BUREAU VERITAS

MEASUREMENT OF PARTICULATE EMISSIONS FROM ARRESTMENT PLANT AT SARGINSONS PRECISION COMPONENTS, COVENTRY

Part 1 Executive Summary

Sampling on 22 May 2008

Sampling at Sarginsons Precision Components
Torrington Avenue
Coventry
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Report prepared for

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MM02084
Level 2, TE1, TE2, TE3, TE4

[redacted]

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MONITORING REPORT FORMS

Wet Arrestor Exhaust

WFL1	Flow	22 May 2008	
WFL2	Flow	22 May 2008	18
WH2O	Water vapour	22 May 2008	21
WTPM	Total particulate matter	22 May 2008	24
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Dry Arrestor Exhaust

DFL1	Flow	22 May 2008	30
DFL2	Flow	22 May 2008	33
DH2O	Water vapour	22 May 2008	36
DTPM	Total particulate matter	22 May 2008	38

SUMMARY

Sarginsons Precision Components placed a contract with Bureau Veritas to undertake an assessment of emissions to atmosphere of particulate species from arrestment plant located at their Coventry site. Measurements were made in the exhausts serving the wet and dry arrestors on the 22 May 2008.

The following results were obtained for the required determinands:

Monitoring Results

Summary of Measurements of Particulate Releases

Permitted Releases – Wet Arrestor

22 May 2008

Determinand	Reported as	Date	Time Start	Time End	Concentration		Emission Limit Value
Total particulate matter	TPM	22.5.08	1150	1257	4 ± 4	mg/m^3	50

Permitted Releases – Dry Arrestor

22 May 2008

Determinand	Reported as	Date	Time Start	Time End	Concentration		Emission Limit Value
Total particulate matter	TPM	22.5.08	1400	1504	6 ± 2	mg/m^3	-

All determinands reported above are expressed at plant reference conditions of 273 K temperature and 101.3 kPa pressure (Standard Temperature & Pressure (STP)) in a wet gas with no correction for oxygen content.

All measurements reported above are UKAS accredited to the MCERTs performance standard.

Monitoring Methods & Accreditation

Sampling Methodology and Accreditation

Sampling Methods

Determinand	Sampling method	Procedure No.
TPM	BS EN 13284-1 using EPA 5-type equipment	143
Velocity	BS EN 13284-1 using a Pitot static tube	143
O_2	BS EN 14789 (zirconium cell analyser)	IEM 2
H_2O	BS EN 14790	160

Summary of Analytical Methods

Determinand	Analytical method	Analysis house
TPM	Gravimetric determination	Bureau Veritas
H_2O	Gravimetric determination	Bureau Veritas

A description of the sampling and analytical methods employed in the execution of the measurements reported herein is presented above. All sampling and associated analytical activities were undertaken by Bureau Veritas.

Summary of UKAS and MCERTs Compliance

Determinand	Sampling		Analysis	
	UKAS Accreditation	MCERTs Compliant	UKAS Accreditation	MCERTs Compliant
TPM	1296	✓	1296	✓
Velocity	1296	✓	not applicable	
O_2	1296	✓	1296	✓
H_2O	1296	✓	1296	✓

Plant Operating Information

Exhaust Gas Measurements and Plant Operating Conditions

Wet Arrestor Exhaust

Date		22 May 2008	
Exhaust gas characterisation information			
Test		WFL1	WFL2
Time start		1004	1428
Time end		1018	1439
Velocity	m/s	12.1	12.2
Temperature	°C	22	22
Flow	m^3/s, ref cond.	3.30	3.32
Oxygen	%, v/v, dry	20.9	
Water vapour	% v/v	1.4	

Dry Arrestor Exhaust

Date		22 May 2008	
Exhaust gas characterisation information			
Test		DFL1	DFL2
Time start		1240	1528
Time end		1252	1539
Velocity	m/s	11.7	11.6
Temperature	°C	28	27
Flow	m^3/s, ref cond.	8.33	8.34
Oxygen	%, v/v, dry	20.9	
Water vapour	% v/v	1.3	

The plant served by the dry and wet arrestors were operating normally during the periods of sampling.

1. INTRODUCTION

Sarginsons Precision Components placed a contract with Bureau Veritas to undertake an assessment of emissions to atmosphere of particulate species from arrestment plant exhausts at their Coventry site. Measurements were made at the following release points:

- Wet Arrestor exhaust
- Dry Arrestor exhaust

Measurements were made on the 22 May 2008. This report describes the test work undertaken.

The on-site testing of ducted emissions of gaseous and particulate species by Bureau Veritas is covered by accreditation by the United Kingdom Accreditation Service (UKAS) under UKAS Testing Laboratory No. 1296. Section 3.3 and Table 4c specify the measurements that are within the scope of this accreditation.

The results of the measurements made are summarised in Tables 1a and 1b.

2. TEST PROGRAMME AND OBJECTIVES

The overall objective of this test programme was to provide measurements of releases to atmosphere of particulate species from two release points as part of Sarginson's obligations with regard to routine monitoring of releases to atmosphere.

Sarginsons Precision Components requested that the following determinands be measured:

1. Total particulate matter (TPM)

In addition, measurements of the following determinands were made to enable correction of measured concentrations of the above determinands to plant reference conditions:

2. Oxygen (O_2)
3. Water vapour (H_2O)

It was also requested that flow measurements (exhaust gas velocity and temperature) be undertaken during each sampling period as appropriate.

All of the above determinands were measured at the exhausts of the wet and dry arrestors.

Tables 2a and 2b summarise the test schedule.

Tables 3, 4a, 4b and 4c summarise the methods and resources employed in the execution of these measurements and their accreditation status with regard to UKAS and MCERTs.

3. METHODS OF MEASUREMENT

The methodology employed for the measurement of selected releases to atmosphere was agreed with Sarginsons Precision Components.

3.1 Measurements of Releases to Atmosphere

Sampling for total particulate matter was undertaken in accordance with the requirements of BS EN 13284-1[1] using United States Environmental Protection Agency (US EPA) Method 5-type sampling equipment. One determination was undertaken at each release point, each over a sampling period of around 60 minutes.

The waste gas concentration of oxygen was measured using a continuous zirconium cell oxygen analyser in accordance with BS EN 14789[2].

Measurements of the waste gas water vapour content were undertaken using a gravimetric technique in accordance with BS EN 14790[3]. One determination of water vapour was made at each release point. The result of the measurement was used to correct other, corresponding measurements, where appropriate, to plant reference conditions.

Measurements of the exhaust gas conditions (i.e. exhaust gas velocity and temperature) were undertaken at the beginning and end of testing at each point, and during testing, as appropriate. Measurement of the exhaust gas temperature was undertaken using a type K thermocouple and digital temperature indicator. Measurements of the exhaust gas velocity were made using an ellipsoidal ('L' type) Pitot static tube in conjunction with an inclined liquid manometer. Temperature and velocity traverses were undertaken as specified within BS EN 13284-1[1].

Tables 4a and 4b present a summary of the sampling and analysis methodology employed in the measurements described above.

3.2 Sampling Locations

At the sampling location associated with the wet arrestor exhaust, the sampling plane is of square cross section, of depth 0.55 m and sampling plane area 0.30 m^2. 2 off 4" BSP sockets (A & B) are available for sampling access.

BS EN 13284-1[1] requires that sampling be undertaken at a minimum of 4 points over a minimum of two sample lines for this geometry of sampling plane. Sampling for particulate matter was undertaken at two points on each of the two available lines in accordance with the requirements of the standard.

Sampling locations at the wet arrestor exhaust

Determinand	Sampling Socket	Sampling positions on line (fraction of depth, D)
TPM	A & B	0.25, 0.75
Oxygen	A	0.5
Water vapour	A & B	0.25, 0.75
Flow	A & B	0.05, 0.15, 0.25, 0.35, 0.45, 0.55, 0.65, 0.75, 0.85 & 0.95

At the dry arrestor exhaust, the sampling plane is of square cross section, of depth 0.90 m and sampling plane area 0.81 m^2. 2 off 4" BSP sockets (A & B) are available for sampling access.

BS EN 13284-1[1] requires that sampling be undertaken at a minimum of 4 points over a minimum of two sample lines for this geometry of sampling plane. Due to the presence of baffles just below the sampling socket there was little indication of flow along line B. As such all sampling was restricted to the sampling line accessible through socket A. Sampling for particulate matter was undertaken at eight points along line A. This does not comply with the requirements of the standard.

