



NATIONAL PHYSICAL LABORATORY

Teddington Middlesex UK TW11 0LW Telephone +44 20 8977 3222

Test Report



This test report is issued in accordance with the laboratory accreditation requirements of the United Kingdom Accreditation Service. It provides traceability of measurement to recognised national standards, and to units of measurement realised at the National Physical Laboratory or other recognised national standards laboratories. This test report may not be reproduced other than in full, except with the prior written approval of the issuing laboratory.

EMISSIONS COMPLIANCE TESTING FOR PAXFORD COMPOSITES LTD

11TH MAY 2011

FOR: Paxford Composites Limited
2 - 4 Redwongs Way
Huntingdon
PE29 7HB

FAO: Mr Neil Search

Work By: Kevin Blakley & Matthew Ellison

Reference: PAXFORD_HUNTINGDON_03MAY11_PPC

Date of Issue: 18TH May 2011

MCERTS Level 2 Approval

Name: MR. K. BLAKLEY

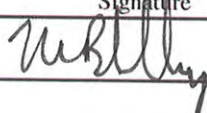
Signature:

Authorised Signatory:

Name: Mr R Robinson (For NPLML)

Signature:

NATIONAL PHYSICAL LABORATORY
Continuation Sheet

Part 1: Executive Summary		
Process Operator Paxford Composites Limited		PPC Permit Number B01/02
		Site Specific Protocol Reference PAX03MAY11/SSP
Address 2 - 4 Redwongs Way Huntingdon PE29 7HB		Contact Neil Search
		Telephone Number 01480 420808
		Email neil.search@paxfordcomposites.co.uk
Tests Carried Out on:	Spray Booths 1,2,3	Date Work Carried Out 11th May 2011
Testing Laboratory National Physical Laboratory		UKAS Accreditation Number 002
Address Hampton Road Teddington Middlesex United Kingdom TW11 0LW		Contact Kevin Blakley
		Telephone Number 0208 943 6118
		Email kevin.blakley@npl.co.uk
Species to be Monitored		Particulates Volatile Organic Compounds (VOCs)
Emission Limit Values (ELV)		Particulates - 50 mg/Nm³ VOCs - 50 mgC/Nm³
Compliance With Standards? See Section 1.5 Deviations		NO
Deviations from Standards? See Section 1.5 Deviations		NO
Corrective Actions Required? See Section 1.5 Deviations		NO
Test Team		Kevin Blakley & Matthew Ellison
Full Report Reference Number		PAXFORD/HUNTINGDON/03MAY11/PPC
Summary Report Submitted by	Signature	MCERTS ID Number
Matthew Ellison		MM-05-682
Summary Report Checked by	Signature	MCERTS ID Number
Kevin Blakley		MM-03-317

CONTENTS

	PAGE
PART ONE: EXECUTIVE SUMMARY	
1.1 Monitoring Objectives	4
1.2 Particulate Monitoring Results	5
1.3 Volatile Organic Compound (VOC) Monitoring Results	6
1.4 Plant & Equipment Information	7
1.5 Monitoring Deviations	7
1.6 Conclusions	7
1.7 References	7
PART TWO: SUPPORTING INFORMATION	
APPENDIX ONE	
2.1.1 Emission Testing Procedures	10
2.1.2 Emission Testing Personnel	10
2.1.3 Equipment Checklist Reference	10
2.1.4 Raw Data Reference	10
2.1.5 Calculations Used in Reporting Results	11
APPENDIX TWO - SPRAY BOOTH ONE	
2.2.1 Stack Diagram & Traverse Information	15
2.2.2 Particulate Summary Results	17
2.2.3 Particulate Field Data Sheet	18
2.2.4 Moisture Calculation	22
2.2.5 VOC One Minute Graphical Data	24
2.2.6 Gas Calibration Data	25
2.2.7 Uncertainty Calculations	27
APPENDIX THREE - SPRAY BOOTH TWO	
2.3.1 Stack Diagram & Traverse Information	31
2.3.2 Particulate Summary Results	33
2.3.3 Particulate Field Data Sheet	34
2.3.4 Moisture Calculation	38
2.3.5 VOC One Minute Graphical Data	40
2.3.6 Gas Calibration Data	41
2.3.7 Uncertainty Calculations	43
APPENDIX FOUR - SPRAY BOOTH THREE	
2.4.1 Stack Diagram & Traverse Information	47
2.4.2 Particulate Summary Results	49
2.4.3 Particulate Field Data Sheet	50
2.4.4 Moisture Calculation	54
2.4.5 VOC One Minute Graphical Data	56
2.4.6 Gas Calibration Data	57
2.4.7 Uncertainty Calculations	59

1.1 Monitoring Objectives

NPL were awarded a contract by Paxford Composites Limited to carry out compliance emissions monitoring at their plant located in Huntingdon, Cambridgeshire. Monitoring was carried out on Spray Booth 1 (SB1), Spray Booth 2 (SB2), and Spray Booth 3 (SB3).

The requirement of the contract was to carry out VOC and Particulate emissions monitoring on each spray booth as is set out in their permit (Ref B01/02).

Reference Conditions

VOCs are expressed as Carbon at 273K, 101.3 kPa on a wet gas basis.

Particulates are expressed at 273K, 101.3 kPa on a wet gas basis.

1.2 Particulates Monitoring Results

Client: Paxford Composites Ltd
 Site: Huntingdon
 Stack: SB1,2,3
 Reference Conditions: 273k, 101.3kPa, on a wet basis

Field	Units	Spray Booth One		Spray Booth Two		Spray Booth Three	
		Run One	Blank	Run One	Blank	Run One	Blank
Date	dd/mm/yyyy	11/05/2011	11/05/2011	11/05/2011	11/05/2011	11/05/2011	11/05/2011
Sample Period	From hh:mm	11:18	-	13:34	-	15:33	-
	To hh:mm	11:48	-	14:04	-	16:03	-
Run Duration	Minutes	30	-	30	-	30	-
Average Concentration	mg/Nm ³	7.8	<0.2	4.1	<0.2	3.9	<0.2
Uncertainty	±mg/Nm ³	0.4	-	0.3	-	0.3	-
Emission Limit Value	mg/Nm ³	50	-	50	-	50	-
Average Stack Velocity	m/s	6.2	-	9.3	-	7.60	-
Moisture	% Vol/Vol	0.8	-	0.3	-	0.3	-
Mass Emission	kg/hr, Reference Conditions	0.1	-	0.1	-	0.1	-
Process Status	Load	Normal	-	Normal	-	Normal	-
Monitoring Method		BS EN 13284-1:2002					
Accreditation		UKAS & MCERTS					

