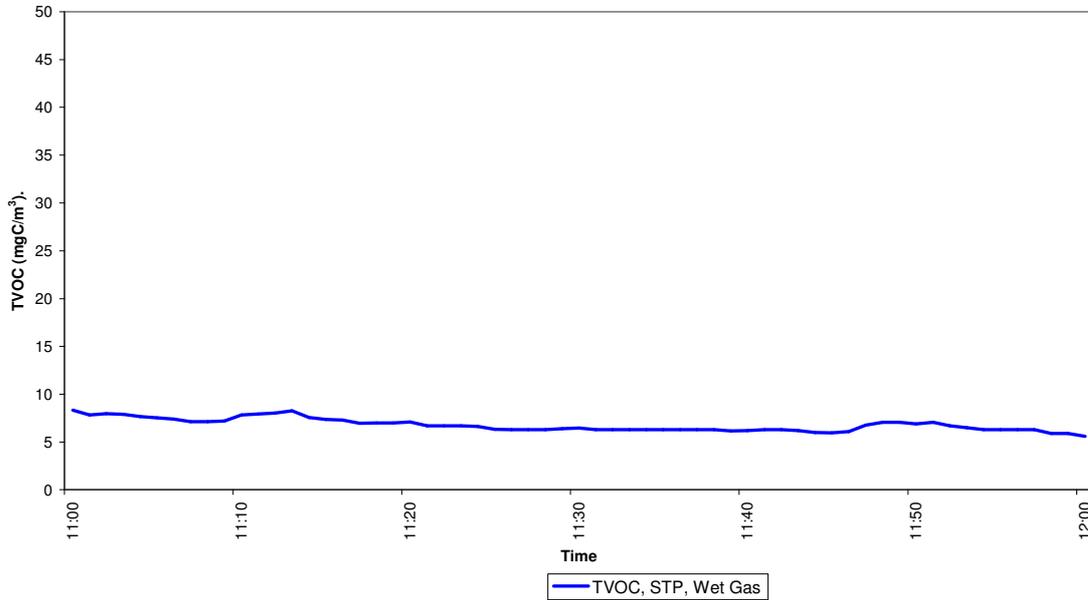
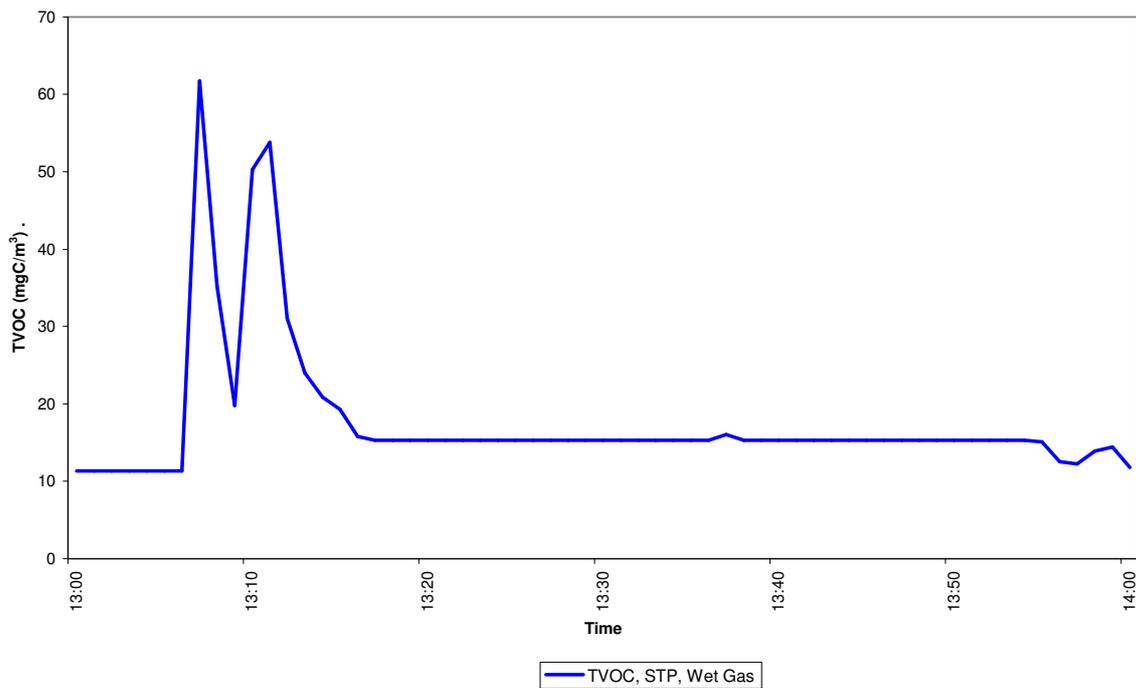


Figure 2

TVOC Data Recorded From Morgan Composite & Defence Systems - NP,
Abrading / Degreasing Booth (A1), on 18/07/2013, Between 13:00 and 14:00.
Data expressed at reference conditions of 273K, 101.3kPa & Wet Gas



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TABLES

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Table 1
Data Recorded from – Abrading / Degreasing Booth (A1)
Sample Period: 13:00 – 14:00 on the 18th July 2013

Volumetric Flowrate (Reference Conditions) = 2.74 m³/sec *

	Average	Emission Rate
	mg/m ³	Kg/hr
TVOC (as carbon)*	17.61	0.174

* Reference Conditions (273K, 101.3 kPa, Wet Gas)

Table 2
Data Recorded from – Linex Booth (A2)
Sample Period: 11:00 – 12:00 on the 18th July 2013

Volumetric Flowrate (Reference Conditions) = 2.61 m³/sec *

	Average	Emission Rate
	mg/m ³	Kg/hr
TVOC (as carbon)*	6.77	0.064

* Reference Conditions (273K, 101.3 kPa, Wet Gas)

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Table 3 – Particulates
Data Recorded from Site 3 - Linex Booth (A2)

Emission Parameter	Units	TPM- 1	Blank
Stack Diameter	metres	0.70	...
			...
Area of Sample Plane	m ²	0.385	...
Moisture Content	%	0.10	...
Oxygen Content	%	20.90	...
Stack Temperature	°C	25	...
Gas Velocity (at Stack Conditions)	m/sec	7.38	...
Gas Velocity (Reference Conditions)	m/sec*	6.77	...
Volumetric Flowrate (Stack Conditions)	m ³ /sec	2.84	...
Volumetric Flowrate (Reference Conditions)	m ³ /sec*	2.61	...
Sample Date	...	18/07/2013	...
Sample Period	...	10:50 - 11:31	...
Sample Volume (at Stack)	m ³	0.55	...
Sample Volume (reference Conditions)	m ³ *	0.51	0.51
Isokinetic Sampling Rate	%	105.5	...
Sample Reference (ECL ID)	ECL/13/	3131 & 3132	3135 & 3136
Mass of Particulate Matter Collected	mg	0.76	0.35
Concentration of Particulate Matter	mg/m ³ *	1.50	0.69
Emission Rate of Particulate Matter	g/hr	14.04	...
Expanded Uncertainty (%Relative)	%	40	...
Emission Limit Value (ELV)	mg/m ³ *	50	...
Blank Concentration as Percentage of ELV	%	...	1.38

*Reference Conditions (273K, 101.3kPa, Wet Gas)

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Table 4 – Particulates
Data Recorded from Site 3 - Linex Booth (A2)