Sampling locations at the dry arrestor exhaust

Determinand	Sampling Socket	Sampling positions on line (fraction of depth, D)
TPM	A	0.063, 0.188, 0.313, 0.438, 0.563, 0.688, 0.813, 0.938
Oxygen	A	0.5
Water vapour	A	0.063, 0.188, 0.313, 0.438, 0.563, 0.688, 0.813, 0.938
Flow	A	0.05, 0.15, 0.25, 0.35, 0.45, 0.55, 0.65, 0.75, 0.85 & 0.95

3.3 Accreditation of Measurements

The accreditation status of the measurements made under the UKAS scheme is summarised in Table 4c. Table 4c also summarises the MCERTs compliance status of the methodology employed.

All sampling and associated analytical activities were undertaken by Bureau Veritas.

All measurements are UKAS accredited to the MCERTs performance standard.

4. RELEASES TO ATMOSPHERE

The results of the measurements made are summarised in Tables 1a and 1b and are reported in detail in the monitoring report forms (see Contents). In these tables measurements are reported at plant reference conditions of 273K temperature and 101.3 kPa pressure (Standard Temperature and Pressure (STP)) in a wet gas with no correction for oxygen content.

These tables also provide estimates of the discharge rate of each determinand and the measurement uncertainty expressed on a 95% confidence limit basis. It should be noted that discharge rates for all determinands are based on the volume flow rates measured at the beginning of testing.

Full details of all measurements made are presented in the monitoring report forms at the end of this report. Each determination has been given a unique reference number comprising up to three elements e.g. WFL1

Plant	Determinand	Determination No.
W	FL	1
Wet arrestor	Flow	Determination 1

WTPM and DTPM summarise the results of the measurements of total particulate matter at the wet arrestor and dry arrestor exhaust respectively. One determination was undertaken at each point. The result of each measurement is presented, together with the corresponding discharge rate.

WFL1 and 2 and DFL1 and 2 summarise the measurements of duct gas conditions (i.e. temperature, velocity and flow) made at the wet arrestor and dry arrestor exhausts respectively. Measurements were made at the beginning and end of testing and during testing as appropriate.

5. RESULTS AND DISCUSSION

In the following discussion the compliance of the measurements with the requirements of the relevant standards is discussed, along with any issues affecting the representativeness of the measurements made. All emissions of particulate species are presented as a concentration at the applicable plant reference conditions unless otherwise stated.

5.1 Emissions from the wet arrestor exhaust

The results of the measurements made at the wet arrestor exhaust are summarised in Table 1a.

The measurement for total particulate matter complied fully with the main procedural requirements of BS EN 13284-1[(1)].

5.2 Emissions from the dry arrestor exhaust

The results of the measurements made at the dry arrestor exhaust are summarised in Table 1b.

As discussed in Section 3.2, the sampling positions employed did not comply fully with BS EN 13284-1[(1)].

With the exception of the failure to comply meet the sampling position requirements of BS 13284-1[(1)], the measurement for total particulate matter complied with the main procedural requirements of the standard.

It is not considered that the noted non-compliances had a significant impact on the representativeness of the measurements made. In all cases uncertainties have been

adjusted, where appropriate, to take into account deviations from the requirements of the standard methods.

6. REFERENCES

1. BS EN 13284-1, 'Stationary source emissions – Determination of low range mass concentration of dust – Part 1: Manual gravimetric method', 2002.

2. BS EN 14789:2005 - 'Stationary source emissions - Determination of volume concentration of oxygen (O_2) – Reference method: Paramagnetism', 16 January 2006

3. BS EN 14790:2005 - 'Stationary source emissions - Determination of the water vapour in ducts', 16 January 2006

TABLE 1a

Summary of Measurements of Particulate Releases

Wet arrestor exhaust – 22 May 2008

Determinand	Reported as	Test No. (W)	Concentration		Release kg/h
Total particulate matter	TPM	TPM	4 ± 4	mg/m^3	0.04

Notes to Table 1a:

1. Waste gas concentrations are expressed at the standard reference conditions for this plant of STP in a wet gas with no correction for oxygen content. The measured average oxygen and water vapour contents on the 22 May 2008 were:

Date		22 May 2008
Oxygen	% by volume, dry	20.9
Water vapour	% by volume	1.4

These values have been employed to correct the measurements of required determinands to plant reference conditions.

2. Uncertainty is the likely range of the true value around the measured value and is determined in accordance with Internal Procedure 55 and the relevant uncertainty policies. These procedures follow the guidance in BS EN ISO 14956:2002 and ENV 13005 (GUM). For all determinands the uncertainty is expressed in the measurement units on a 95% confidence limit basis.

3. The reported concentration of oxygen is the arithmetic mean of all spot measurements made during the sampling period. The reported concentration of water vapour is the result of a single determination.

4. The measured exhaust gas conditions on each day of testing were:

Date		22 May 2008	
Test		WFL1	WFL2
Time start		1004	1428
Time end		1018	1439
Velocity	m/s	12.1	12.2
Temperature	°C	22	22
Flow	m^3/s, ref cond.	3.30	3.32

The above values have been used in the calculation of the discharge rates of measured determinands (see monitoring report forms).

TABLE 1b

Summary of Measurements of Particulate Releases

Dry arrestor exhaust – 22 May 2008

Determinand	Reported as	Test No. (D)	Concentration		Release kg/h
Total particulate matter	TPM	TPM	6 ± 2	mg/m^3	0.17

Notes to Table 1b:

1. Waste gas concentrations are expressed at the standard reference conditions for this plant of STP in a wet gas with no correction for oxygen content. The measured average oxygen and water vapour contents on the 22 May 2008 were:

Date		22 May 2008
Oxygen	% by volume, dry	20.9
Water vapour	% by volume	1.3

These values have been employed to correct the measurements of required determinands to plant reference conditions.

2. Uncertainty is the likely range of the true value around the measured value and is determined in accordance with Internal Procedure 55 and the relevant uncertainty policies. These procedures follow the guidance in BS EN ISO 14956:2002 and ENV 13005 (GUM). For all determinands the uncertainty is expressed in the measurement units on a 95% confidence limit basis.

3. The reported concentration of oxygen is the arithmetic mean of all spot measurements made during the sampling period. The reported concentration of water vapour is the result of a single determination.

4. The measured exhaust gas conditions on each day of testing were:

Date		22 May 2008	
Test		DFL1	DFL2
Time start		1240	1528
Time end		1252	1539
Velocity	m/s	11.7	11.6
Temperature	°C	28	27
Flow	m^3/s, ref cond.	8.33	8.34

The above values have been used in the calculation of the discharge rates of measured determinands (see monitoring report forms).

TABLE 2a

Test Programme – Wet arrestor exhaust

Determinand	Determination		Time		Duration
	No.	Code	Start	End	(min)
22 May 2008					
Total particulate matter	1	WTPM	1150	1257	60
Water vapour	1	WH2O	1150	1257	60
Oxygen	1	-	1150	1257	60
Flow	1	WFL1	1004	1018	14
Flow	2	WFL2	1428	1439	11

TABLE 2b

Test Programme – Dry arrestor exhaust

Determinand	Determination		Time		Duration
	No.	Code	Start	End	(min)
22 May 2008					
Total particulate matter	1	DTPM	1400	1504	64
Water vapour	1	DH2O	1400	1504	64
Oxygen	1	-	1400	1504	64
Flow	1	DFL1	1240	1252	12
Flow	2	DFL2	1528	1539	11

1. The sampling time is the period over which the measurements were undertaken. The sampling duration is the actual period during the sampling time, for which the ducted gases were sampled.

MEASUREMENT OF PARTICULATE EMISSIONS FROM ARRESTMENT PLANT AT SARGINSONS PRECISION COMPONENTS, COVENTRY

Part 2 Supporting Information

Sampling on 22 May 2008

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Report prepared for

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Report prepared by

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Unit D, Acacia Building
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GL17 0DD

TABLE 3

Summary of UKAS and MCERTs Compliance - Staff Competency

Function	Name	MCERTs						
		MM	Level	Technical Endorsements				
				1	2	3	4	5
Manager	N Ford	**02084**	2	✓	✓	✓	✓	
Team leader	M Davies	**02087**	2	✓	✓	✓	✓	
Team leader	J Ward	**02080**	2	✓	✓	✓	✓	
Technician	T Davies	**07900**	Trainee					

1. The qualifications, under the MCERTs scheme, of all staff involved in the execution of the work reported herein are presented above.