1.3 Volatile Organic Compound (VOC) Monitoring Results

Client: Paxford Composites Ltd
Site: Huntingdon
Stack: SB1,2,3
Reference Conditions: 273k, 101.3kPa, on a wet basis

Field	Units	Spray Booth One		Spray Booth Two		Spray Booth Three	
		Run One		Run One		Run One	
Date	dd/mm/yyyy	11/05/2011		11/05/2011		11/05/2011	
Sample Period	From hh:mm	11:30		13:30		15:30	
	To hh:mm	12:00		14:00		16:30	
Run Duration	Minutes	30		30		30	
Average Concentration	mgC/Nm ³	90.6		55.5		88.9	
Uncertainty	±mgC/Nm ³	2.0		1.2		1.9	
Emission Limit Value	mgC/Nm ³	50		50		50	
Percentage of ELV	%	181		111		178	
Moisture	% Vol/Vol	0.8		0.3		0.3	
Mass Emission	kg/hr, Reference Conditions	0.9		1.2		1.5	
Process Status	Load	Normal		Normal		Normal	
Monitoring Method		BS EN 13526:2002					
Accreditation		UKAS & MCERTS					

1.4 Plant & Equipment Operating Information

Paxford Composites Spray Booths 1 - 3

Each spray booth is about the size of a car garage and is a sealed room. Each booth operates as a batch process with two or three skilled workers operating inside on each run. Air is pumped in from outside the spray booths and can be heated if necessary to aid in the curing of the products inside. Each batch run lasts for approximately twenty minutes, however this varies depending on the shape and size of the components being painted, as well as the number of layers that are required. The paint filled air inside the booth goes through particulate filters situated in the roof, before being exhausted to atmosphere through a short vent in the ceiling of the main building.

Each spray booth exhaust vent has been fitted with two four inch BSP ports situated at ninety degrees to one another. These are accessed via ladder to the roof of each spray booth. A ten mm sample hole is also situated here to allow VOC monitoring.

There are no CEM systems installed on any of the three spray booths. No gas homogeneity tests have been carried out on any of the stacks.

1.5 Monitoring Deviations

The monitoring for VOCs was undertaken in accordance to BS EN 13526 with no deviations.

Due to the size of the exhaust duct from each spray booth it is necessary to sample particulates over two sampling lines in order to gain a representative sample. Whilst suitable ports had been installed, external obstructions prevented the use of both of these during sampling. Therefore only one port was accessed for each spray booth with double the sample points instead. This isn't deemed to have a significant effect on the results.

1.6 Conclusions

Concentrations of particulate and VOCs were successfully carried out on each of the three spray booths on the 11th May 2011.

1.7 References

1. Guidance on Assessing Measurement Uncertainty in Stack Emissions Monitoring, by Pullen J & Robinson R, Source Testing Association, Quality Guidance Note QGN1.
2. Environmental Agency - Manual Stack emission monitoring performance standard for Organisations – Version 7 - Januray 2011.
3. Environmental Agency – M2 Technical Guidance Note – Monitoring of stack emissions to air – Version 7 – August 2010.
4. STA – Risk Assessment Guide: Industrial-emission monitoring – Version 10 - April 2008.

NATIONAL PHYSICAL LABORATORY
Continuation Sheet

Part 2: Supporting Information		
Process Operator Paxford Composites Limited		PPC Permit Number B01/02 Site Specific Protocol Reference PAX03MAY11/SSP
Address 2 - 4 Redwongs Way Huntingdon PE29 7HB		Contact Neil Search Telephone Number 01480 420808 Email neil.search@paxfordcomposites.co.uk
Tests Carried Out on:	Spray Booths 1,2,3	Date Work Carried Out 11th May 2011
Testing Laboratory National Physical Laboratory		UKAS Accreditation Number 002
Address Hampton Road Teddington Middlesex United Kingdom TW11 0LW		Contact Kevin Blakley Telephone Number 0208 943 6118 Email kevin.blakley@npl.co.uk
Species to be Monitored		Particulates Volatile Organic Compounds (VOCs)
Emission Limit Values (ELV)		Particulates - 50 mg/Nm³ VOCs - 50 mg C/Nm³
Compliance With Standards? See Section 1.5 Deviations		NO
Deviations from Standards? See Section 1.5 Deviations		NO
Corrective Actions Required? See Section 1.5 Deviations		NO
Test Team		Kevin Blakley & Matthew Ellison
Full Report Reference Number	PAXFORD/HUNTINGDON/03MAY11/PPC	
Summary Report Submitted by	Signature	MCERTS ID Number
Matthew Ellison		MM-05-682
Summary Report Checked by	Signature	MCERTS ID Number
Kevin Blakley		MM-03-317

APPENDIX ONE

2.1.1 Emissions Testing Procedures

Date of Tests	11th May 2011
Main Pollutants Measured	1. Particulates 2. Volatile Organic Compounds
Additional Species Measured	3. Water Vapour 4. Flue Gas Velocity 5. Temperature 6. Pressure
Test Methods	1,3,4,5,6. Sampling conducted isokinetically according to BS EN 13284-1:2002. Equipment APEX Method 5 serial AS0240. 2. Sampling conducted according to BS EN 13526:2002. Analysis performed using a SICK Bernath FID AS0452.
Procedure	1,3,4,5,6 - Procedure No QPAS B 536 - STACK GAS SAMPLING FOR PARTICULATE MATTER USING A US EPA METHOD 5 TYPE SAMPLING TRAIN ACCORDING TO BS EN 13284-1:2002 AND BS ISO 9096:2003. 2 - Procedure No QPAS B 538 - STACK GAS SAMPLING FOR CARBON MONOXIDE, CARBON DIOXIDE, OXYGEN, SULPHUR DIOXIDE, VOLATILE ORGANIC COMPOUNDS AND NITROGEN OXIDES USING EXTRACTIVE INSTRUMENTAL TECHNIQUES.
Guidance Documents	1-6: M1 & M2.
Analytical Laboratories	1: National Physical Laboratory UKAS Lab No 0002.