Emission Parameter	Units	TPM- 2	Blank
Stack Diameter	metres	0.70	...
			...
Area of Sample Plane	m ²	0.385	...
Moisture Content	%	0.10	...
Oxygen Content	%	20.90	...
Stack Temperature	°C	25	...
Gas Velocity (at Stack Conditions)	m/sec	7.38	...
Gas Velocity (Reference Conditions)	m/sec*	6.77	...
Volumetric Flowrate (Stack Conditions)	m ³ /sec	2.84	...
Volumetric Flowrate (Reference Conditions)	m ³ /sec*	2.61	...
Sample Date	...	18/07/2013	...
Sample Period	...	11:36 - 12:17	...
Sample Volume (at Stack)	m ³	0.56	...
Sample Volume (reference Conditions)	m ³ *	0.51	0.51
Isokinetic Sampling Rate	%	106.4	...
Sample Reference (ECL ID)	ECL/13/	3133 & 3134	3135 & 3136
Mass of Particulate Matter Collected	mg	0.35	0.35
Concentration of Particulate Matter	mg/m ³ *	0.68	0.68
Emission Rate of Particulate Matter	g/hr	6.41	...
Expanded Uncertainty (%Relative)	%	>100%	...
Emission Limit Value (ELV)	mg/m ³ *	50	...
Blank Concentration as Percentage of ELV	%	...	1.37

*Reference Conditions (273K, 101.3kPa, Wet Gas)

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Table 5 – Isocyanates (MDI)

Morgan Composite & Defence Systems - NP Coventry Site 3 Linex

Emission Parameter	Units	Value		
Stack Diameter	mm	700		
Area of Sample Plane	m ²	0.385		
Measured Oxygen (Dry)	%Vol	...		
Meter Temperature	°C	19.00		
Stack Temperature	°C	25.00		
Sample Date	...	18/07/2013		
Sample Period	...	11:00 - 12:00		
Sample Volume (as Measured)	m ³	0.12		
Sample Volume (reference Conditions)	m ^{3*}	0.11		
Sample Tube Results		Test		Blank
Sample Reference ECL/12/3137	Units	Concentration*	Uncertainty	Concentration
Concentration of MDI	mg/m ³	0.0018	102.95%	0.0018

*Reference Conditions: 273 K, 101.3 kPa, Wet Gas

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VELOCITY TRAVERSE PROFILES

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FIELD CALIBRATION AND SAMPLING DATA

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TVOC - FIELD DATA SHEET

Client	Morgan Composite & Defence Systems - NP	Barometric Pressure mb	1014
Site	Coventry	Barometer ID	ECL/ID/ 351
Date	18/07/2013	Analyser ID	ECL/ID/301
Location	Site 3	Sonimix/ MFC ID	ECL/ID/ n/a
Stack ID	Linex Booth (A2)	Heated Line/ Controller ID	ECL/ID/ 432 & 433
Stack Temp °C	25	Heated Line Set Temp °C	180
Ambient Temp	During Pre-test Calibration 20	Heated Line Length	20 m
Ambient Temp (sampling)	1= 20 2= 22 3= 26	Heated Filter ID	ECL/ID/ 633
Job No	P1830	Heated Filter Set Temp °C	180
Operators	JL & PC	Logger ID	FID 4

Calibration Gas Details

Calibration Gas	Gas Bottle ID	Gas Value	Uncertainty of Gas (k=2)	Analyser Range	Span Gas value used
Zero Gas (Synthetic Air)	Gas/ 1156	...	...	Propane	40ppm
Hydrogen / Helium	Gas/ 1165	...	...
Propane (In Air)	Gas/ 1163	30.95ppm	0.3095ppm		

Analyser Range should be not less than the expected peak emissions.
 Span Gas Values should be either approximately the half-hourly ELV **OR** 50% to 90% of the Selected Analyser Range.

Direct Calibration (Rear of Analyser)						
	Zero Cal		Span Gas Cal		Zero Check	
	Start Time	End Time	Start Time	End Time	Start Time	End Time
ZERO /SPAN/ ZERO	09:35	09:40	09:41	09:46	09:47	09:52

NOTE: RESPONSE TIME
 Response Time to be carried out at the same time as "Span Check" on system verification (via the sample probe)
 Start Time = when gas turned on. 90% Time = when analyser displays 90% of span gas value used. Response must be within 200 seconds.

	PRE System Verification Check (Down Line)				Response Time SYSTEM Span Gas Cal		
	Zero Check		Span Check		Start Time	90% Time	less than 200s (Y/N)
	Start Time	End Time	Start Time	End Time			
ZERO / SPAN	10:33	10:38	10:41	10:46	10:40	10:41	Y

	Start Time	End Time	Location	Production Details
	Sample Period	11:00	12:00	A2
Sample Period				

	POST System Verification Check (Down Line)			
	Zero Check		Span Check	
	Start Time	End Time	Start Time	End Time
ZERO / SPAN	12:06	12:11	12:12	12:17

Process Details / Comments

Environmental Compliance Limited

Morgan Composite & Defence Systems - NP
 Permit No : 189
 Variation No : n/a
 Report Ref : P1830 : R001

Installation Name : Site 3
 Visit Details : Annual Compliance
 Survey Dates : 18th July 2013
 Report Issue Date : 14th August 2013

TVOC - FIELD DATA SHEET

Client	Morgan Composite & Defence Systems - NP	Barometric Pressure mb	1014
Site	Coventry	Barometer ID	ECL/ID/ 351
Date	18/07/2013	Analyser ID	ECL/ID/ 301
Location	Site 3	Sonimix/ MFC ID	ECL/ID/ n/a
Stack ID	Abrading / Degreasing Booth (A1)	Heated Line/ Controller ID	ECL/ID/ 432 & 433
Stack Temp °C	25	Heated Line Set Temp °C	180
Ambient Temp	During Pre-test Calibration 25	Heated Line Length	20 m
Ambient Temp (sampling)	1= 25 2= 26 3= 26	Heated Filter ID	ECL/ID/ 633
Job No	P1830	Heated Filter Set Temp °C	180
Operators	JL & PC	Logger ID	FID 4

Calibration Gas Details

Calibration Gas	Gas Bottle ID	Gas Value	Uncertainty of Gas (k=2)	Analyser Range	Span Gas value used
Zero Gas (Synthetic Air)	Gas/ 1156	...	...	Propane	400 ppm
Hydrogen / Helium	Gas/ 1165	...	...
Propane (In Air)	Gas/ 1162	307.3 ppm	3.073ppm		

Analyser Range should be not less than the expected peak emissions.
 Span Gas Values should be either approximately the half-hourly ELV **OR** 50% to 90% of the Selected Analyser Range.

Direct Calibration (Rear of Analyser)						
	Zero Cal		Span Gas Cal		Zero Check	
	Start Time	End Time	Start Time	End Time	Start Time	End Time
ZERO /SPAN/ ZERO	12:21	12:26	12:27	12:33	12:34	12:39

NOTE: RESPONSE TIME
 Response Time to be carried out at the same time as "Span Check" on system verification (via the sample probe)
 Start Time = when gas turned on. 90% Time = when analyser displays 90% of span gas value used. Response must be within 200 seconds.