TABLE 4a

Summary of Sampling Methods

Determinand	Sampling method	Procedure No.
TPM	BS EN 13284-1 using EPA 5-type equipment	143
Velocity	BS EN 13284-1 using a Pitot static tube	143
O_2	BS EN 14789 (zirconium cell analyser)	IEM 2
H_2O	BS EN 14790	160

TABLE 4b

Summary of Analytical Methods

Determinand	Analytical method	Analysis house
TPM	Gravimetric determination	Bureau Veritas
H_2O	Gravimetric determination	Bureau Veritas

1. A description of the sampling and analytical methods employed in the execution of the measurements reported herein is presented above. All sampling and associated analytical activities were undertaken by Bureau Veritas.

TABLE 4c

Summary of UKAS and MCERTs Compliance - Sampling and Analytical Methods

Determinand	Sampling		Analysis	
	UKAS Accreditation	MCERTs Compliant	UKAS Accreditation	MCERTs Compliant
TPM	1296	✓	1296	✓
Velocity	1296	✓	not applicable	
O_2	1296	✓	1296	✓
H_2O	1296	✓	1296	✓

1. The above table provides details of the UKAS accreditation status and compliance with the requirements of MCERTs for the work reported herein.

2. Where an activity is UKAS accredited the accreditation number of the laboratory is provided. Where an activity is not accredited this is marked as 'not accredited'. Where a measurement has a sampling and an analytical component, UKAS accreditation only applies if both activities are accredited.

3. An activity is determined to comply with the requirements of MCERTs where the laboratories involved have UKAS accreditation to the MCERTs performance standard for the method employed.

BUREAU VERITAS MONITORING REPORT FORM
PITOT TRAVERSE (RECTANGULAR DUCT) - BS EN 13284:2002

Company	Sarginsons Precision Components	Date	22-May-08
Site	Coventry	Test Ref	WFL1/080507
Sample point	Wet Arrestor exhaust	Time Start	1004
Test carried out by	J Ward & T Davies	Time End	1018

DUCT CONDITIONS

Depth traversed by sampling probe (D)	m	0.55
Width of sampling plane	m	0.55
Cross sectional area of sampling plane (A)	m^2	0.3025

MOLECULAR WEIGHT & DENSITY DETERMINATION

Duct gas conditions

Ambient temperature	°C	18.00
Duct static gas pressure	kPa	0.03
Average duct gas temperature (Tduct)	°C	22.00
Barometric pressure	kPa	98.60

Calculation of molecular weight from assumed gas composition

Gas	Vol% Dry gas	Vol% Wet gas	Dry Mol Wt g/gmole	Wet Mol Wt g/gmole
CO_2	0.00	0.00	0.00	0.00
O_2	20.90	20.60	6.69	6.59
CO	0.00	0.00	0.00	0.00
N_2	79.10	77.96	22.15	21.83
H_2O	———	1.44	———	0.26
		Total	28.84	28.68

Calculation of dry and wet gas density from molecular weight results

Dry density	kg/m^3	1.29	At STP
Wet density	kg/m^3	1.28	(0°C & 101.3 kPa)
Dry density	kg/m^3	1.16	At Duct Conditions
Wet density (ρ_s)	kg/m^3	1.15	(see above)
Wet specific gravity (sg)		0.99	

PITOT TRAVERSE

Details of measurement equipment and supplementary measurements

Manometer calibration temperature	°C	20.7
Ambient temperature	°C	18
Scale factor		0.1
Pitot type ('L' or 'S' type)		L
Pitot calibration factor		0.99
Pitot reference No.		P863
Manometer reference No.		P216
Thermocouple reference No.		P1204
Timer reference No.		P1153
Barometric gauge reference No.		P222
Angle of gas flow less than 15°?		Yes
Temperature correction factor		0.00257

Measurements and calculation of duct gas velocity

Traverse Point	Port	Distance from inside wall of duct (fraction of D)	Scale Pitot Reading kPa	Differential Pressure (h) Pa	Temperature (T_s) °C	√h	Gas Velocity (V_s) m/s
1	A	0.05	0.67	65.84	22	8.11	10.63
2	A	0.15	0.84	82.54	22	9.09	11.90
3	A	0.25	0.33	32.43	22	5.69	7.46
4	A	0.35	0.18	17.69	22	4.21	5.51
5	A	0.45	0.21	20.63	22	4.54	5.95
6	A	0.55	0.26	25.55	22	5.05	6.62
7	A	0.65	0.33	32.43	22	5.69	7.46
8	A	0.75	0.57	56.01	22	7.48	9.80
9	A	0.85	0.87	85.49	22	9.25	12.11
10	A	0.95	1.46	143.46	22	11.98	15.69
11	B	0.05	1.27	124.79	22	11.17	14.63
12	B	0.15	1.51	148.37	22	12.18	15.96
13	B	0.25	1.44	141.50	22	11.90	15.58
14	B	0.35	1.52	149.36	22	12.22	16.01
15	B	0.45	1.38	135.60	22	11.64	15.26
16	B	0.55	1.29	126.76	22	11.26	14.75
17	B	0.65	1.11	109.07	22	10.44	13.68
18	B	0.75	1.40	137.57	22	11.73	15.37
19	B	0.85	1.15	113.00	22	10.63	13.93
20	B	0.95	1.08	106.12	22	10.30	13.50
			Averages		T_{Duct} 22.00	$\sqrt{h}_{Duct}$ 9.23	

CALCULATION OF VELOCITY & FLOW RATE

$V_{Duct} = K_{pt} \times (1-a) \times \sqrt{2/\rho_s} \times \sqrt{h}$ (Reference BS 1042:Section 2.1:1983 (ISO 3966), pages 8&9)

where
- V_{Duct} = gas velocity at sampling point (m/s)
- K_{pt} = pitot calibration factor (dimensionless)
- 1-a = compressibility correction (assumed constant at 0.995)
- ρ_s = wet gas density under duct conditions (kg/m^3)
- h = differential pressure (Pa)

Average gas velocity ($V_{Duct(a)}$) = 12.09 ± 1.23 m/s

Average volume flowrate (Q_{Duct}) = $V_{Duct(a)} \times A$

= 3.66 ± 0.39 m^3/s

Conversion of actual duct gas flow to reference conditions

Actual Duct Flow Conditions			Reference Conditions		
Average temperature (T_{Duct})	°C	22.00	Temperature (T_{Ref})	°C	0.00
Total pressure (P_{Duct})	kPa	98.63	Pressure (P_{Ref})	kPa	101.30
Oxygen (O_{2Duct})	% vol.dry	20.90	Oxygen (O_{2Ref})	% vol. dry	20.90
Water vapour (H_2O_{Duct})	% vol	1.44	Water vapour (H_2O_{Ref})	% vol	1.44

Calculation of gas flowrate at STP, Q_{STP}

$Q_{STP} = Q_{Duct} \times [(273 \times P_{Duct})/(101.3 \times (273 + T_{Duct}))]$

Q_{STP} = 3.30 ± 0.35 m^3/s

Calculation of gas flow at reference conditions, Q_{Ref}

Q_{Ref} = $Q_{Duct} \times$ $|273 + T_{Ref}|/|273 + T_{Duct}|$ Corrections: Temperature

P_{Duct}/P_{Ref} Pressure

$|100-H_2O_{Duct}|/|100-H_2O_{Ref}|$ Water vapour

$|20.9-O_{2Duct}|/|20.9-O_{2Ref}|$ Oxygen

QRef = 3.30 ± 0.35 m^3/s

Measurements from other tests

Determinand	Test Reference
Oxygen	Spot measurements
Water vapour	WH2O/080507

Uncertainty Calculation Parameters

Standard uncertainty for pressure measurement (U12)	5.0 %
Standard uncertainty for Pitot coefficient (U13)	1.0 %
Standard uncertainty for density estimate (U13)	1.0 %
Standard uncertainty for linear measurement (U14)	1.0 %

Uncertainty budget

Uncertainties		
Pressure measurement (m_p)	%	5.00
Pitot coefficicient (m_K)	%	1.00
Gas density estimate (m_ρ)	%	1.00
Total for velocity measurement (U_v)	%	5.20
Velocity at 95% confidence interval (U_{v95})	%	10.18
Linear measurement (m_l)	%	1.00
Total for flowrate measurement (U_f)	%	5.39
Flow rate at 95% confidence interval (U_{f95})	%	10.55

Based on Procedure 55 and Uncertainty Policies 13 & 14
(in accordance with requirements of BS EN ISO 14956:2002 and ENV 13005 (GUM))