A SICK Bernath FID analyser was used to measure the concentration of VOCs in each spray booth. Prior to monitoring each spray booth the analyser was zeroed using Nitrogen and then calibrated using a 10.9 ppm bottle of Propane span gas, before a final zero check. This process was then repeated again at the end of the monitoring to ensure that no drifting of the analyser had occurred.

A Squirrel Data Logger was used to record the results. The logger was connected to the front of the SICK Bernath and took readings every two seconds. The average of these readings were then recorded every minute. This data was downloaded upon return to NPL and uploaded to the internal server.

Particulate sampling was carried out using a Method 5 sampling train, using an in-stack filter. This filter was weighed before and after the field trial to determine the weight of Particulates captured during testing. A rinse of all parts upstream of the filter was carried out and evaporated back in the laboratory. This result was added to the mass collected from the filter.

2.1.2 Emissions Testing Personnel Details

Name	Position	MCERTS Reg Number	MCERTS Level	Function
Kevin Blakley	SRS	MM-03-317	Level 2, TE1-4	Team Leader
Matthew Ellison	HRS	MM-05-682	Level 2, TE1-4	Team Leader

2.1.3 Equipment Checklist Reference

See P:\Stack Emissions Team\Paxford Composites\PX03MAY11\4. Equipment Checklist

2.1.4 Raw Data Reference

See P:\Stack Emissions Team\Paxford Composites\PX03MAY11\7. Calculation and Work sheets

2.1.5 Calculations Used in Reporting Results

Nozzle Selection

For isokinetic sampling, the pressure difference of the orifice meter must equal the pressure difference of the Pitot tube pressure multiplied by the K-factor. Where:

$$K = \text{Constant} \times C_p^2 \times D_n^4 \times DH_{@} \times \left(\frac{M_d}{M_s} \right) \left(\frac{1 - B_{wm}}{1 - B_{ws}} \right)^2 \left(\frac{T_m + 273}{T_s + 273} \right) \left(\frac{P_s}{P_m} \right)$$

$$DH = K \times Dp$$

Where:-

Constant: is a constant dependent on the units used to measure the nozzle (8.038×10^{-5} for mm)

D_n the nozzle diameter mm

$DH_{@}$ a constant dependent on the sampler control box orifice and gas meter

B_{ws} the percent water vapour in the emission as a fraction i.e. 12% = 0.12

B_{wm} the percentage water vapour in the air around the meter box often assumed to be zero

C_p Pitot tube coefficient dependent on the Pitot tube type

T_m the meter temperature in °C

T_s the stack temperature in °C

P_s the stack pressure

P_m the meter pressure

M_d dry gas molecular weight

M_s apparent stack gas molecular weight

DH pressure drop across the orifice (mm water)

DP differential Pitot pressure (mm water)

From this the correct nozzle size can be determined.

$$D_n = \sqrt{\left(\frac{\text{Constant} \cdot Q_m \cdot P_m}{(T_m + 273) C_p} \right) \left(\frac{1 - B_{wm}}{1 - B_{ws}} \right) \sqrt{\frac{(T_s + 273) M_s}{P_s \cdot (\Delta P)_{avg}}}}$$

Where the Constant = 0.6071 Metric

Q_m = Orifice flow rate normally 21.2 actual lmin^{-1}

$$= K_m \sqrt{\frac{(T_m + 273) \Delta H}{P_m M_m}}$$

Where K_m = Orifice meter coefficient

$$K_m = Q_m \sqrt{\frac{P_m M_m}{\Delta H (T_m + 273)}} = \text{Const} \sqrt{\frac{1}{\Delta H_{@}}}$$

Where Const = 183.7 metric

Moisture Determination Calculations

These calculations are based at 273K and 101.325kPa

To calculate moisture the following equation is used:

$$B_{ws} = \frac{0.001245 \times W_I \times 100}{(0.001245 \times W_I) + 0.359 V_m \left(\frac{P_b + \frac{\Delta H_{avg}}{13.6}}{(T_m + 273)} \right)}$$

Particulate Concentration C_s in stack Gases

At 273K and 101.325kPa and dry gas

$$C_s = \frac{W_t}{V_m} \times \frac{T_m + 273}{273} \times \frac{760}{\left(P_b + \frac{\Delta H_{avg}}{13.6} \right)} \times 1000 \quad \text{mg/Nm}^3$$

Oxygen Concentration Correction C_{oxy} to Particulate concentration

$$C_{oxy} = C \times \frac{(20.9 - \%O_2 \text{ref})}{(20.9 - \%O_2 \text{Meas})} \quad \text{mg/Nm}^3$$

Dry Molecular Weight of gases

$$M_D = 0.44(\%CO_2) + 0.32(\%O_2) + 0.28(\%CO + \%N)$$

Stack Molecular Weight of gases

$$M_s = 0.18(B_{ws}) + \frac{M_d}{100} (100 - B_{ws})$$

Stack Gas Velocity

$$(V_s)_{avg} = 34.96 \times C_p \times \sqrt{(\Delta P)_{avg}} \sqrt{\frac{T_s + 273}{P_s M_s}} \quad \text{m/s}$$

Mass Emission Rate M_R

$$M_R = \frac{C_m \times (V_s)_{avg} \times A \times 3600}{10^6} \quad \text{kg/hr}$$

IsoKinicity

$$I = \frac{2.12 \times 10^8 \times V_m \times Y \times \left(P_b + \left(\frac{\Delta H_{avg}}{13.6} \right) \right) \left(\frac{273 + T_s}{273 + T_m} \right)}{\Theta P_s \pi D_n^2 (V_s)_{avg} (100 - B_{ws})} \%$$

- W_t = the weight change of the impingers during sampling in g
- V_m = volume of dry gas sample in litres at temperature of the meter box
- B_{ws} = the percent water vapour in the emission
- Q = length of time sampling in minutes
- Y = Gas Meter Calibration correction factor
- V_s = Velocity of stack gas m/s
- C_M = measured concentration of particulate matter (mg/m³)
- T_m = average temperature at dry gas meter (°C)
- P_b = atmospheric pressure (mmHg)
- $\%O_{2ref}$ = % oxygen at standard temperature & pressure
- $\%O_{2Meas}$ = % oxygen measured on site
- C_p = Pitot tube coefficient
- DP = mean differential Pitot pressure drop (mm H₂O)
- DH = mean orifice pressure drop (mm H₂O)
- D_s = diameter of stack (m)
- D_n = Nozzle diameter (mm)
- T_s = stack temperature (°C)
- M_d = molecular weight of dry stack gas
- B_w = moisture fraction
- P_s = stack pressure (mmHg)
- A = duct c.s.a. (m²)
- M_s = molecular weight of wet stack gas
- M_d = molecular weight of dry stack gas
- W_t = total weight of particulate matter (g)