	PRE System Verification Check (Down Line)				Response Time SYSTEM Span Gas Cal		
	Zero Check		Span Check		Start Time	90% Time	less than 200s (Y/N)
	Start Time	End Time	Start Time	End Time			
ZERO / SPAN	12:40	12:45	12:46	12:51	12:45	12:46	Y

	Start Time	End Time	Location	Production Details
Sample Period	13:00	14:00	A1	Abrading / Degreasing Booth - Normal
Sample Period				

	POST System Verification Check (Down Line)			
	Zero Check		Span Check	
	Start Time	End Time	Start Time	End Time
ZERO / SPAN	14:03	14:08	14:08	14:13

Process Details / Comments

Environmental Compliance Limited

Morgan Composite & Defence Systems - NP
 Permit No : 189
 Variation No : n/a
 Report Ref : P1830 : R001

Installation Name : Site 3
 Visit Details : Annual Compliance
 Survey Dates : 18th July 2013
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Environmental Compliance Limited		PARTICULATE DATA SAMPLING PROFORMA				Date of Measurement		18/07/2013		
ECL/TPD	27a	Time taken to change Ports		1	Start Time	10:50	End Time	11:31	Duration (mins)	40
Client	NP	Stack Profile	Circular	Pilot ID	488	Stack Thermocouple ID	866	Impingers	n/a	
Site	Coventry	Stack Area (m ²)	0.38	Manometer ID	422	Stack Temp Reader ID	431	SOL	n/a	
Location	Site 3	Barometric Pressure (mb)	1014	Barometer ID	351	Meter Thermocouple ID	367c	Start Weight (g)	0.00	
Stack ID	Linex Booth (A2)	Stat Pres. (mm H ² O) (Pa@9.81)	5	DCM Vd	1.0202	Meter Temp Reader ID	367c	End Weight (g)	0.40	
Test No.	TPM - 1	Pilot coefficient	1	Nozzle ID	800	Dry Gas Meter ID	367a	Total weight (g)	0.40	
Job No	P1830	Balance ID	n/a	Nozzle Size (mm)	6.14	Timer ID	367d			
ECL Site Staff	JL & PC	Console ID	367	Filter ID	745	Rotameter ID	367b			

Sample	Leak 1	Leak 2	Leak 3	Leak 4
Start Volume	1347342.0			
Final Volume	1347890.0			
Total Volume	548.0	0.0	0.0	0.0

Total	Volume (litres) @ STP Dry
548.0	Expected Sample Volume 480.89
	Actual Sample Volume 507.93
	Isokinetic Percentage 105.52

Leak Check	First	Second	Third	Final	Maximum allowed leak rate is 2% of the set rate	Measured O ₂	20.90	Moisture	0.10
Leak Rate l/min	0.2			0.2		Measured CO ₂ %		Ref O ₂	11
Set Rate (l/min)	25			25		Measured CO ppm		Dry Gas Molecular Weight	28.84
Time Of Leak Check	10:35			11:33					
Leak % of set rate	0.8			0.8					

TPD/27A is carried out with an unheated sampling system only.

Traverse Point	A1	A1	A2	A2	A3	A3	B4	B4	Total
Time Interval (mins)	4	4	4	4	4	4	4	4	
Time Point (mins)	0 - 4	4 - 8	8 - 12	12 - 16	16 - 20	20 - 24	24 - 28	28 - 32	
AP (Pa)	40.00	40.00	30.00	30.00	10.00	10.00	40.00	40.00	30.0
Velocity at Stack (m/s)	8.23	8.23	7.13	7.13	4.12	4.12	8.23	8.23	
Sample Rate (l/min) 101.3 mbar, Tm, Dry Gas	14.5	14.6	12.7	12.8	7.4	7.4	14.9	14.9	12.4
Meter (Tm)	22.00	25.00	26.00	27.00	30.00	30.00	31.00	31.00	27.6
Stack Temp (Ts)	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.0

Traverse Point	B5	B5	Total
Time Interval (mins)	4	4	
Time Point (mins)	32 - 36	36 - 40	
AP (Pa)	50.00	50.00	50.0
Velocity at Stack (m/s)	9.20	9.20	
Sample Rate (l/min) 101.3 mbar, Tm, Dry Gas	16.7	16.7	16.7
Meter (Tm)	31.00	31.00	31.0
Stack Temp (Ts)	25.00	25.00	25.0

Traverse Point	Total
Time Interval (mins)	
Time Point (mins)	
AP (Pa)	
Velocity at Stack (m/s)	
Sample Rate (l/min) 101.3 mbar, Tm, Dry Gas	
Meter (Tm)	
Stack Temp (Ts)	

If moisture was not measured and gas was dried before entering the gas meter, impinger weights must be included to produce the moisture concentration used in the isokinetic calculations. If the gas was not dried before it entered the gas meter then impinger weights may be included to produce a nominal 0.1% moisture value.

Acetone SOL	2146
DI Rinse SOL	2221

Original Flowrate Settings	
Tm	30
Ts	25
% moisture	

Environmental Compliance Limited		PARTICULATE DATA SAMPLING PROFORMA				Date of Measurement		18/07/2013		
ECL/TPD	27a	Time taken to change Ports		1	Start Time	11:36	End Time	12:17	Duration (mins)	40
Client	NP	Stack Profile	Circular	Pilot ID	488	Stack Thermocouple ID	866	Impingers	n/a	
Site	Coventry	Stack Area (m ²)	0.38	Manometer ID	422	Stack Temp Reader ID	431	SOL	n/a	
Location	Site 3	Barometric Pressure (mb)	1014	Barometer ID	351	Meter Thermocouple ID	367c	Start Weight (g)	0.00	
Stack ID	Linex Booth (A2)	Stat Pres. (mm H ² O) (Pa@9.81)	5	DCM Vd	1.0202	Meter Temp Reader ID	367c	End Weight (g)	0.40	
Test No.	TPM - 2	Pilot coefficient	1	Nozzle ID	800	Dry Gas Meter ID	367a	Total weight (g)	0.40	
Job No	P1830	Balance ID	n/a	Nozzle Size (mm)	6.14	Timer ID	367d			
ECL Site Staff	JL & PC	Console ID	367	Filter ID	776	Rotameter ID	367b			

Sample	Leak 1	Leak 2	Leak 3	Leak 4
Start Volume	1348004.0			
Final Volume	1348560.0			
Total Volume	556.0	0.0	0.0	0.0

Total	Volume (litres) @ STP Dry
556.0	Expected Sample Volume 480.93
	Actual Sample Volume 511.75
	Isokinetic Percentage 106.41

Leak Check	First	Second	Third	Final	Maximum allowed leak rate is 2% of the set rate	Measured O ₂	20.90	Moisture	0.10
Leak Rate l/min	0.2			0.1		Measured CO ₂ %		Ref O ₂	11
Set Rate (l/min)	25			20		Measured CO ppm		Dry Gas Molecular Weight	28.84
Time Of Leak Check	11:35			12:20					
Leak % of set rate	0.8			0.5					

TPD/27A is carried out with an unheated sampling system only.

Traverse Point	A1	A1	A2	A2	A3	A3	B4	B4	Total
Time Interval (mins)	4	4	4	4	4	4	4	4	
Time Point (mins)	0 - 4	4 - 8	8 - 12	12 - 16	16 - 20	20 - 24	24 - 28	28 - 32	
AP (Pa)	40.00	40.00	30.00	30.00	10.00	10.00	40.00	40.00	30.0
Velocity at Stack (m/s)	8.23	8.23	7.13	7.13	4.12	4.12	8.23	8.23	
Sample Rate (l/min) 101.3 mbar, Tm, Dry Gas	14.8	14.8	12.8	12.8	7.4	7.4	14.9	14.9	12.5
Meter (Tm)	28.00	28.00	29.00	29.00	30.00	30.00	31.00	31.00	29.5
Stack Temp (Ts)	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.0

Traverse Point	B5	B5	Total
Time Interval (mins)	4	4	
Time Point (mins)	32 - 36	36 - 40	
AP (Pa)	50.00	50.00	50.0
Velocity at Stack (m/s)	9.20	9.20	
Sample Rate (l/min) 101.3 mbar, Tm, Dry Gas	16.7	16.7	16.7
Meter (Tm)	32.00	32.00	32.0
Stack Temp (Ts)	25.00	25.00	25.0