$U_v = \sqrt{m_p^2 + m_K^2 + m_\rho^2}$

$U_{v95} = 1.96 \times U_v$

$U_f = \sqrt{U_v^2 + 2m_l^2}$

$U_{f95} = 1.96 \times U_f$

Prepared by: M Davies **Checked by:** N Ford

BUREAU VERITAS MONITORING REPORT FORM
PITOT TRAVERSE (RECTANGULAR DUCT) - BS EN 13284:2002

Company	Sarginsons Precision Components	Date	22-May-08
Site	Coventry	Test Ref	WFL2/080507
Sample point	Wet Arrestor exhaust	Time Start	1428
Test carried out by	J Ward & T Davies	Time End	1439

DUCT CONDITIONS

Depth traversed by sampling probe (D)	m	0.55
Width of sampling plane	m	0.55
Cross sectional area of sampling plane (A)	m^2	0.3025

MOLECULAR WEIGHT & DENSITY DETERMINATION

Duct gas conditions

Ambient temperature	°C	18.00
Duct static gas pressure	kPa	0.03
Average duct gas temperature (Tduct)	°C	22.00
Barometric pressure	kPa	98.60

Calculation of molecular weight from assumed gas composition

Gas	Vol% Dry gas	Vol% Wet gas	Dry Mol Wt g/gmole	Wet Mol Wt g/gmole
CO_2	0.00	0.00	0.00	0.00
O_2	20.90	20.60	6.69	6.59
CO	0.00	0.00	0.00	0.00
N_2	79.10	77.96	22.15	21.83
H_2O	———	1.44	———	0.26
		Total	28.84	28.68

Calculation of dry and wet gas density from molecular weight results

Dry density	kg/m^3	1.29	At STP
Wet density	kg/m^3	1.28	(0°C & 101.3 kPa)
Dry density	kg/m^3	1.16	At Duct Conditions
Wet density (ρ_w)	kg/m^3	1.15	(see above)
Wet specific gravity (sg)		0.99	

PITOT TRAVERSE

Details of measurement equipment and supplementary measurements

Manometer calibration temperature	°C	20.7
Ambient temperature	°C	18
Scale factor		0.1
Pitot type ('L' or 'S' type)		L
Pitot calibration factor		0.99
Pitot reference No.		P863
Manometer reference No.		P216
Thermocouple reference No.		P1204
Timer reference No.		P1153
Barometric gauge reference No.		P222
Angle of gas flow less than 15°?		Yes
Temperature correction factor		0.00257

Measurements and calculation of duct gas velocity

Traverse Point	Port	Distance from inside wall of duct (fraction of D)	Scale Pitot Reading kPa	Differential Pressure (h) Pa	Temperature (T_s) °C	√h	Gas Velocity (V_s) m/s
1	A	0.05	0.55	54.04	22	7.35	9.63
2	A	0.15	0.94	92.37	22	9.61	12.59
3	A	0.25	0.28	27.51	22	5.25	6.87
4	A	0.35	0.20	19.65	22	4.43	5.81
5	A	0.45	0.24	23.58	22	4.86	6.36
6	A	0.55	0.35	34.39	22	5.86	7.68
7	A	0.65	0.38	37.34	22	6.11	8.01
8	A	0.75	0.68	66.82	22	8.17	10.71
9	A	0.85	0.95	93.35	22	9.66	12.66
10	A	0.95	1.42	139.53	22	11.81	15.47
11	B	0.05	1.30	127.74	22	11.30	14.81
12	B	0.15	1.64	161.15	22	12.69	16.63
13	B	0.25	1.42	139.53	22	11.81	15.47
14	B	0.35	1.51	148.37	22	12.18	15.96
15	B	0.45	1.32	129.71	22	11.39	14.92
16	B	0.55	1.18	115.95	22	10.77	14.11
17	B	0.65	1.21	118.90	22	10.90	14.28
18	B	0.75	1.30	127.74	22	11.30	14.81
19	B	0.85	1.10	108.09	22	10.40	13.62
20	B	0.95	1.00	98.26	22	9.91	12.99
			Averages		T_{Duct} 22.00	$\sqrt{h}_{Duct}$ 9.29	

CALCULATION OF VELOCITY & FLOW RATE

$V_{Duct} = K_{pi} \times (1-\varepsilon) \times \sqrt{2/\rho_s} \times \sqrt{h}$ (Reference BS 1042:Section 2.1:1983 (ISO 3966), pages 8&9)

where
- V_{Duct} = gas velocity at sampling point (m/s)
- K_{pi} = pitot calibration factor (dimensionless)
- $1-\varepsilon$ = compressibility correction (assumed constant at 0.995)
- ρ_s = wet gas density under duct conditions (kg/m³)
- h = differential pressure (Pa)

Average gas velocity (V_{Ducts}) = **12.17 ± 1.24** m/s

Average volume flowrate (Q_{Duct}) = $V_{Ducts} \times A$

= **3.68 ± 0.39** m³/s

Conversion of actual duct gas flow to reference conditions

Actual Duct Flow Conditions			Reference Conditions		
Average temperature (T_{Duct})	°C	22.00	Temperature (T_{Ref})	°C	0.00
Total pressure (P_{Duct})	kPa	98.63	Pressure (P_{Ref})	kPa	101.30
Oxygen (O_{2Duct})	% vol,dry	20.90	Oxygen (O_{2Ref})	% vol, dry	20.90
Water vapour (H_2O_{Duct})	% vol	1.44	Water vapour (H_2O_{Ref})	% vol	1.44

Calculation of gas flowrate at STP, Q_{STP}

$Q_{STP} = Q_{Duct} \times [(273 \times P_{Duct})/(101.3 \times (273 + T_{Duct}))]$

Q_{STP} = **3.32 ± 0.35** m³/s

Calculation of gas flow at reference conditions, Q_{Ref}

$Q_{Ref} = Q_{Duct} \times$

	Corrections
$[273 + T_{Ref}]/[273 + T_{Duct}]$	Temperature
P_{Duct}/P_{Ref}	Pressure
$[100-H_2O_{Duct}]/[100-H_2O_{Ref}]$	Water vapour
$[20.9-O_{2Duct}]/[20.9-O_{2Ref}]$	Oxygen

QRef = **3.32 ± 0.35** m³/s

Measurements from other tests

Determinand	Test Reference
Oxygen	Spot measurements
Water vapour	WH2O/080507

Uncertainty Calculation Parameters

Standard uncertainty for pressure measurement (U12)	5.0 %
Standard uncertainty for Pitot coefficient (U13)	1.0 %
Standard uncertainty for density estimate (U13)	1.0 %
Standard uncertainty for linear measurement (U14)	1.0 %

Uncertainty budget

Uncertainties		
Pressure measurement (m_p)	%	5.00
Pitot coefficicient (m_K)	%	1.00
Gas density estimate (m_ρ)	%	1.00
Total for velocity measurement (U_v)	%	5.20
Velocity at 95% confidence interval (U_{v95})	%	10.18
Linear measurement (m_l)	%	1.00
Total for flowrate measurement (U_f)	%	5.39
Flow rate at 95% confidence interval (U_{f95})	%	10.55

Based on Procedure 55 and Uncertainty Policies 13 & 14
(in accordance with requirements of BS EN ISO 14956:2002 and ENV 13005 (GUM))

$U_v = \sqrt{m_p^2 + m_K^2 + m_\rho^2}$

$U_{v95} = 1.96 \times U_v$

$U_f = \sqrt{U_v^2 + 2m_l^2}$

$U_{f95} = 1.96 \times U_f$

Prepared by: M Davies Checked by: N Ford

BUREAU VERITAS MONITORING REPORT FORM
WATER VAPOUR DETERMINATION to BS EN 14790:2005

Company	Sarginsons Precision Components	Test Ref	WH2O/080507
Site	Coventry	Date	22-May-08
Sample point	Wet Arrestor exhaust	Time start	1150
Test carried out by	J Ward & T Davies	Time End	1257
		Duration, t (min)	60

Sampling Rate

Gas meter start reading (SV_{M1})	m3	1963.2840
Gas meter end reading (SV_{M2})	m3	1964.3970
Volume passed at meter conditions (SV_M=SV_{M2}-SV_{M1}))	m^3	1.1130
Sampling rate at meter conditions (SVM/t)	m^3/min	0.0185