APPENDIX TWO - SPRAY BOOTH ONE

2.2.1 Spray Booth One Stack Diagram & Traverse Information

Test no	TRAVERSE		Site:	Paxford Composites	Stack Description:	SB1
Date	11-5-11		Time of Survey:			
Swirl Test Conducted	OK		SITE TEAM:	KCB/MRE		
Stack Pres (with +/- above barometric if unknown enter zero)	-7	mmH ₂ O	COMMENTS:	TRAVERSE		
Pitot Type and Tube ID	S-Type AS0440					
Conditions	Value	Units				
Stack pressure	770.29	mmHg				
Ref oxygen Value	21	%				
Moisture Content	0.8	%				
CO	0	ppm				
CO ₂	0	%				
N ₂	79.05	%				
O ₂	20.95	%				
dry molecular wt	28.84					
stack molecular wt	28.75					
area of stack	0.47	m ²				
Pbar	1027.4	mbar				
Pbar	771	mmHg				
pitot tube coef	0.83					
Reference Temp	273	K				
Reference Pressure	760	mmHg				
PITOT LEAK CHECK (Yes/No)	YES					
Flow Criteria Measurements			Fulfilled?			
Is the gas flow angle <15° to the duct axis?			Yes			
Is there any local negative flow?			No			
Is the flow rate high enough to be measured?			Yes			
Ratio of flows less than 3:1 (or 9:1 for pressure readings?)			Yes			

SAMPLING LINE: A							
Traverse Point	Distance into duct (m)	Δp mm H ₂ O	Δp Pa	Stack Temp T _s °C	Velocity @ stack gas T&P on wet gas basis m/s	Angle of Swirl °	$\sqrt{\Delta p}$
1	A1	3.25	31.86	16	5.98	<15	1.80
2	A2	3.25	31.86	16	5.98	<15	1.80
3	A3	3.25	31.86	16	5.98	<15	1.80
4	A4	3.50	34.31	16	6.20	<15	1.87
5	A5	3.50	34.31	16	6.20	<15	1.87
6	A6	3.50	34.31	16	6.20	<15	1.87
7	A7	4.25	41.66	16	6.84	<15	2.06
8	A8	4.00	39.21	16	6.63	<15	2.00
9	A9	4.25	41.66	16	6.84	<15	2.06
10	A10	4.00	39.21	16	6.63	<15	2.00
Average values		3.7	36.03	16.0	6.36	<15	1.92
Duct / Stack Flow Characteristics:							
Test No: SB1							
TRAVERSE							
				Average	Units		
Stack Velocity at stack gas T & P and a wet gas basis				6.36	ms ⁻¹		
Stack flow @ STP, O ₂ (ref) and on a dry gas basis				N/A	m ³ s ⁻¹		
Stack flow @ stack gas T & P and on a wet gas basis				2.99	m ³ s ⁻¹		
Stack flow @ stack gas T & P and on a dry gas basis				2.96	m ³ s ⁻¹		
Stack flow @ STP and on a wet gas basis				2.86	m ³ s ⁻¹		
Stack flow @ STP, O ₂ (ref) and on a wet gas basis				N/A	m ³ s ⁻¹		

2.2.2

SB1 Particulates Results Summary

Field	Units	Blank	TEST 1
Date	dd/mm/yyyy	11/05/2011	11/05/2011
Test No.		Blank	SB1 PM Test 1
Filter No.		11TF102	11TF101
Stack Description		SB1	SB1
Start Time	hh:mm	-	11:18
End Time	hh:mm	-	11:48
Total Time	min	-	30
Stack Temp.	C	-	16
Gas Meter Temp	C	-	18
Gas Meter Pressure	kPa	-	102.7
Filter	mg	-0.1	3.5
Washings	mg	0.1	2.8
TOTAL Mass Collected	mg	0.0	6.3
Test H2O	% Vol	-	0.8
Stack Temp	°C	-	15.5
Stack Pressure	kPa	-	102.7
Nozzle Diameter	mm	-	9.52
Duct Area	m ²	-	0.47
Isokinicity	%	-	105
Stack Velocity	Stack T & P, uncorrected, ms ⁻¹	-	6.23
Gas Vol. Sampled	Dry Gas Basis, Ambient T and P	-	0.78
Gas Vol. Sampled	Wet Gas Basis, Standard T and P	-	0.80
Particulate Concentration	Wet Gas Basis, Standard T and P, mg Nm ⁻³	<0.2	7.8
Expanded Uncertainty	+/-mg Nm ⁻³ , 95% Conf. k=2	-	0.5
Emission Limit Value (ELV)	Wet Gas Basis, Standard T and P, mg Nm ⁻³	50	50
Percentage of Emission Limit Value (ELV) for Test	Wet Gas Basis, Standard T and P, %	0	16
Mass Emission	Wet Gas Basis, Standard T and P, g s ⁻¹	-	0.02