Traverse Point	Total
Time Interval (mins)	
Time Point (mins)	
AP (Pa)	
Velocity at Stack (m/s)	
Sample Rate (l/min) 101.3 mbar, Tm, Dry Gas	
Meter (Tm)	
Stack Temp (Ts)	

Acetone SOL	2146
DI Rinse SOL	2221

Original Flowrate Settings	
Tm	30
Ts	25
% moisture	

Environmental Compliance Limited

Morgan Composite & Defence Systems - NP
 Permit No : 189
 Variation No : n/a
 Report Ref : P1830 : R001

Installation Name : Site 3
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Environmental Compliance Limited				ISOCYANATE SAMPLING PROFORMA			
Client	Morgan Composite & Defence Systems - NP	<input checked="" type="checkbox"/> Circular <input type="checkbox"/> Rectangular <input type="checkbox"/> Ellipse	Barometer ID	351	Date of Test	18/07/2013	
Site	Coventry	Stack Diameter (mm)	700	Balance ID	n/a		
Location	Site 3	Stack Area (m ²)	0.385	Pump ID	n/a		
Stack ID	Linex	Barometric Pressure (mb)	1014	Meter ID	n/a		
Test No.	Isocyanates - 1	Heated Line ID	n/a	DGM Yd or ml/count	1		
Job No	P1830	Impinger ID	n/a	Measured O2	...		
ECL Site Staff	PC+JL			O2 Uncertainty %Vol	...		
Meter Units <input checked="" type="checkbox"/> ml <input type="checkbox"/> litres							
Start Volume	0.0	Leak 1		Leak 2		Total	
Final Volume	120.0						
Total Volume	120.0	0.0		0.0		120.0	
Time Point	0-10	10 - 20	20-30	30-40	Impinger 1		
Heated Line Temp °C	...	...	...	...	SOL/	n/a	
Tube Temp °C	...	...	...	...	Start Weight (g)		
Stack Temp °C	25	25	25	25	End Weight (g)		
Meter Temp In °C	19	19	19	19	Total weight (g)	0	
Meter Temp Out °C	19	19	19	19	Impinger 2		
				SOL/			
				Start Weight (g)			
				End Weight (g)			
				Total weight (g)			
				0			
Time Point	40-50	50-60	60-70		Impinger3		
Heated Line Temp °C	...	...	...		SOL/		
Tube Temp °C	...	...	...		Start Weight (g)		
Stack Temp °C	25	25	25		End Weight (g)		
Meter Temp In °C	19	19	19		Total weight (g)	0	
Meter Temp Out °C	19	19	19		Impinger 4		
				SOL/			
				Start Weight (g)			
				End Weight (g)			
				Total weight (g)			
				0			
				Total			
				0			

Environmental Compliance Limited

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FID CALIBRATION A1

		TVOC ppm
Analyser Range		400
Repeatability at Zero		2
Span Gas Concentration Applied		307.3
Zero Gas Concentration Applied		0
Direct Cal	Zero	0.00
	Span	307.3
	Zero	-0.39
Difference (Zero)		0.3892
<2×Repeatability @ Zero?		YES
Pre Test	Zero	-0.39
	Span	307.3
Difference (Zero)		0.0000
<2% Relative to Direct Span		YES
Difference (Span)		0.0000
<2% Relative to Direct Span		YES
Post Test	Zero	-0.44
	Span	304.8
Difference (Zero)		0.0487
Zero Drift <2% of Applied Span?		YES
Difference (Span)		2.4814
Span Drift <2% of Applied Span?		YES
Zero and Span Drift <5% of Applied Span?		YES

Environmental Compliance Limited

Morgan Composite & Defence Systems - NP
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Installation Name : Site 3
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FID CALIBRATION A2

		TVOC ppm
Analyser Range		40
Repeatability at Zero		0.8
Span Gas Concentration Applied		30.95
Zero Gas Concentration Applied		0
Direct Cal	Zero	0.00
	Span	31.0
	Zero	0.12
Difference (Zero)		0.1221
<2×Repeatability @ Zero?		YES
Pre Test	Zero	0.13
	Span	30.3
Difference (Zero)		0.0034
<2% Relative to Direct Span		YES
Difference (Span)		0.6068
<2% Relative to Direct Span		YES
Post Test	Zero	-0.39
	Span	30.1
Difference (Zero)		0.5170
Zero Drift <2% of Applied Span?		YES
Difference (Span)		0.2458
Span Drift <2% of Applied Span?		YES
Zero and Span Drift <5% of Applied Span?		YES

Environmental Compliance Limited

Morgan Composite & Defence Systems - NP
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Variation No : n/a
Report Ref : P1830 : R001

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Visit Details : Annual Compliance
Survey Dates : 18th July 2013
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LABORATORY ANALYSIS RESULTS

Environmental Compliance Limited

Morgan Composite & Defence Systems - NP
Permit No : 189
Variation No : n/a
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Survey Dates : 18th July 2013
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Scientific Analysis Laboratories is a limited company registered in England and Wales (No 2514788) whose address is at Hadfield House, Hadfield Street, Manchester M16 9FE

Scientific Analysis Laboratories Ltd
Certificate of Analysis

Hadfield House
Hadfield Street
Combbrook
Manchester
M16 9FE
Tel : 0161 874 2400
Fax : 0161 874 2404

Report Number: 341565-1

Date of Report: 01-Aug-2013

Customer: Environmental Compliance Ltd
Unit G1
Main Avenue
Treforest Industrial Estate
Pontypridd
CF37 5BF

Customer Contact: Mr John Litterick

Customer Job Reference: P1830
Customer Purchase Order: E1750
Date Job Received at SAL: 23-Jul-2013
Date Analysis Started: 24-Jul-2013
Date Analysis Completed: 01-Aug-2013

The results reported relate to samples received in the laboratory
Opinions and interpretations expressed herein are outside the scope of UKAS accreditation
This report should not be reproduced except in full without the written approval of the laboratory
Tests covered by this certificate were conducted in accordance with SAL SOPs
All results have been reviewed in accordance with QP22



Report checked
and authorised by :
Kayleigh McCann
Project Manager

Issued by :
Kayleigh McCann
Project Manager

Validity unknown
Digitally signed by Kayleigh
McCann
Date: 2013.08.14 17:22:20 BST
Reason: Issued
Location: SAL

Environmental Compliance Limited

Morgan Composite & Defence Systems - NP
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Installation Name : Site 3
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SAL Reference: 341565 Customer Reference: P1830							
Filter GFA 37mm Analysed as Filter GFA 37mm Miscellaneous							
SAL Reference		341565 001	341565 003	341565 005			
Customer Sample Reference		ECL13/3131	ECL13/3133	ECL13/3135			
Test Sample		AR	AR	AR			
Determinand	Method	LOD	Units	Symbol			
Particulates (Total)	Grav (5 Dec)	0.05	mg	U	0.46	0.05	<0.05

SAL Reference: 341565 Customer Reference: P1830							
Wash(Acetone) Analysed as Wash(Acetone) Miscellaneous							
SAL Reference		341565 002	341565 004	341565 006			
Customer Sample Reference		ECL13/3132	ECL13/3134	ECL13/3136			
Test Sample		AR	AR	AR			
Determinand	Method	LOD	Units	Symbol			
Particulates (Total)	Grav	0.3	mg	U	<0.3	<0.3	<0.3

SAL Reference: 341565 Customer Reference: P1830							
Composite(filter+impinger) Analysed as Composite(filter+impinger) Miscellaneous							
SAL Reference		341565 007	341565 008				
Customer Sample Reference		ECL13/3137	ECL13/3138				
Test Sample		AR	AR				
Determinand	Method	LOD	Units	Symbol			
Methylenediphenyl diisocyanate	HPLC	0.2	µg	U	(160) <0.2	(160) <0.2	
Total Isocyanate Polymer	Calo (MDHS 25/3)	0.20	µg	N	(160,12,139) <0.20	(139,160,12) <0.20	