Sampling Conditions

Time	Gas Meter		Probe/heated line
	Temperature T_M °C	Pressure P_M kPa	temperature °C
1155	34.5	98.6	160
1257	37.0	98.6	160
Average	35.8	98.6	160.0

Equipment

Gas meter	P372
Gas meter calibration factor	1.0155
Probe/heated line thermocouple	P1016
Barometer	P222
Timer	P735
Balance	P1238

Leak check

		Start	End
Time start		1151	1300
Time end		1153	1302
Start volume	m3	3.201	4.397
End volume	m3	3.201	4.397
Duration	mins	2	2
Leak rate	m^3/min	1E-04	0.0001
Leak rate <2% of sample rate?		Yes	Yes

Balance Check Weighings

Balance No.	P1238		
Check weight no.	P1245	P1245	P1245
Certified weight	50.0000	50.0000	50.0000
Reading (g)	50.0000	50.0000	50.0000
Allowable tolerance (g)	0.0500	0.0500	0.0500
Acceptable response	Yes	Yes	Yes

Test Ref. WH2O/C39587

Collection of Water from Gas

Collection Stage (ci)	Initial Mass(Mci$_i$) g	Final Mass (Mci$_f$) g	Mass gain (Mci) g
Container 1	811.420	810.560	0.000
Container 2	687.640	688.840	1.155
Container 3	624.030	625.430	1.400
Container 4	897.970	901.660	3.690
Container 5	933.020	938.170	5.150
Total (M)	3954.100	3964.660	11.420

Mass of water collected (M) = Σ(Mc1$_f$-Mc1$_i$),...,(Mc$_f$-Mc$_i$)

Calculation of dry gas sample volume at STP (SV_{STP})

SV_{STP} = SV_m x (273/(273 + T_{gi}) x (P_a/101.3)

Volume of dry gas sampled at STP (SV_{STP})	m^3	0.9727

Calculation of water vapour content (H_2O_{dwb})

H_2O_{dwb} = 100 x [M x MV_{STP} /MW_{H2O}]/[SV_{STP} + [M x MV_{STP} /MW_{H2O}]]

where
MV_{STP} molecular volume at STP (22.412 m^3/kgmole)
MW_{H2O} molecular weight of water (18 kg/kgmole)

Water vapour content (H_2O_{dwb})	%	1.44	±	0.09

Method performance

Water collection efficiency (e=100-(Mci.100/M))	%	64.9
Water content in final container	%	0.7
Correction for collection efficiency ($Corr_e$)	%	0.7

Compliance with BS 14790

Uncertainty less than 20% of measured value (Clause 7.3)
Temperature is greater than 4oC based on calculated water dew point (Clause 6.4.2) - outside standard
Leak rate is no more than 2% of sample flow rate
Sampling duration is within minimum of 30 minutes (Clause 6.1)
Sampling volume is within minimum of 6Cl (Clause 6.1)
Residual water content at outlet is below 1.25% (Clause 6.3)
Sampling temperature was within minimum of 120oC during sampling (Clause 6.2)

Uncertainty Budget (based on BS 14790 and Uncertainty Policy U25)

Volume of sampled gas	V	0.973 m^3
Average temperature of gas at meter	T	35.75 °C
Average barometric pressure at meter	P	938 mb
Sampling line leakage		0.0001 m^3/min
Duration of sampling	t	60 min
Total mass weighed	M	3964.66 g

Source of uncertainty		Value		Value of standard uncertainty		Relative standard uncertainty (%)	
Measurement of sample gas volume	$u.V_m$	2.0 %	u_v	$u_v V_m = \frac{V}{\sqrt{3}}$	0.0112 m^3	$u_v V_m$	1.15
Measurement of sample gas temperature	$u.T_m$	1.0 %	u_t	$u_t T_m = \frac{T+273}{\sqrt{3}}$	1.7826 K	$u_t T_m$	0.58
Measurement of absolute pressure	$u.P_m$	1.0 %	u_p	$u_p P_m = \frac{P}{\sqrt{3}}$	5.6927 mb	$u_p P_m$	0.58
Leakage in sampling line	u.L	0.5 %	u_l	$u_l L = \frac{L}{\sqrt{3}}$	0.0030 m^3	u.L	0.31
Measurement of weight - balance uncertainty	u.W_m	0.01 %	u_{wm}	$u_{wm} W_m = \frac{wm}{\sqrt{3}}$	0.2289 g		-
Measurement of weight - balance repeatability	u.W.	0.011 g	u_w	$u_w W_r$ = w_r	0.0110 g		-
Total measurement of weight	u.W	-	-	$u_t W$ = $u_t W_m + u_t W_r$	0.2309 g	$u_t W$	2.10

Total standard relative uncertainty	$u = \sqrt{u_v V_m^2 + u_t T_m^2 + u_p P_m^2 + u_l L^2 + u_t W^2 + Corr_e}$	3.21 %
Total relative uncertainty	$U = 1.96u$	6.28 %

Prepared by: M Davies Checked by: N Ford

BUREAU VERITAS MONITORING REPORT FORM
TOTAL PARTICULATE MATTER to BS EN 13284-1/BS ISO 9096

Company	Sarginsons Precision Components	Test Ref	WTPM/080507
Site	Coventry		
Sample point	Wet Arrestor exhaust		
Test carried out by	J Ward & T Davies		

SAMPLING TIMES

Determination		1
Date		22-May-08
Time Start		1150
Time End		1257
Duration	min	60

Duct conditions

Dimension traversed by sampling probe (D)	m	0.55
Cross sectional area of sampling plane (A)	m^2	0.30

Duct gas conditions

Determination		1
Ambient temperature (T_{Amb})	°C	18.0
Average duct gas temperature (T_{Duct})	°C	22.0
Duct static gas pressure (P_{Static})	kPa	0.03
Barometric pressure (P_{Baro})	kPa	98.60
Duct gas volume flowrate @ ref. conditions (Q_{Ref})	m^3/s	3.30
Gas compressibility correction (z)		0.995
Wet gas specific gravity (sg)		0.99
Exhaust gas conditions measurements		WFL1

Reference conditions

Determination		1
Actual Duct Flow Conditions		
Average temperature (T_{Duct})	°C	22.0
Total pressure (P_{Duct})	kPa	98.63
Oxygen (O_{2Duct})	% vol,dry	20.90
Water vapour (H_2O_{Duct})	% vol	1.44
Reference Conditions		
Temperature (T_{Ref})	°C	0
Pressure (P_{Ref})	kPa	101.3
Oxygen (O_{2Ref})	% vol, dry	20.9
Water vapour (H_2O_{Ref})	% vol	1.44

Sampling conditions

Determination		1
Nozzle diameter (d in mm or in)	in	0.252
Initial gas meter reading	m^3	1963.284
Final gas meter reading	m^3	1964.397
Sampled volume (SV_{Meter})	m^3	1.113

Calculation of sample gas volume at reference conditions, SV_{Ref}

$$SV_{Ref} = SV_{Meter} \times [273 + T_{Ref}]/[273 + T_{Meter}] \times P_{Baro}/P_{Ref} \times [100-H_2O_{Meter}]/[100-H_2O_{Ref}] \times [20.9-O_{2Duct}]/[20.9-O_{2Ref}]$$

Corrections: Temperature; Pressure; Water vapour; Oxygen

Determination		1
Sampled volume @ ref. conditions (SVR_{ref})	m^3	0.989

Prepared by: M Davies Checked by: N Ford

SAMPLING DATA 1

Distance from Duct Wall Fraction of D	Port	Time of Day h.mm	Orifice ΔH in w.g. Desired (ΔH_d)	Orifice ΔH in w.g. Actual (ΔH_a)	Pitot Reading (b) in w.g.	Temperatures Sample Gas (T_{temp}) °C	Temperatures Filter (T_{Filter}) °C	Meter (T_{Meter}) Inlet °C	Meter (T_{Meter}) Outlet °C	% isokinetic	Pitot Reading (b) " w.g.	Sampling Rate at meter l/min
0.250	A	1150	1.27	1.30	0.350	22	160	39.0	31.0	101.2	0.4	20.5
0.250	A	1155	1.20	1.20	0.330	22	160	39.0	30.0	100.0	0.3	19.9
0.250	A	1200	1.17	1.20	0.320	22	160	40.0	29.0	101.3	0.3	19.6
0.750	A	1205	1.27	1.30	0.350	22	160	41.0	28.0	101.2	0.4	20.5
0.750	A	1210	1.31	1.30	0.360	22	160	41.0	28.0	99.6	0.4	20.8
0.750	A	1215	1.35	1.40	0.370	22	160	41.0	27.0	101.8	0.4	21.0
0.250	B	1220	2.37	2.40	0.650	22	160	41.0	27.0	100.6	0.7	27.8
0.250	B	1225	2.44	2.40	0.670	22	160	43.0	27.0	99.2	0.7	28.4
0.250	B	1230	2.26	2.30	0.620	22	160	43.0	27.0	100.9	0.6	27.3
0.750	B	1235	1.89	1.90	0.520	22	160	45.0	29.0	100.3	0.5	25.1
0.750	B	1240	1.82	1.80	0.500	22	160	45.0	29.0	99.4	0.5	24.7
0.750	B	1245	1.86	1.90	0.510	22	160	45.0	29.0	101.1	0.5	24.9
	Averages				0.463	22.0	160.0	35.2		100.5	0.5	23.4