2.2.3 - Particulate Field Data Sheet

Test no	SB1 PM Test 1		Site:	Paxford	Stack Description:	SB1
Date	11-5-11		Filter No:	11TF101	Absorber No(s):	T01,A-D
nozzle diameter	mm		Blank I.D.:	11TF102		
Stack Pres (with +/- above barometric if unknown enter zero)	-7		SITE TEAM:		KCB & MRE	
			COMMENTS:			
			Particulates Test 1 of 1			
end volume reading	510.882	m ³	end time	11:48	hh:mm	Control Box I.D. No:
start volume reading	510.102	m ³	start time	11:18	hh:mm	Stack Thermocouple I.D. No.
volume sampled	0.780000	m ³	total time	00:30	hh:mm	Probe and Pitot I.D. No.
Conditions	Value	Units	stop time	00:00	hh:mm	Barometer I.D. No.
Stack pressure	770.31	mmHg	Diagram of Sample Location: See Traverse			
Gas Meter Calibration Factor Y	1.0623					
Ref oxygen Value	21	%				
Moisture content	0.8	%				
CO	0	ppm				
CO ₂	0	%				
N ₂	79.05	%				
O ₂	20.95	%				
dry molecular wt	28.84					
stack molecular wt	28.75					
Orifice ΔH@ Factor	44.80	mmH ₂ O				
area of stack	0.47	m ²				
Pbar	1027.4	mbar	Pre Vac (in Hg):		15	Post Vac (in Hg):
Pbar	770.8	mmHg	Leak rate (m ³ /l) or (%):		<2%	Leak rate (m ³ /l) or (%):
pitot tube coeft	0.830		Leak rate (m ³ /l) or (%):		<2%	Leak rate (m ³ /l) or (%):
Reference Temp	273	K				
Reference Pressure	760	mmHg				

	Start Time at this Position or Setting hh:mm	volume reading at start m ³	Probe position	Time at each position / setting min	Δ p mm H ₂ O	Δ h mm H ₂ O	Stack Temp T _s °C	Probe Temp T _p °C	Oven Temp °C	Impinger Temp °C	Resin/Line °C	Meter in T _m (in) °C	Meter out T _m (out) °C	Vacuum in Hg
1:	11:18	510.1020	A1	5	3.25	65.0	18	N/A	N/A	16	N/A	15	15	0.5
2:	11:23	510.2240	A2	5	3.25	65.0	15	N/A	N/A	17	N/A	16	16	0.5
3:	11:28	510.3430	A3	5	3.50	72.0	15	N/A	N/A	19	N/A	17	17	0.5
4:	11:33	510.4840	B1	5	4.00	80.0	15	N/A	N/A	11	N/A	18	18	0.5
5:	11:38	510.6080	B2	5	3.75	75.0	15	N/A	N/A	13	N/A	19	19	0.5
6:	11:43	510.7420	B3	5	3.50	72.0	15	N/A	N/A	15	N/A	20	20	0.5
7:	11:48	510.8820	STOP											
8:														
9:														
10:														

Start Time at this Position or Setting hh: mm	Volume reading at start m ³	Probe position	Time at each position / setting min	Δ p mm H ₂ O	Δ h mm H ₂ O	Stack Temp T _s °C	Probe Temp T _p °C	Oven Temp °C	Impinger Temp °C	Resin/Line °C	Meter in T _m (in) °C	Meter out T _m (out) °C	Vacuum in Hg
44:													
45:													
46:													
47:													
48:													
Summary values					71.50	15.5	#DIV/0!	#DIV/0!	15.2	n/a		17.5	0.5

Duct / Stack Flow Characteristics:		SB1		SB1 PM Test 1		Units	
Test No							
Stack Velocity at stack gas T & P and a wet gas basis					6.23	m s ⁻¹	
Stack flow @ STP, O ₂ (ref) and on a dry gas basis					N/A	m ³ s ⁻¹	
Stack flow @ stack gas T & P and on a wet gas basis					2.90	m ³ s ⁻¹	
Stack flow @ stack gas T & P and on a dry gas basis					2.88	m ³ s ⁻¹	
Stack flow @ STP and on a wet gas basis					2.78	m ³ s ⁻¹	
Stack flow @ STP, O ₂ (ref) and on a wet gas basis					N/A	m ³ s ⁻¹	
Gas vol. samp. @ STP and on a dry gas basis					0.80	m ³	
Gas vol. samp. @ STP, O ₂ (ref), and on a dry gas basis					N/A	m ³	
Gas vol. samp. @ STP and on a wet gas basis					0.80	m ³	
Gas vol. samp. @ STP, O ₂ (ref) and on a wet gas basis					N/A	m ³	
Percentage isokinicity					105	%	

2.2.4 - Moisture Calculation

NATIONAL PHYSICAL LABORATORY
Continuation Sheet

National Physical Laboratory
Absorber Test Form

Test No	SB1 PM Test 1
Date	11-5-11
pbar (mbar)	1027
pbar (mmHg):	771
nozzle diameter (mm)	9.52
Temp of Meter (In)/(out) deg. C	18
ΔH_{ave} (mmH ₂ O)	71.5
Filter No (if app)	11TF101

Site	Paxford
Stack	SB1
Site Team:	KCB & MRE
Data Entered By:	Kevin Blakley

End Volume Reading	510.88	m ³
Start Volume reading	510.10	m ³
Volume Sampled	0.78	m ³

end time	11:48	hr:min
start time	11:18	hr:min
total time	00:30	hr:min

IMPINGER	1	2	3	4	5	6	7	Initials of Analyst
Absorber Solution (Type):	DI Water	DI Water	Empty	Silica Gel				MRE
Sample No:	T1/A	T1/B	T1/C	T1/D				MRE
Analysis Required:	Moisture	Moisture	Moisture	Moisture				MRE
Weight of jars plus absorber plus washings (g)								
Weight of Jars plus absorber after sampling (g)	727.300	848.070	657.420	949.980				MRE
Weight of Jars plus absorber (g)	734.570	847.300	657.690	938.360				MRE
Weight of Jars (g)								
Weight Gain (g)	-7.27	0.77	-0.27	11.62	0	0	0	

Total Weight Gain (1+2+3+4) (g)	4.85
---------------------------------	------

Gas Volume of water at 0°C (l)	6.04
Gas Meter volume at 0°C (l)	748.50

Moisture content of Gases (%)	0.8
-------------------------------	-----

NOTES:

at 0°C

Volume (l) of water in gas phase is $V_{wc} = 1.2444 \times \text{wt of water collected (g)}$

Volume of gas sampled by meter (l) dry $V_{mc} = 359.2 \times \text{gas meter reading (m}^3\text{)} \times (\text{Pbar} + \Delta H/13.6) / (\text{meter temp} + 273)$

moisture content (fraction) = $V_{wc}/(V_{wc}+V_{mc})$

an approximation is: 1 m³ of gas weighs approx 1.2 kg

moisture content approx =

wt of water collected (g) x 100

wt of water collected (g) + (m³ of gas on meter x 1200)