Index to symbols used in 341565-1

Value	Description
AR	As Received
160	Expressed as NCO
12	Isocyanate polymers are based on a calculation which is defined in MDHS 25/3
139	Excluding Targets
U	Analysis is UKAS accredited
N	Analysis is not UKAS accredited

Environmental Compliance Limited

Morgan Composite & Defence Systems - NP
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Installation Name : Site 3
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UNCERTAINTY CALCULATIONS

Environmental Compliance Limited

Morgan Composite & Defence Systems - NP
 Permit No : 189
 Variation No : n/a
 Report Ref : P1830 : R001

Installation Name : Site 3
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 Report Issue Date : 14th August 2013

TVOC – Measurement Uncertainty

Abrading / Degreasing Booth (A1)

Performance Characteristics	Standard Uncertainty	Distributioun	Min Certified Ranges
			TVOC 0 - 15 mgC/m ³
Lack of fit ⁽¹⁾	U_{lof}	Rectangular (Divisor = $\sqrt{3}$)	0.40
Span drift ⁽²⁾	$U_{d,s}$	Rectangular (Divisor = $\sqrt{3}$)	0.35
Repeatability Standard Deviation (span)	U_r	Normal (Divisor = 1)	1.95
Losses / leakage in the sample system ⁽³⁾	U_{loss}	Rectangular (Divisor = $\sqrt{3}$)	0.00
Temperature dependant span drift ⁽⁵⁾	U_t	Rectangular (Divisor = $\sqrt{3}$)	0.30
Interferents ⁽⁴⁾	U_i	Rectangular (Divisor = $\sqrt{3}$)	4.39
Uncertainty of Reference Gas ⁽⁶⁾	U_{ref}	Rectangular (Divisor = $\sqrt{3}$)	4.94

Note:

$$\text{when } |(x_{i,max} - x_{i,adj})| = |(x_{i,min} - x_{i,adj})|, \text{ then } u(x_i) = \frac{\Delta x_i}{\sqrt{3}}$$

- 1 Expressed as a percentage of the analyser range
- 2 Expressed as maximum drift per 24hr period
- 3 Expressed in units of final measurement, dry gas
- 4 Expressed as a percentage of the final measured value
- 5 Per one degree centigrade
- 6 Expressed as standard uncertainty in units of measurement i.e. mg/m³ / %Vol
- 7 Applies to TOC analyser (*Signal 3030 FID) only

Performance Characteristics	Uncertainty	Value of Standard Uncertainty	*TVOC 0 - 15 mgC/m ³
Lack of fit	U_{lof}	$u(x_i) = \frac{u_{lof} \times R_i}{\sqrt{3}} =$	0.035
Span drift	$U_{d,s}$	$u(x_i) = \frac{u_{d,s} \times R_i}{\sqrt{3}} =$	0.031
Repeatability Standard Deviation (span)	U_r	$\sigma = \sqrt{\frac{\sum_{i=1}^n (x_i - \bar{x})^2}{n-1}} =$	1.95
Losses / leakage in the sample system	U_{loss}	$u(x_i) = \frac{u_{loss} \times R_i}{\sqrt{3}} =$	0.00
Temperature dependant span drift	U_t	$u(x_i) = \frac{u_t \times R_i}{100} \times \sqrt{\frac{(x_{i,max} - x_{i,adj})^2 + (x_{i,min} - x_{i,adj})(x_{i,max} - x_{i,adj}) + (x_{i,min} - x_{i,adj})^2}{3}}$	0.026
Interferents	U_i	$u(x_i) = \frac{u_i \times R_i}{\sqrt{3}} =$	0.38
Uncertainty of Reference Gas	U_{ref}	$u(x_i) = \frac{u_{ref}}{\sqrt{3}} =$	4.94
Combined Standard Uncertainty		$u_c = \sqrt{u_{lof}^2 + u_{d,s}^2 + u_r^2 + u_{loss}^2 + u_t^2 + u_i^2 + u_{ref}^2}$	5.34
Expanded measurement uncertainty (at 95% confidence)		$U_{EXP} = 2 \times u_c$	10.68
Applied Span Concentration			493.83
Measured Span Concentration, STP Dry Gas			492.50
Expanded measurement uncertainty as % of Applied Span			2%

* Signal 3030 FID

Environmental Compliance Limited

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 Variation No : n/a
 Report Ref : P1830 : R001

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TVOC – Measurement Uncertainty Linex Booth (A2)

Performance Characteristics	Standard Uncertainty	Distributioun	Min Certified Ranges
			TVOC 0 - 15 mgC/m ³
Lack of fit ⁽¹⁾	U_{lof}	Rectangular (Divisor = $\sqrt{3}$)	0.40
Span drift ⁽²⁾	$U_{d,s}$	Rectangular (Divisor = $\sqrt{3}$)	0.35
Repeatability Standard Deviation (span)	U_r	Normal (Divisor = 1)	0.55
Losses / leakage in the sample system ⁽³⁾	U_{loss}	Rectangular (Divisor = $\sqrt{3}$)	1.96
Temperature dependant span drift ⁽⁵⁾	U_t	Rectangular (Divisor = $\sqrt{3}$)	0.30
Interferents ⁽⁷⁾	U_i	Rectangular (Divisor = $\sqrt{3}$)	4.39
Uncertainty of Reference Gas ⁽⁶⁾	U_{ref}	Rectangular (Divisor = $\sqrt{3}$)	0.50

Note:

$$\text{when } |(x_{i,max} - x_{i,adj})| = |(x_{i,min} - x_{i,adj})|, \text{ then } u(x_i) = \frac{\Delta x_i}{\sqrt{3}}$$

- 1 Expressed as a percentage of the analyser range
- 2 Expressed as maximum drift per 24hr period
- 3 Expressed in units of final measurement, dry gas
- 4 Expressed as a percentage of the final measured value
- 5 Per one degree centigrade
- 6 Expressed as standard uncertainty in units of measurement i.e. mg/m³ / %Vol
- 7 Applies to TOC analyser (*Signal 3030 FID) only

Performance Characteristics	Uncertainty	Value of Standard Uncertainty	*TVOC 0 - 15 mgC/m ³
Lack of fit	U_{lof}	$u(x_i) = \frac{u_{lof} \times R_i}{\sqrt{3}} =$	0.035
Span drift	$U_{d,s}$	$u(x_i) = \frac{u_{d,s} \times R_i}{\sqrt{3}} =$	0.031
Repeatability Standard Deviation (span)	U_r	$\sigma = \sqrt{\frac{\sum_{i=1}^n (x_i - \bar{x})^2}{n-1}} =$	0.55
Losses / leakage in the sample system	U_{loss}	$u(x_i) = \frac{u_{loss} \times R_i}{\sqrt{3}} =$	0.53
Temperature dependant span drift	U_t	$u(x_i) = \frac{u_t \times R_i}{100} \times \sqrt{\frac{(x_{i,max} - x_{i,adj})^2 + (x_{i,min} - x_{i,adj})(x_{i,max} - x_{i,adj}) + (x_{i,min} - x_{i,adj})^2}{3}}$	0.16
Interferents	U_i	$u(x_i) = \frac{u_i \times R_i}{\sqrt{3}} =$	0.38
Uncertainty of Reference Gas	U_{ref}	$u(x_i) = \frac{u_{ref}}{\sqrt{3}} =$	0.50
Combined Standard Uncertainty		$u_c = \sqrt{u_{lof}^2 + u_{d,s}^2 + u_r^2 + u_{loss}^2 + u_t^2 + u_i^2 + u_{ref}^2}$	1.09
Expanded measurement uncertainty (at 95% confidence)		$U_{EXP} = 2 \times u_c$	2.17
Applied Span Concentration			49.74
Measured Span Concentration, STP Dry Gas			48.83
Expanded measurement uncertainty as % of Applied Span			4 %