Equipment used

Item	File No.
Control box	P372
Meter coefficient	1.0155
Orifice units (in or mm w.g.)	in
Pitot differential units (in or mm w.g.)	in
Pitot	S
Probe liner thermocouple	P1016
Duct gas thermocouple	P988
Oven thermocouple	P710
Impinger bath thermocouple	P1212
Timer	P735
Field blank filter No.	011646
Sample filter No.	011655

Measurements from other tests

Determinand	Test Reference
Duct gas conditions	WFL1

Leak check

		Start	End
Start Time		1151	1300
End Time		1153	1302
Initial meter reading	m^3	3.2011	4.3971
Final meter reading	m^3	3.2013	4.3973
Duration of leak test	min	2	2
Pump vacuum	"Hg	15	15
Leak rate	l/min	0.1	0.1
Less than 2% of normal sampling rate?		Yes	Yes

PARTICULATE WEIGHINGS

Filters

Determination		Method Blank	Field Blank	1
Filter No.			011646	011655
Pre-sampling conditioning temperature (±5°C)	°C	180	180	180
Post-sampling conditioning temperature (±5°C)	°C	160	160	160
Diameter	mm	110	110	110
Material		Quartz	Quartz	Quartz
Pre-sampling weights				
after 1 min	g		0.7848	0.7829
after 2 min	g		0.7849	0.7828
after 3 min	g		0.7850	0.7827
Weight extrapolated to zero time (M_{f0})	g		0.7847	0.7830
Post-sampling weights				
after 1 min	g		0.7825	0.7816
after 2 min	g		0.7827	0.7817
after 3 min	g		0.7829	0.7818
Weight extrapolated to zero time (M_{f0})	g		0.7823	0.7815

Rinsings

Pre-sampling conditioning temperature (±5°C)	°C	180	180	180
Post-sampling conditioning temperature (±5°C)	°C	160	160	160
Pre-sampling weights (container only)				
after 1 min	g		68.6913	67.5583
after 2 min	g		68.6912	67.5582
after 3 min	g		68.6912	67.5582
Weight extrapolated to zero time (M_{r0})	g		68.6913	67.5583
Post-sampling weights (container and evaporated rinsings)				
after 1 min	g		68.6918	67.5633
after 2 min	g		68.6916	67.5632
after 3 min	g		68.6915	67.5631
Weight extrapolated to zero time (M_{r0})	g		68.6919	67.5634

Summary

Determination		Method Blank (M_{mb})	Field Blank	1
Mass collected on filter ($M_f = (M_{f0} - M_{f0} - M_{fmb})$)	g	0.0000	-0.0024	-0.0015
Mass collected in rinsings ($M_r = (M_{r0} - M_{r0} - M_{rmb})$)	g	0.0000	0.0006	0.0051
Total mass collected ($M = M_f + M_r$)	g	0.0000	-0.0018	0.0036

Uncertainty Calculation Parameters

Standard uncertainty for gas volume measurement (U6)	2.9 %
Standard uncertainty for filter weighing (U17)	0.57 mg
Standard uncertainty for washings weighing (U17)	0.50 mg
Limit of detection for filter weighing (U17)	0.50 mg
Limit of detecion for washings weighing (U17)	0.50 mg
Standard uncertainty for oxygen correction (U11)	0.95 %
Standard uncertainty for gas flow measurement (U14)	5.7 %

Emission Limit Value

Emission limit value (ELV) at reference conditions	50 mg/m^3

SUMMARY OF MEASUREMENTS

Calculation of Particulate Concentration and Discharge Rate

Particulate concentration (C), mg/m^3 = M x 1000/ SVRef

Discharge rate, kg/h = C x Qref x 0.0036

Determination		Field Blank	1
Particulate concentration at reference conditions	mg/m^3	-1.82	3.61
Uncertainty	mg/m^3	-1.82	3.61
Particulate concentration at duct conditions (raw)	mg/m^3	-1.64	3.25
Particulate discharge rate	kg/h	-0.02	0.04
Uncertainty	kg/h	-0.08	0.04

Note: Field blank results based on average sampling conditions

COMPLIANCE WITH BS EN 13248-1:2002/BS ISO 9096 CONDITIONS

Standard	EN 13284-1
Determination	1
Angle of gas flow less than 15°	Yes
No local negative gas flow	Yes
Minimum differential pressure greater than 5 Pa	Yes
Ratio of highest to lowest local gas velocites less than 3:1	Yes

Determination 1 BS EN 13284-1

Blank value is less than 10% of ELV (Clause 4f)
Nozzle dimeter greater than 6 mm (Clause 6.2.4)
Average sampling rate was within -5% and +15% of isokinetic conditions (Clause 8.4)
Leak rate is within 2% of sample rate (Clause 8.4)

Uncertainty budget

Uncertainties		Field Blank	1
Volume measurement (m_{vol})	mg	-0.05	0.10
Filter weighings (m_f)	mg	-2.40	-1.50
Rinsings weighings (m_w)	mg	-2.40	-1.50
Total for uncorrected measurement (U_u)	mg	3.39	2.12
Correction to reference conditions (m_{corr})	mg	0.00	0.00
Total for corrected measurement (U_c)	mg	3.39	2.12
Concentration at 95% confidence interval (U_{95c})	mg/m^3	-1.82	3.61

Based on Procedure 55 and Uncertainty Policies 11 & 17
(in accordance with requirements of BS EN ISO 14956:2002 and ENV 13005 (GUM))

$U_u = \sqrt{m_{vol}^2 + m_f^2 + m_w^2}$

$U_c = \sqrt{U_u^2 + m_{corr}^2}$

$U_{95c} = 1.96 \times U_c / SV_{ref}$

BUREAU VERITAS MONITORING REPORT FORM
PITOT TRAVERSE (RECTANGULAR DUCT) - BS EN 13284:2002

Company	Sarginsons Precision Components	Date	22-May-08
Site	Coventry	Test Ref	DFL1/080507
Sample point	Dry Arrestor exhaust	Time Start	1240
Test carried out by	J Ward & T Davies	Time End	1252

DUCT CONDITIONS

Depth traversed by sampling probe (D)	m	0.90
Width of sampling plane	m	0.90
Cross sectional area of sampling plane (A)	m^2	0.8100

MOLECULAR WEIGHT & DENSITY DETERMINATION

Duct gas conditions

Ambient temperature	°C	18.00
Duct static gas pressure	kPa	-0.04
Average duct gas temperature (Tduct)	°C	28.00
Barometric pressure	kPa	98.60

Calculation of molecular weight from assumed gas composition

Gas	Vol% Dry gas	Vol% Wet gas	Dry Mol Wt g/gmole	Wet Mol Wt g/gmole
CO_2	0.00	0.00	0.00	0.00
O_2	20.90	20.63	6.69	6.60
CO	0.00	0.00	0.00	0.00
N_2	79.10	78.10	22.15	21.87
H_2O	———	1.27	———	0.23
		Total	28.84	28.70

Calculation of dry and wet gas density from molecular weight results

Dry density	kg/m^3	1.29	At STP
Wet density	kg/m^3	1.28	(0°C & 101.3 kPa)
Dry density	kg/m^3	1.14	At Duct Conditions
Wet density (ρ_s)	kg/m^3	1.13	(see above)
Wet specific gravity (sg)		0.99	

PITOT TRAVERSE

Details of measurement equipment and supplementary measurements

Manometer calibration temperature	°C	20.7
Ambient temperature	°C	18
Scale factor		0.1
Pitot type ('L' or 'S' type)		L
Pitot calibration factor		0.99
Pitot reference No.		P863
Manometer reference No.		P216
Thermocouple reference No.		P1204
Timer reference No.		P1153
Barometric gauge reference No.		P222
Angle of gas flow less than 15°?		Yes
Temperature correction factor		0.00257