Reference: PAXFORD_HUNTINGDON_03MAY11_PPC

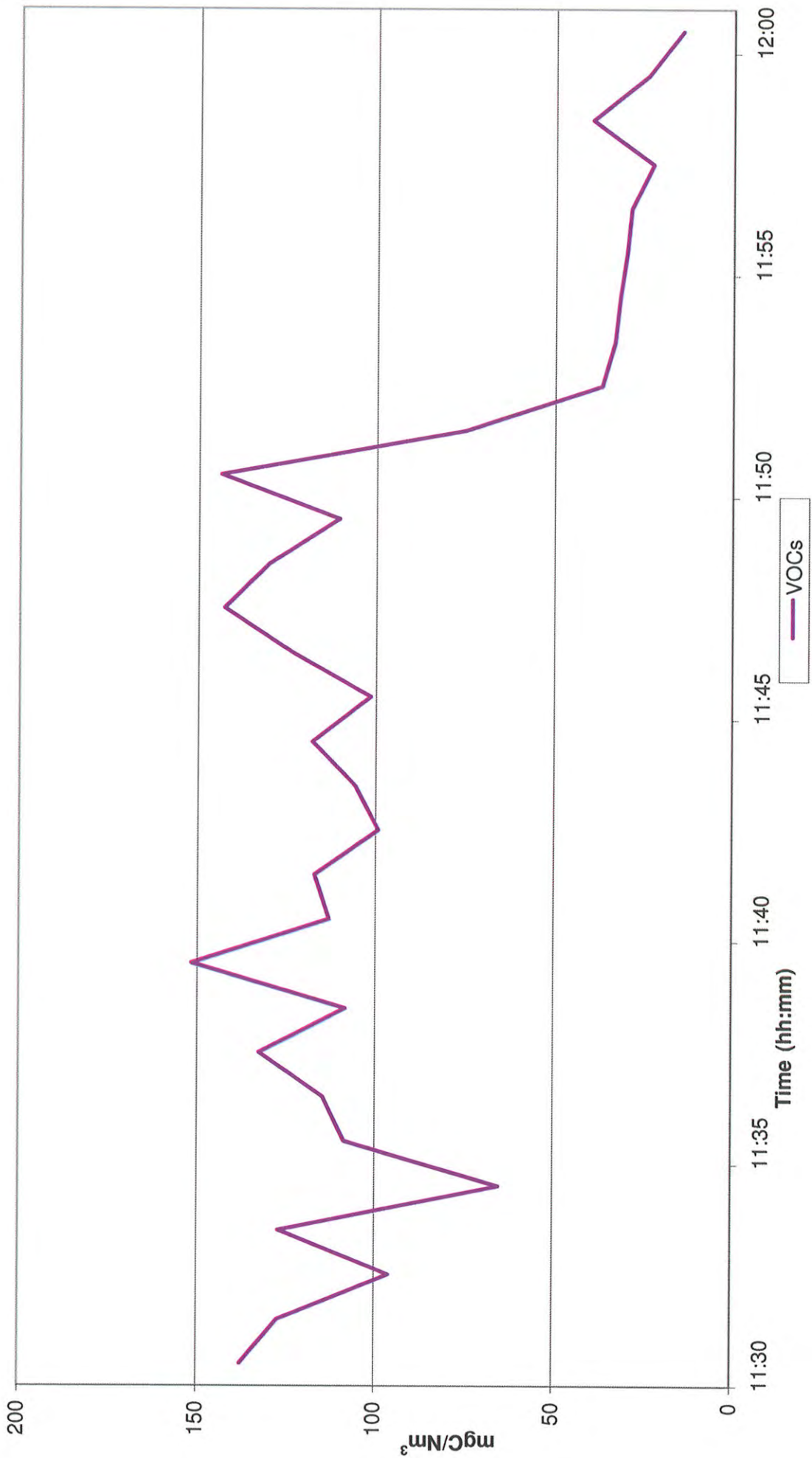
Permit: B01/02

Checked By: 

Version 1

Page 23 of 61

2.2.5 - Paxford Composites Minute Averaged VOC Emissions Data, Spray Booth One - 11th May 2011
(273.15K, 101.325kPa, on a Wet Gas basis) using the NPL Conventional Analysis Package



2.2.6 - Gas Calibration Record

NATIONAL PHYSICAL LABORATORY
Continuation Sheet

Calibration Log

Instrument SN:		Type		Job No:		Page No:	
						3 of 3	
Mobile Lab:		NPL		Client Site:			
				Other Equipment:			
Gas Cyl. No.		Gas Cyl Conc.		Date.		Instrument Range:	
Cal Type	Time (Start and Finish)	Initial Reading	Initial Gain/Setting (if app.)	Final Reading	Final Gain/Setting (if app.)	System(S) / Direct(D)	Signature
Check Zero							Zero Drift: ____ %
Zero Adj							Span Drift: ____ %
Check Span							Response Time : ____ sec
Span Adj							Span Value: ____ ppm
Check Zero							2 X Repeatability @ Zero =
Check Zero							
Check Span							
Zero Adj							
Span Adj							
Check Zero							
Instrument SN:		Type		Paxford Composites			
AS0452				Spray Booth One			
		VOC					
		NPL					
Gas Cyl. No. 163226		Gas Cyl Conc. 10.9ppm Propane		Date. 11/05/2011		Instrument Range: 0 - 1000 ppm	
Cal Type	Time (Start and Finish)	Initial Reading	Initial Gain/Setting (if app.)	Final Reading	Final Gain/Setting (if app.)	System(S) / Direct(D)	Signature
Check Zero	11:04	0.211	5.11			D	KCB
Zero Adj	11:05			0.001	4.82	D	KCB
Check Span	11:06	1.449	3.02			D	KCB
Span Adj	11:08			1.095	2.32	D	KCB
Check Zero	11:10	0.001	4.82			D	KCB
Check Zero	12:00	0.112	-			D	KCB
Check Span	12:02	1.175	-			D	KCB
Zero Adj							
Span Adj							
Check Zero	12:05	0.067	-			D	KCB

Distribute to Job File

IF REGULATOR PRESSURE IS LESS THAN 500 PSI (35 bar) CONTACT SUPPLIER IMMEDIATELY

MCERTS LEVEL2 with TE4
MCERTS ID: MM-05-682

Name: M.Ellison

NPL Ltd: 15 OCT 2009
Author: KCB

Revision 3
QPAS B 538

Reference: PAXFORD_HUNTINGDON_03MAY11_PPC

Permit: B01/02

Checked By: 