* Signal 3030 FID

Environmental Compliance Limited

Morgan Composite & Defence Systems - NP
 Permit No : 189
 Variation No : n/a
 Report Ref : P1830 : R001

Installation Name : Site 3
 Visit Details : Annual Compliance
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 Report Issue Date : 14th August 2013

TVOC - Uncertainty of Measurement Abrading / Degreasing Booth (A1)

Uncertainty Calculations Part 1

Performance Characteristics	Standard Uncertainty (% of Range)	Distribution	Divisor	Min Certified Range	
				TVOC 0 - 15 mgCm ³	
Lack of fit ⁽¹⁾	u_{lof}	Rectangular	$\sqrt{3}$	0.40	
Span drift ⁽²⁾	u_{ds}			0.35	
Losses / leakage in the sample system ⁽⁴⁾	u_{loss}			0.00	
Temperature dependant span drift ⁽⁵⁾	u_t			0.30	
Interferents ⁽¹⁾	u_i			4.39	
Effect of Voltage Fluctuation ⁽⁷⁾	u_v			1.80	
Effect of Oxygen Synergism ⁽⁷⁾	u_{syn}				

Notes:

For rectangular distributions, $u(x_i) = \frac{u \times R_i}{\sqrt{3}}$

For $u(x_i) = \Delta x_i \sqrt{\frac{(x_{i,max} - x_{i,adj})^2 + (x_{i,min} - x_{i,adj})(x_{i,max} - x_{i,adj}) + (x_{i,min} - x_{i,adj})^2}{3}}$, when $|x_{i,max} - x_{i,adj}| = |x_{i,min} - x_{i,adj}|$, then $u(x_i) = \frac{\Delta x_i}{\sqrt{3}}$

Where $u(x_i) = \frac{\sigma}{\sqrt{n}}$ (See note 6 below), $\sigma = \sqrt{\frac{\sum_{i=1}^n (x_i - \bar{x})^2}{n-1}}$

Performance Characteristics	Uncertainty (Units of final measurement)	Distribution	Divisor	TVOC 0 - 15 mgCm ³
Lack of fit	u_{lof}	Rectangular	$\sqrt{3}$	0.035
Span drift	u_{ds}			0.031
Temperature dependant span drift	u_t			0.026
Interferents	u_i			0.38
Effect of Voltage Fluctuation (See Note)	u_v			0.16

Uncertainty Calculations Part 2

Performance Characteristics	Uncertainty (Units of final measurement)	Date & Time	TVOC 0 - 15 mgCm ³
Losses / leakage in the sample system	u_{loss}	18/07/13 13:00 - 14:00	0.00
Standard Error of Measured Value	u_{SE}	18/07/13 13:00 - 14:00	1.22

Effect on Uncertainty Caused by Oxygen

$$u_{Corr_{O_2}} = \frac{20.9\% - O_{2,ref}}{(20.9\% - O_{2,measured}) \times (20.9\% - O_{2,measured})} \times \text{Uncertainty of } O_2 \text{ Meas} =$$

$$f_{O_2} = \frac{20.9\% - O_{2,ref}}{20.9\% - O_{2,measured}} = 1.0000$$

$$u_{f_{O_2}} = \frac{u_{Corr_{O_2}} \times 100}{f_{O_2}} = 0.00 \%$$

The effect of oxygen on the overall uncertainties (below) is incorporated using the following equation:-

$$u_{combined} = \sqrt{\sum (u_{f_{O_2}})^2 + (\text{Uncertainty of Measurement of Determinand})^2}$$

Where oxygen or moisture correction is required, uncertainty based on the standard error of the measured peripheral value is converted to units of final measurement using a sensitivity coefficient C,

$$\therefore u(x_i) = C_i u_i \text{ where } C_i = \frac{\partial f}{\partial x_i}$$

Uncertainty Calculations Part 3

Uncertainty	Date & Time	*TVOC 0 - 15 mgCm ³
Measured Concentration	18/07/13 13:00 - 14:00	17.61
Expanded Uncertainty as Percentage of Measured Concentration		15%

Combined Standard Uncertainty $u_c = \sqrt{u_{lof}^2 + u_{ds}^2 + u_{loss}^2 + u_t^2 + u_i^2 + u_{ref}^2 + u_{syn}^2}$

Expanded uncertainty (at 95% confidence) $U_{Exp} = 2 \times u_c$

- 1 Expressed as a percentage of the analyser range
- 2 Expressed as maximum drift per 24hr period
- 3 Expressed in units of final measurement
- 4 Expressed as a percentage of the final measured value
- 5 Per one degree centigrade
- 6 Where the uncertainty of Oxygen is taken as the standard error of the time averaged value used to correct to Reference Oxygen
- 7 Where the uncertainty of Moisture is taken as the standard error of the time averaged value used to correct to Dry Conditions
- 8 Where no uncertainty is presented above, the uncertainty is >100%

Environmental Compliance Limited

Morgan Composite & Defence Systems - NP
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Installation Name : Site 3
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TVOC - Uncertainty of Measurement Linex Booth (A2)

Uncertainty Calculations Part 1

Performance Characteristics	Standard Uncertainty (% of Range)	Distribution	Divisor	Min Certified Range	
				TVOC	mgC/m ³
Lack of fit ⁽¹⁾	u_{lof}	Rectangular	$\sqrt{3}$	0 - 15	0.40
Span drift ⁽²⁾	$u_{d,s}$			0.35	
Losses / leakage in the sample system ⁽⁴⁾	u_{loss}			1.96	
Temperature dependant span drift ⁽⁵⁾	u_t			0.30	
Interferents ⁽¹⁾	u_i			4.39	
Effect of Voltage Fluctuation ⁽⁷⁾	u_v			1.80	
Effect of Oxygen Synergism ⁽⁷⁾	u_{syn}				

Notes:

For rectangular distributions, $u(x_i) = \frac{u \times R_i}{\sqrt{3}}$

For $u(x_i) = \Delta x_i \sqrt{\frac{(x_{i,max} - x_{i,adj})^2 + (x_{i,min} - x_{i,adj})^2 + (x_{i,max} - x_{i,adj})(x_{i,min} - x_{i,adj})}{3}}$, when $|x_{i,max} - x_{i,adj}| = |x_{i,min} - x_{i,adj}|$, then $u(x_i) = \frac{\Delta x_i}{\sqrt{3}}$

Where $u(x_i) = \frac{\sigma}{\sqrt{n}}$ (See note 6 below), $\sigma = \sqrt{\frac{\sum_{i=1}^n (x_i - \bar{x})^2}{n-1}}$

Performance Characteristics	Uncertainty (Units of final measurement)	Distribution	Divisor	TVOC
				0 - 15 mgC/m ³
Lack of fit	u_{lof}	Rectangular	$\sqrt{3}$	0.035
Span drift	$u_{d,s}$			0.031
Temperature dependant span drift	u_t			0.16
Interferents	u_i			0.38
Effect of Voltage Fluctuation (See Note)	u_v			0.16

Uncertainty Calculations Part 2

Performance Characteristics	Uncertainty (Units of final measurement)	Date & Time	TVOC
			0 - 15 mgC/m ³
Losses / leakage in the sample system	u_{loss}	18/07/13 11:00 - 12:00	0.13
Standard Error of Measured Value	u_{SE}	18/07/13 11:00 - 12:00	0.085