Measurements and calculation of duct gas velocity

Traverse Point	Port	Distance from inside wall of duct (fraction of D)	Scale Pitot Reading kPa	Differential Pressure (h) Pa	Temperature (T_s) °C	√h	Gas Velocity (V_s) m/s
1	A	0.05	0.96	94.33	28	9.71	12.85
2	A	0.15	0.94	92.37	28	9.61	12.72
3	A	0.25	0.87	85.49	28	9.25	12.24
4	A	0.35	0.87	85.49	28	9.25	12.24
5	A	0.45	0.80	78.61	28	8.87	11.73
6	A	0.55	0.84	82.54	28	9.09	12.02
7	A	0.65	0.67	65.84	28	8.11	10.74
8	A	0.75	0.74	72.71	28	8.53	11.28
9	A	0.85	0.73	71.73	28	8.47	11.21
10	A	0.95	0.53	52.08	28	7.22	9.55
					T_{Duct}	$\sqrt{h}_{Duct}$	
			Averages		28.00	8.81	

CALCULATION OF VELOCITY & FLOW RATE

$V_{Duct} = K_{pi} \times (1-a) \times \sqrt{2/\rho_s} \times \sqrt{h}$ (Reference BS 1042:Section 2.1:1983 (ISO 3966), pages 8&9)

where V_{Duct} = gas velocity at sampling point (m/s)
K_{pi} = pitot calibration factor (dimensionless)
$1-a$ = compressibility correction (assumed constant at 0.995)
ρ_s = wet gas density under duct conditions (kg/m^3)
h = differential pressure (Pa)

Average gas velocity (V_{Ducts}) = 11.66 ± 1.19 m/s

Average volume flowrate (Q_{Duct}) = $V_{Ducts} \times A$

= 9.44 ± 1.00 m^3/s

Conversion of actual duct gas flow to reference conditions

Actual Duct Flow Conditions			Reference Conditions		
Average temperature (T_{Duct})	°C	28.00	Temperature (T_{Ref})	°C	0.00
Total pressure (P_{Duct})	kPa	98.56	Pressure (P_{Ref})	kPa	101.30
Oxygen (O_{2Duct})	% vol.dry	20.90	Oxygen (O_{2Ref})	% vol. dry	20.90
Water vapour (H_2O_{Duct})	% vol	1.27	Water vapour (H_2O_{Ref})	% vol	1.27

Calculation of gas flowrate at STP, Q_{STP}

$Q_{STP} = Q_{Duct} \times [(273 \times P_{Duct})/(101.3 \times (273 + T_{Duct}))]$

Q_{STP} = 8.33 ± 0.88 m^3/s

Calculation of gas flow at reference conditions, Q_{Ref}

				Corrections
Q_{Ref}	=	$Q_{Duct} \times$	$[273 + T_{Ref}]/[273 + T_{Duct}]$	Temperature
			P_{Duct}/P_{Ref}	Pressure
			$[100-H_2O_{Duct}]/[100-H_2O_{Ref}]$	Water vapour
			$[20.9-O_{2Duct}]/[20.9-O_{2Ref}]$	Oxygen

QRef = 8.33 ± 0.88 m^3/s

Measurements from other tests

Determinand	Test Reference
Oxygen	Spot measurements
Water vapour	DH2O/080507

Uncertainty Calculation Parameters

Standard uncertainty for pressure measurement (U12)	5.0 %
Standard uncertainty for Pitot coefficient (U13)	1.0 %
Standard uncertainty for density estimate (U13)	1.0 %
Standard uncertainty for linear measurement (U14)	1.0 %

Uncertainty budget

Uncertainties		
Pressure measurement (m_p)	%	5.00
Pitot coefficicient (m_K)	%	1.00
Gas density estimate (m_ρ)	%	1.00
Total for velocity measurement (U_v)	%	5.20
Velocity at 95% confidence interval (U_{v95})	%	10.18
Linear measurement (m_l)	%	1.00
Total for flowrate measurement (U_f)	%	5.39
Flow rate at 95% confidence interval (U_{f95})	%	10.55

Based on Procedure 55 and Uncertainty Policies 13 & 14
(in accordance with requirements of BS EN ISO 14956:2002 and ENV 13005 (GUM))

$U_v = \sqrt{m_p^2 + m_K^2 + m_\rho^2}$
$U_{v95} = 1.96 \times U_v$
$U_f = \sqrt{U_v^2 + 2m_l^2}$
$U_{f95} = 1.96 \times U_f$

Prepared by: M Davies Checked by: N Ford

BUREAU VERITAS MONITORING REPORT FORM
PITOT TRAVERSE (RECTANGULAR DUCT) - BS EN 13284:2002

Company	Sarginsons Precision Components	Date	22-May-08
Site	Coventry	Test Ref	DFL2/080507
Sample point	Dry Arrestor exhaust	Time Start	1528
Test carried out by	J Ward & T Davies	Time End	1539

DUCT CONDITIONS

Depth traversed by sampling probe (D)	m	0.90
Width of sampling plane	m	0.90
Cross sectional area of sampling plane (A)	m^2	0.8100

MOLECULAR WEIGHT & DENSITY DETERMINATION

Duct gas conditions

Ambient temperature	°C	18.00
Duct static gas pressure	kPa	-0.04
Average duct gas temperature (Tduct)	°C	27.00
Barometric pressure	kPa	98.60

Calculation of molecular weight from assumed gas composition

Gas	Vol% Dry gas	Vol% Wet gas	Dry Mol Wt g/gmole	Wet Mol Wt g/gmole
CO_2	0.00	0.00	0.00	0.00
O_2	20.90	20.63	6.69	6.60
CO	0.00	0.00	0.00	0.00
N_2	79.10	78.10	22.15	21.87
H_2O	———	1.27	———	0.23
		Total	28.84	28.70

Calculation of dry and wet gas density from molecular weight results

Dry density	kg/m^3	1.29	At STP
Wet density	kg/m^3	1.28	(0°C & 101.3 kPa)
Dry density	kg/m^3	1.14	At Duct Conditions
Wet density (ρ_s)	kg/m^3	1.13	(see above)
Wet specific gravity (sg)		0.99	

PITOT TRAVERSE

Details of measurement equipment and supplementary measurements

Manometer calibration temperature	°C	20.7
Ambient temperature	°C	18
Scale factor		0.1
Pitot type ('L' or 'S' type)		L
Pitot calibration factor		0.99
Pitot reference No.		P863
Manometer reference No.		P216
Thermocouple reference No.		P1204
Timer reference No.		P1153
Barometric gauge reference No.		P222
Angle of gas flow less than 15°?		Yes
Temperature correction factor		0.00257

Measurements and calculation of duct gas velocity

Traverse Point	Port	Distance from inside wall of duct (fraction of D)	Scale Pitot Reading kPa	Differential Pressure (h) Pa	Temperature (T_s) °C	√h	Gas Velocity (V_s) m/s
1	A	0.05	0.94	92.37	27	9.61	12.70
2	A	0.15	0.97	95.31	27	9.76	12.90
3	A	0.25	0.88	86.47	27	9.30	12.29
4	A	0.35	0.86	84.50	27	9.19	12.15
5	A	0.45	0.81	79.59	27	8.92	11.79
6	A	0.55	0.83	81.56	27	9.03	11.93
7	A	0.65	0.66	64.85	27	8.05	10.64
8	A	0.75	0.72	70.75	27	8.41	11.11
9	A	0.85	0.71	69.77	27	8.35	11.04
10	A	0.95	0.55	54.04	27	7.35	9.71
					T_{Duct}	$\sqrt{h}_{Duct}$	
			Averages		27.00	8.80	

CALCULATION OF VELOCITY & FLOW RATE

$V_{Duct} = K_{pi} \times (1-a) \times \sqrt{2/\rho_s} \times \sqrt{h}$ (Reference BS 1042:Section 2.1:1983 (ISO 3966), pages 8&9)

where
- V_{Duct} = gas velocity at sampling point (m/s)
- K_{pi} = pitot calibration factor (dimensionless)
- 1-a = compressibility correction (assumed constant at 0.995)
- ρ_s = wet gas density under duct conditions (kg/m³)
- h = differential pressure (Pa)