Version 1

Page 26 of 61

2.2.7 - Uncertainty Calculations

Uncertainty calculation for EN 13284 Determination of low range mass concentration of dust, Manual Gravimetric Method

v15

Measurement Equation

$$c = \frac{m}{V} f_c$$

Limit value (ELV)	50	mg.m ⁻³	Reference oxygen	21	% by volume
Measured concentration	7.81	mg.m ⁻³ (at reference conditions)			

Measured Quantities	Symbol	Value	Standard uncertainty	Units	Uncertainty as percentage	Uncertainty at lv	Requirement of std
Sampled Volume	V _m	0.5	0.001	m ³	0.20		<=2%
Sampled gas Temperature	T _m	299	2	K	0.67		<=1%
Sampled gas Pressure	p _m	101.3	1	kPa	0.99		<=1%
Sampled gas Humidity	H _m	0	1	% by volume	1.00		<=1%
Mass particulate	m	6.3	0.11	mg	1.76	0.27	<5% of limit value
Note - Sampled gas humidity, temperature and pressure are values at the gas meter							
Leak	L	2		%	2.00		<=2%
Uncollected Mass (Instack filter - no rinse)	UCM	0		mg	0		<=10%

Intermediate calculations	
Factor for std conds	f _s 0.91
uncertainty components	symbol sensitivity coeff u (in units of fs)
	p _m 0.009 0.009
	H _m 0.009 0.009
	T _m 0.003 0.006
	ufs 0.014 0.014
Corrected volume	V 0.46 0.007 m ³ V = V _m f _s
	1.56 1.57

$$f_s = \frac{(100 - H_m) 273}{100 T_m 101.3}$$

Parameter	Value	Units	Sensitivity coeff	Uncertainty contribution	Uncertainty as %
Corrected Volume (standard)	V	0.46 m ³	17.12	0.12 mg.m ⁻³	1.57 %
Mass	m	6.26 mg	1.25	0.14 mg.m ⁻³	1.76 %
Leak	L	0.09 mg.m ⁻³	1.00	0.09 mg.m ⁻³	1.15 %
Uncollected mass	UCM	0.00 mg	1.25	0.00 mg.m ⁻³	0.00 %
Combined measurement uncertainty				0.21 mg.m ⁻³	

Expanded uncertainty as percentage of measured value	5.35	% measured of value	expressed with a level of confidence of 95% (Using a coverage factor k=2)
Expanded uncertainty in units of measurement	0.42	mg.m ⁻³	
Expanded uncertainty as percentage of limit value	0.84	% ELV	

Note: Enter values into green boxes

Developed for the STA by R Robinson, NPL

Uncertainty calculation for Gaseous Measurement TOC to EN 12619:1999
V3.3
Nov-09

Limit value	50 (mg/m ³ (corrected))	TOC	Cal gas conc	17.49 (mg.m ⁻³ TOC
Measured concentration	90.6 (mg/m ³		Full Scale	1605 (mg/m ³
Measured concentration	90.6 (mg/m ³ (Corrected))			

Correction for reference conditions				
	O ₂ , %	Moisture, %	Pressure, kPa	Temperature, K
	ref	21.00	0.00	101.30
	measured	20.95	0.80	101.30
	Uncert	0.00	1.00	0.00
Factors		0.00	1.01	1.00
Uncertainty in factor		0.00	0.01	0.00
Correction Factor		0.001 ^{af}		0.01

Performance characteristics		Value		specification
Response time		15	seconds	
Longer sampling interval		60	seconds	60 000
Measurement period		30	minutes	
Number of readings in measurement		30		
Repeatability at zero		0.133	mg/m ³	0.133 mg/m ³
Repeatability at span level		0.15	mg/m ³	0.2 mg/m ³
Deviation from linearity(lack of fit)		0.4	mg/m ³	< 0.4 mg/m ³
Zero drift		0.16	mg/m ³	0.4 mg/m ³ (long term)
Span drift		0.13	mg/m ³	0.7 mg/m ³ (long term)
Volume or pressure flow dependence		0.02	% of full scale/3 kPa	
atmospheric pressure dependence		0.8	% of full scale/2 kPa	
ambient temperature dependence		0.01	mg/m ³	<3% / 2 kPa
O ₂ (% vol)	20	0.2	mg/m ³	0.5 mg/m ³ /10k (at span)
SO ₂ (mg/m ³)	260	0.2	mg/m ³	0.8 mg/m ³
NO (mg/m ³)	860	0.2	mg/m ³	
NO ₂ (mg/m ³)	150	0.2	mg/m ³	sum of all effects of these
CO (mg/m ³)	430	0.2	mg/m ³	interferents when taking all
CO ₂ (% vol)	18	0.2	mg/m ³	positive or all negative effects
HCl (mg/m ³)	40	0.2	mg/m ³	shall be less than 1 mg/m ³
H ₂ O (% vol)	20	0.2	mg/m ³	
dependence on voltage		0.1	% full scale/10V	
Control gas reducing difference		10	% of value	<2% range
leakage in the line (leak)		1	% of value	within 15% of test gas value (5 m
crepancy of calibration gas		1.25	% of value	< 0.1%vol /10 volt
				< 2% of value

Effect of drift
0.83 mg/m ³
0.05 % full scale

ranges		value at call	
min	max		
95.00	105	100 kPa	
100.76	100.92	100.88 kPa	
287	288.5	287.5 K	
6	16	20 % vol	
0	300	0 mg/m ³	
0	600	0 mg/m ³	
0	50	0 mg/m ³	
0	500	0 mg/m ³	
0	20	0 % vol	
0	5	0 mg/m ³	
0	20	0 % vol	
93	121	110 V	