Effect on Uncertainty Caused by Oxygen

$$u_{Corr_{O_2}} = \frac{20\% - O_{2,ref}}{(20\% - O_{2,measured}) \times (20\% - O_{2,measured})} \times \text{Uncertainty of } O_2 \text{ Meas} =$$

$$f_{O_2} = \frac{20.9\% - O_{2,ref}}{20.9\% - O_{2,measured}} = 1.0000$$

$$u_{f_{O_2}} = \frac{u_{Corr_{O_2}} \times n_{O_2}}{f_{O_2}} \times 100 = 0.00 \%$$

The effect of oxygen on the overall uncertainties (below) is incorporated using the following equation:-

$$u_{combined} = \sqrt{\sum (u_{f_{O_2}})^2 + (\text{Uncertainty of Measurement of Determinand})^2}$$

Where oxygen or moisture correction is required, uncertainty based on the standard error of the measured peripheral value is converted to units of final measurement using a sensitivity coefficient C,

$$\therefore u(x_i) = C_i u_i \text{ where } C_i = \frac{\partial f}{\partial x_i}$$

Uncertainty Calculations Part 3

Uncertainty	Date & Time	*TVOC
		0 - 15 mgC/m ³
Measured Concentration	18/07/13 11:00 - 12:00	6.77
Expanded Uncertainty as Percentage of Measured Concentration		13 %

Combined Standard Uncertainty $u_c = \sqrt{u_{lof}^2 + u_{d,s}^2 + u_t^2 + u_{loss}^2 + u_i^2 + u_v^2 + u_{syn}^2}$

Expanded uncertainty (at 95% confidence) $U_{Exp} = 2 \times u_c$

- Expressed as a percentage of the analyser range
- Expressed as maximum drift per 24hr period
- Expressed in units of final measurement
- Expressed as a percentage of the final measured value
- Per one degree centigrade
- Where the uncertainty of Oxygen is taken as the standard error of the time averaged value used to correct to Reference Oxygen
- Where the uncertainty of Moisture is taken as the standard error of the time averaged value used to correct to Dry Conditions
- Where no uncertainty is presented above, the uncertainty is >100%

Environmental Compliance Limited

Morgan Composite & Defence Systems - NP
 Permit No : 189
 Variation No : n/a
 Report Ref : P1830 : R001

Installation Name : Site 3
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Total Particulates – Uncertainty

Linex Booth (A2)

Site: Morgan Composite & Defence Systems NP, Coventry
 Location: Site 3, Stack ID: Linex Booth (A2)

$$u_{mass} = \sqrt{\sum(u_{filter})^2 + (u_{solution})^2}$$

Determinand	Filter mg	Solution mg	Recovered Mass mg	LAB Method Filter mg	Solution mg	Standard Filter mg	Solution mg	Combined Uncertainty mg
TPM - 1								
Particulates	0.46	0.30	0.76	0.14	0.27	0.0700	0.14	0.15

TPM - 1			Standard Uncertainty @ 95%		
Sampled Volume (V _m)	0.55	m ³	uV _m	0.001	m ³
Meter Correction Factor (Y _d)	1.02	...	...	...	...
Meter Temperature (T _m)	301.45	k	uT _m	1.5	k
Static Pressure of Stack P _{static}	5.00	mmH ₂ O	uP _{static}	0.25	mmH ₂ O
Absolute Stack Pressure P _s	760.56	mmHg	uP _s	3.8	mmHg
Barometric Pressure P _b	760.75	mmHg	uP _b	3.8	mmHg
Average Differential Pressure (ΔP) + ps	101.86	mmH ₂ O	uΔH	0.25	mmH ₂ O
Oxygen content (O _{2,m})	20.90	% by volume	uO _{2,m} = σ/√n	0.00	% by volume
Moisture Content (H ₂ O)	0.0977	% by volume	uH ₂ O	0.30	% by volume

Note: In the following calculations, the sensitivity coefficient (C) is estimated using: $C_i = \frac{\partial f}{\partial x_i}$

For each factor, uncertainty is then calculated by C_iu_i where C is the sensitivity coefficient, u is the standard uncertainty and i is the index identifying the contributing factor e.g. i=uV_m, uT_m etc.

Where results are required at wet conditions, the following correction factor is used to convert the data from the dry gas meter:

$$f_{s,wet} = \frac{100}{(100 - H_2O)} = 1.00$$

Uncertainty in correction factor to STP due to measured barometric pressure uncertainty component (uP _b), measured static pressure uncertainty component (uP _{static}) & measured temperature of dry gas uncertainty component (uT _m)					Uncertainty in volume @ STP due to volume correction factor uncertainty component (uV _{std}) & volume uncertainty component (uV _m)				
$f_s = \frac{273}{760} \times \frac{P_b + \Delta H}{T_m} \times Y_d = 0.935$					$V_{std} = V_{measured} \times f_s = 0.5123$				
	Maximum	Minimum	Sensitivity	u _{stps}		Maximum	Minimum	Sensitivity	Standard Uncertainty (m ³)
uΔH	0.49	0.49	0.0000470	0.0000117	Effect of uV _{std}	0.51	0.51	0.55	0.00155
uP _b	0.49	0.49	0.000639	0.00239	Effect of uV _m	0.51	0.51	0.93	0.000935
uT _m	0.49	0.49	0.000854	0.00128					
H ₂ O	0.49	0.49	0.00491	0.00147					
$\frac{u_f}{f_s} = \sqrt{\left(\frac{u(\Delta H)}{P_b + \Delta H}\right)^2 + \left(\frac{uP_{static}}{P_b + \Delta H}\right)^2 + \left(\frac{uT_m}{T_m}\right)^2 + \left(\frac{uH_2O}{100 - H_2O}\right)^2} = 0.00283$					$\frac{uV_{std}}{V_{std}} = \sqrt{\left(\frac{uV_{std}}{f_s}\right)^2 + \left(\frac{uV_m}{V_m}\right)^2} = 0.00122$				

Uncertainty of correction factor to reference oxygen due to measured oxygen uncertainty component (u _{f_{O₂}}) & Uncertainty in final measurement @ reference conditions due to uncertainty component arising from leak and/or loss (assumed 2% max) in the sample system (u _L)					Uncertainty in final measurement @ reference conditions due to mass uncertainty component (u _M), oxygen correction uncertainty component (u _{O₂}) and STP volume uncertainty component (u _{V_{stps}})																			
$f_{O_2} = \frac{20.9\% - O_{2,ref}}{20.9\% - O_{2,measured}} = 1.00$					$Conc = \frac{M_{Recovered}}{V_m \times f_s \times f_{O_2}} = 1.48$																			
$u_{Corr_{O_2}} = \frac{20.9\% - O_{2,ref}}{(20.9\% - O_{2,measured}) \times (20.9\% - O_{2,measured})} \times \text{Uncertainty of } O_2 \text{ Measurement} = 1.00$					<table border="1"> <thead> <tr> <th></th> <th>Maximum mg/Nm³</th> <th>Minimum mg/Nm³</th> <th>Sensitivity</th> <th>u mg/Nm³</th> </tr> </thead> <tbody> <tr> <td>u_M</td> <td>1.78</td> <td>1.19</td> <td>1.95</td> <td>0.30</td> </tr> <tr> <td>u_{V_{stps}}</td> <td>1.49</td> <td>1.48</td> <td>2.90</td> <td>0.00353</td> </tr> </tbody> </table>						Maximum mg/Nm ³	Minimum mg/Nm ³	Sensitivity	u mg/Nm ³	u _M	1.78	1.19	1.95	0.30	u _{V_{stps}}	1.49	1.48	2.90	0.00353
	Maximum mg/Nm ³	Minimum mg/Nm ³	Sensitivity	u mg/Nm ³																				
u _M	1.78	1.19	1.95	0.30																				
u _{V_{stps}}	1.49	1.48	2.90	0.00353																				
$u_{f_{O_2}} = \frac{u_{Corr_{O_2}} \times O_{2,ref}}{f_{O_2}} \times 100 = 0.00$																								

Measurement Uncertainty of Determinand (excluding correction for oxygen)

$$u_{combined} = \sqrt{\sum(u_M)^2 + (u_L)^2 + (uV_{stps})^2}$$

Combined Uncertainty mg/Nm ³	Expanded Uncertainty mg/Nm ³	Measured Concentration mg/Nm ³	Percent of Measured Concentration
0.30	0.59	1.48	40.0%

Measurement Uncertainty of Determinand (including correction for oxygen)

$$u_{combined} = \sqrt{\sum(u_{f_{O_2}})^2 + (\text{Uncertainty of Measurement of Determinand})^2}$$

Determinand	Measurement Uncertainty of Determinand	Measurement Uncertainty of Oxygen Corr ⁿ Factor	Overall Measurement Uncertainty inc O ₂ Corr ⁿ factor (U _{combined}) %
Particulates	40.0	0.0	40.0

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Total Particulates – Uncertainty Linex Booth (A2)

Site: Morgan Composite & Defence Systems NP, Coventry
 Location: Site 3, Stack ID: Linex Booth (A2)

$$u_{mass} = \sqrt{\sum(u_{filter})^2 + (u_{solution})^2}$$

Determinand	Filter mg	Solution mg	Recovered Mass mg	LAB Method Filter mg	Solution K=2 mg	Standard Uncertainty Filter mg	Solution mg	Combined Uncertainty mg
TPM - 2								
Particulates	0.0500	0.30	0.35	0.14	0.27	0.0700	0.14	0.15

TPM - 2		Standard Uncertainty @ 95%	
Sampled Volume (V _m)	0.56 m ³	uV _m	0.001 m ³
Meter Correction Factor (Y _d)	1.02	...	...
Meter Temperature (T _m)	303.15 k	uT _m	1.5 k
Static Pressure of Stack P _{static}	5.00 mmHg	uP _{static}	0.25 mmHg
Absolute Stack Pressure P _s	760.56 mmHg	uP _s	0.8 mmHg
Barometric Pressure P _b	760.75 mmHg	uP _b	3.8 mmHg
Average Differential Pressure (ΔP) + ps	101.86 mmHg	uΔH	0.25 mmHg
Oxygen content (O _{2,m})	20.90 % by volume	uO _{2,m} = σ/√n	0.00 % by volume
Moisture Content (H ₂ O)	0.0968 % by volume	uH ₂ O	0.30 % by volume

Note: In the following calculations, the sensitivity coefficient (C) is estimated using: $C_i = \frac{\partial f}{\partial x_i}$

For each factor, uncertainty is then calculated by C_i u_i where C_i is the sensitivity coefficient, u_i is the standard uncertainty and i is the index identifying the contributing factor e.g. i = uV_m, uT_m etc.

Where results are required at wet conditions, the following correction factor is used to convert the data from the dry gas meter:

$$f_{s,wet} = \frac{100}{(100 - H_2O)} = 1.00$$

Uncertainty in correction factor to STP due to measured barometric pressure uncertainty component (uP _b), measured static pressure uncertainty component (uP _{static}) & measured temperature of dry gas uncertainty component (uT _m)				Uncertainty in volume @ STP due to volume correction factor uncertainty component (uV _{std}) & volume uncertainty component (uV _m)				
$f_s = \frac{273}{760} \times \frac{P_b + \Delta H}{T_m} \times Y_d = 0.930$				$V_{std} = V_{measured} \times f_s = 0.5169$				
	Maximum	Minimum	Sensitivity	ufstp	Maximum	Minimum	Sensitivity	Standard Uncertainty (m ³)
uΔH	0.49	0.49	0.0000468	0.0000117	m ³	m ³	0.56	0.00156
uP _b	0.49	0.49	0.000637	0.00239	Effect of uV _{std}	0.52	0.52	0.93
uT _m	0.49	0.49	0.000849	0.00127	Effect of uV _m	0.52	0.52	0.93
H ₂ O	0.49	0.49	0.00490	0.00145				
$\frac{u_{f_s}}{f_s} = \sqrt{\left(\frac{u(\Delta H)}{P_b + \Delta H}\right)^2 + \left(\frac{uP_b}{P_b + \Delta H}\right)^2 + \left(\frac{uT_m}{T_m}\right)^2} = 0.00280$				$\frac{uV_{std}}{V_{std}} = \sqrt{\left(\frac{uV_{std}}{f_s}\right)^2 + \left(\frac{uV_m}{V_m}\right)^2} = 0.00122$				

Uncertainty of correction factor to reference oxygen due to measured oxygen uncertainty component (ufo ₂) & Uncertainty in final measurement @ reference conditions due to uncertainty component arising from leak and/or loss (assumed 2% max) in the sample system (uL)				Uncertainty in final measurement @ reference conditions due to mass uncertainty component (uM), oxygen correction uncertainty component (ufo ₂) and STP volume uncertainty component (uV _{stp})																		
$f_{o_2} = \frac{20.9\% - O_{2,ref}}{20.9\% - O_{2,measured}} = 1.00$				$Conc = \frac{M_{Recovered}}{V_m \times f_s \times f_{o_2}} = 0.68$																		
$u_{Corr_{o_2}} = \frac{20.9\% - O_{2,ref}}{(20.9\% - O_{2,measured}) \times (20.9\% - O_{2,measured})} \times \text{Uncertainty of } O_2 \text{ Measurement} = 1.00$				<table border="1"> <thead> <tr> <th></th> <th>Maximum mg/Nm³</th> <th>Minimum mg/Nm³</th> <th>Sensitivity</th> <th>u mg/Nm³</th> </tr> </thead> <tbody> <tr> <td>uM</td> <td>0.97</td> <td>0.38</td> <td>1.93</td> <td>0.29</td> </tr> <tr> <td>uV_{stp}</td> <td>0.68</td> <td>0.68</td> <td>1.31</td> <td>0.00160</td> </tr> </tbody> </table>					Maximum mg/Nm ³	Minimum mg/Nm ³	Sensitivity	u mg/Nm ³	uM	0.97	0.38	1.93	0.29	uV _{stp}	0.68	0.68	1.31	0.00160
	Maximum mg/Nm ³	Minimum mg/Nm ³	Sensitivity	u mg/Nm ³																		
uM	0.97	0.38	1.93	0.29																		
uV _{stp}	0.68	0.68	1.31	0.00160																		
$u_{f_{o_2}} = \frac{u_{Corr_{o_2}}}{f_{o_2}} \times 100 = 0.00$																						

Measurement Uncertainty of Determinand (excluding correction for oxygen)

$$u_{combined} = \sqrt{\sum(u_M)^2 + (u_L)^2 + (uV_{stp})^2}$$

Combined Uncertainty mg/Nm ³	Expanded Uncertainty mg/Nm ³	Measured Concentration mg/Nm ³	Percent of Measured Concentration
0.29	0.59	0.68	86.9%

Measurement Uncertainty of Determinand (including correction for oxygen)

$$u_{combined} = \sqrt{\sum(u_{f_{o_2}})^2 + (\text{Uncertainty of Measurement of Determinand})^2}$$

Determinand	Measurement Uncertainty of Determinand	Measurement Uncertainty of Oxygen Corr ⁿ Factor	Overall Measurement Uncertainty inc O ₂ Corr ⁿ factor (U _{combined}) %
Particulates	86.9	0.0	86.9