Performance characteristic		Uncertainty	Value of uncertainty quantity		mg/m3
Standard deviation of repeatability at zero		U_0	for mean		0.02
Standard deviation of repeatability at span level		U_s	for mean		use sp at zero
Lack of fit		U_L			0.23
Drift					
volume or pressure flow dependence		U_{Vp}			0.48
atmospheric pressure dependence		$U_{p\text{atm}}$			0.31
ambient temperature dependence		$U_{T\text{amb}}$			0.39
O ₂					0.00
SO ₂ (mg/m ³)		U_{SO_2}			0.11
NO (mg/m ³)		U_{NO}			0.13
NO ₂ (mg/m ³)		U_{NO_2}			0.08
CO (mg/m ³)		U_{CO}			0.04
CO ₂ (% vol)		U_{CO_2}			0.13
HCl (mg/m ³)		U_{HCl}			0.13
H ₂ O (% vol)		$U_{\text{H}_2\text{O}}$			0.01
Dependence on voltage					0.12
losses in the line (leak)		U_{Leak}			1.38
Uncertainty of calibration gas		U_{Cal}			0.52
control gas		U_{Control}			0.67
Uncertainty in factor		U_f			92.66
					0.98

0.76 all-yes	Criteria sum < 1 mg/m3 1.811682581
0.00 all-yes	
0.76 largest	
Value to use for interreference uncertainty	
u_{ref}	0.76

Measurement uncertainty				
Combined uncertainty				
Expanded uncertainty	$k =$	2		92.69 mg/m^3 185.37 mg/m^3
Uncertainty corrected to aid conditions				
Expanded uncertainty		expressed with a level of confidence of 95%		1.96
Expanded uncertainty		expressed with a level of confidence of 95%		$3.91 \text{ } \mu\text{g ELV/m}^3$
Expanded uncertainty		expressed with a level of confidence of 95%		1.86 mg/m^3
Expanded uncertainty		expressed with a level of confidence of 95%		$2.16 \text{ } \mu\text{g value}$

APPENDIX THREE - SPRAY BOOTH TWO

2.3.1 Spray Booth Two Stack Diagram & Traverse Information

Test no	TRAVERSE		Site:	Paxford Composites	Stack Description:	SB2
Date	11-5-11		Time of Survey:	13:16		
Swirl Test Conducted	OK		SITE TEAM:	KCB/MRE		
Stack Pres (with +/- above barometric if unknown enter zero)	-7	mmH ₂ O	COMMENTS:	TRAVERSE		
Pitot Type and Tube ID	S-Type AS0440					
Conditions	Value	Units				
Stack pressure	770.29	mmHg				
Ref oxygen Value	21	%				
Moisture Content	0.3	%				
CO	0	ppm				
CO ₂	0	%				
N ₂	79.05	%				
O ₂	20.95	%				
dry molecular wt	28.84					
stack molecular wt	28.81					
area of stack	0.64	m ²				
Pbar	1027.4	mbar				
Pbar	771	mmHg				
Flow Criteria Measurements			Fulfilled?			
pitot tube coef	0.83		Is the gas flow angle <15° to the duct axis?			
Reference Temp	273	K	Is there any local negative flow?			
Reference Pressure	760	mmHg	Is the flow rate high enough to be measured?			
PITOT LEAK CHECK (Yes/No)	YES		Ratio of flows less than 3:1 (or 9:1 for pressure readings?)			
			Yes			

SAMPLING LINE: A							
Traverse Point	Distance into duct (m)	Δp mm H ₂ O	Δp Pa	Stack Temp T _s °C	Velocity @ stack gas T&P on wet gas basis m/s	Angle of Swirl °	$\sqrt{\Delta p}$
1	A1	10.25	100.48	17	10.62	<15	3.20
2	A2	10.50	102.93	17	10.75	<15	3.24
3	A3	10.00	98.03	17	10.49	<15	3.16
4	A4	8.75	85.78	17	9.82	<15	2.96
5	A5	8.50	83.33	17	9.67	<15	2.92
6	A6	8.00	78.42	17	9.39	<15	2.83
7	A7	8.00	78.42	17	9.39	<15	2.83
8	A8	7.25	71.07	17	8.93	<15	2.69
9	A9	8.00	78.42	17	9.39	<15	2.83
10	A10	6.25	61.27	17	8.30	<15	2.50
Average values		8.6	83.82	17.0	9.70	<15	2.92
Duct / Stack Flow Characteristics:							
Test No: SB2							
TRAVERSE							
		Average		Units			
Stack Velocity at stack gas T & P and a wet gas basis		9.70		ms ⁻¹			
Stack flow @ STP, O ₂ (ref) and on a dry gas basis		N/A		m ³ s ⁻¹			
Stack flow @ stack gas T & P and on a wet gas basis		6.21		m ³ s ⁻¹			
Stack flow @ stack gas T & P and on a dry gas basis		6.19		m ³ s ⁻¹			
Stack flow @ STP and on a wet gas basis		5.92		m ³ s ⁻¹			
Stack flow @ STP, O ₂ (ref) and on a wet gas basis		N/A		m ³ s ⁻¹			

2.3.2

SB2 Particulates Results Summary

Field	Units	Blank	TEST 1
Date	dd/mm/yyyy	11/05/2011	11/05/2011
Test No.		Blank	SB2 PM Test 1
Filter No.		11TF104	11TF103
Stack Description		SB2	SB2
Start Time	hh:mm	-	13:34
End Time	hh:mm	-	14:04
Total Time	min	-	30
Stack Temp.	C	-	18
Gas Meter Temp	C	-	20
Gas Meter Pressure	kPa	-	102.7
Filter	mg	0.0	3.8
Washings	mg	0.0	0.9
TOTAL Mass Collected	mg	0.0	4.7
Test H2O	% Vol	-	0.3
Stack Temp	°C	-	17.5
Stack Pressure	kPa	-	102.7
Nozzle Diameter	mm	-	9.52
Duct Area	m ²	-	0.64
Isokinicity	%	-	99
Stack Velocity	Stack T & P, uncorrected, ms ⁻¹	-	9.32
Gas Vol. Sampled	Dry Gas Basis, Ambient T and P	-	1.10
Gas Vol. Sampled	Wet Gas Basis, Standard T and P	-	1.12
Particulate Concentration	Wet Gas Basis, Standard T and P, mg Nm ⁻³	<0.2	4.1
Expanded Uncertainty	+/-mg Nm ⁻³ , 95% Conf. k=2	-	0.3
Emission Limit Value (ELV)	Wet Gas Basis, Standard T and P, mg Nm ⁻³	50	50
Percentage of Emission Limit Value (ELV) for Test	Wet Gas Basis, Standard T and P, %	0	8
Mass Emission	Wet Gas Basis, Standard T and P, g s ⁻¹	-	0.02