Average gas velocity (V_{Ducts}) = 11.62 ± 1.18 m/s

Average volume flowrate (Q_{Duct}) = $V_{Ducts} \times A$

= 9.42 ± 0.99 m³/s

Conversion of actual duct gas flow to reference conditions

Actual Duct Flow Conditions			Reference Conditions		
Average temperature (T_{Duct})	°C	27.00	Temperature (T_{Ref})	°C	0.00
Total pressure (P_{Duct})	kPa	98.56	Pressure (P_{Ref})	kPa	101.30
Oxygen (O_{2Duct})	% vol,dry	20.90	Oxygen (O_{2Ref})	% vol, dry	20.90
Water vapour (H_2O_{Duct})	% vol	1.27	Water vapour (H_2O_{Ref})	% vol	1.27

Calculation of gas flowrate at STP, Q_{STP}

$Q_{STP} = Q_{Duct} \times [(273 \times P_{Duct})/(101.3 \times (273 + T_{Duct}))]$

Q_{STP} = 8.34 ± 0.88 m³/s

Calculation of gas flow at reference conditions, Q_{Ref}

				Corrections
Q_{Ref}	=	Q_{Duct} ×	$\lvert 273 + T_{Ref} \rvert / \lvert 273 + T_{Duct} \rvert$	Temperature
			P_{Duct}/P_{Ref}	Pressure
			$\lvert 100-H_2O_{Duct} \rvert / \lvert 100-H_2O_{Ref} \rvert$	Water vapour
			$\lvert 20.9-O_{2Duct} \rvert / \lvert 20.9-O_{2Ref} \rvert$	Oxygen

QRef = 8.34 ± 0.88 m³/s

Measurements from other tests

Determinand	Test Reference
Oxygen	Spot measurements
Water vapour	DII2O/080507

Uncertainty Calculation Parameters

Standard uncertainty for pressure measurement (U12)	5.0 %
Standard uncertainty for Pitot coefficient (U13)	1.0 %
Standard uncertainty for density estimate (U13)	1.0 %
Standard uncertainty for linear measurement (U14)	1.0 %

Uncertainty budget

Uncertainties		
Pressure measurement (m_p)	%	5.00
Pitot coefficicient (m_k)	%	1.00
Gas density estimate (m_ρ)	%	1.00
Total for velocity measurement (U_v)	%	5.20
Velocity at 95% confidence interval (U_{v95})	%	10.18
Linear measurement (m_l)	%	1.00
Total for flowrate measurement (U_f)	%	5.39
Flow rate at 95% confidence interval (U_{f95})	%	10.55

Based on Procedure 55 and Uncertainty Policies 13 & 14
(in accordance with requirements of BS EN ISO 14956:2002 and ENV 13005 (GUM))

$U_v = \sqrt{m_p^2 + m_k^2 + m_\rho^2}$

$U_{v95} = 1.96 \times U_v$

$U_f = \sqrt{U_v^2 + 2m_l^2}$

$U_{f95c} = 1.96 \times U_f$

Prepared by: M Davies Checked by: N Ford

BUREAU VERITAS MONITORING REPORT FORM
WATER VAPOUR DETERMINATION to BS EN 14790:2005

Company	Sarginsons Precision Components	Test Ref	DH2O/080507
Site	Coventry	Date	22-May-08
Sample point	Dry Arrestor exhaust	Time start	1400
Test carried out by	J Ward & T Davies	Time End	1504
		Duration, t (min)	64

Sampling Rate

Gas meter start reading (SV_{M1})	m3	1964.7220
Gas meter end reading (SV_{M2})	m3	1965.8830
Volume passed at meter conditions ($SV_M=SV_{M2}-SV_{M1}$)	m^3	1.1610
Sampling rate at meter conditions (SVMR)	m^3/min	0.0181

Sampling Conditions

Time	Gas Meter		Probe/heated line
	Temperature T_M, °C	Pressure P_M, kPa	temperature °C
1405	34.5	98.6	160
1504	35.0	98.6	160
Average	34.8	98.6	160.0

Equipment

Gas meter	P372
Gas meter calibration factor	1.0155
Probe/heated line thermocouple	P1016
Barometer	P222
Timer	P735
Balance	P1238

Leak check

		Start	End
Time start		1331	1507
Time end		1333	1508
Start volume	m3	4.412	5.883
End volume	m3	4.412	5.883
Duration	mins	2	2
Leak rate	m^3/min	0.0002	0.00015
Leak rate <2% of sample rate?		Yes	Yes

Balance Check Weighings

Balance No.	P1238		
Check weight no.	P1245	P1246	P1245
Certified weight	50.0000	50.0000	50.0000
Reading (g)	50.0000	50.0000	50.0000
Allowable tolerance (g)	0.0500	0.0500	0.0500
Acceptable response	Yes	Yes	Yes

Test Ref: DH2O/080507

Collection of Water from Gas

Collection Stage (ci)	Initial Mass(Mci,) g	Final Mass (Mci,) g	Mass gain (Mci) g
Container 1	810.840	808.530	0.000
Container 2	688.840	692.170	3.330
Container 3	625.430	626.580	1.150
Container 4	901.840	905.233	3.670
Container 5	938.170	940.610	2.440
Total (Mi)	3964.680	3973.120	10.490

Mass of water collected (M) = Σ(Mc1$_f$-Mc1$_i$)....(Mci$_f$-Mci$_i$)

Calculation of dry gas sample volume at STP (SV_{STP})

SV_{STP} = $SV_m \times (273/(273 + T_m)) \times (P_m/101.3)$

Volume of dry gas sampled at STP (SV_{STP})	m^3	1.0180

Calculation of water vapour content (H_2O_{cont})

H_2O_{cont} = $100 \times (M \times MV_{STP}/MW_{H2O})/[SV_{STP} + (M \times MV_{STP}/MW_{H2O})]$

where
MV_{STP} molecular volume at STP (22.412 m^3/kgmole)
MW_{H2O} molecular weight of water (18 kg/kgmole)

Water vapour content (H_2O_{cont})	%	1.27	± 0.08

Method performance

Water collection efficiency (c=100-(Mci.100/M))	%	76.7
Water content in final container	%	0.3
Correction for collection efficiency ($Corr_c$)	%	0.3

Compliance with BS 14790

Uncertainty less than 20% of measured value (Clause 7.3)
Temperature at outlet is less than 4oC based on calculated dew point (Clause 6.4.2)
Leak rate is no more than 2% of sample flow rate
Sampling duration is within minimum of 30 minutes (Clause 6.1)
Sampling volume is within minimum of 0.6 (Clause 6.1)
Residual water content at outlet is below 1.25% (Clause 6.2)
Sampling temperature was within minimum of 120oC during sampling (Clause 6.2)

Uncertainty Budget (based on BS 14790 and Uncertainty Policy U25)

Volume of sampled gas	V	1.018 m^3
Average temperature of gas at meter	T	34.75 °C
Average barometric pressure at meter	P	998 mb
Sampling line leakage		0.000175 m^3/min
Duration of sampling	t	64 mn
Total mass weighed	M	3973.12 g

Source of uncertainty		Value		Value of standard uncertainty		Relative standard uncertainty (%)	
Measurement of sample gas volume	$u.V_m$	2.0 %	u_1	$u_1 V_m = \frac{u_1 V}{\sqrt{3}}$	0.0116 m^3	$u_1 V_m$	1.15
Measurement of sample gas temperature	$u.T_m$	1.0 %	u_2	$u_2 T_m = \frac{u_2 T \cdot (T+273)}{\sqrt{3}}$	1.7768 K	$u_2 T_m$	0.58
Measurement of absolute pressure	$u.P_m$	1.0 %	u_3	$u_3 P_m = \frac{u_3 P}{\sqrt{3}}$	5.6927 mb	$u_3 P_m$	0.58
Leakage in sampling line	u.L	1.0 %	u_4	$u_4 L = \frac{u_4 V}{\sqrt{3}}$	0.0057 m^3	$u_4 L$	0.50
Measurement of weight - balance uncertainty	$u.W_m$	0.01 %	u_{wm}	$u_{wm} W_m = \frac{u_{wm} W}{\sqrt{3}}$	0.2294 g		-
Measurement of weight - balance repeatability	$u.W_r$	0.011 g	u_{wr}	$u_{wr} W_r =$	0.0110 g		-
Total measurement of weight	u.W	-	-	$u_w W = u_{wm} W_m + u_{wr} W_r$	0.2404 g	u.W	2.29

Total standard relative uncertainty	$u = \sqrt{u.V_m^2 + u.T_m^2 + u.P_m^2 + u.L^2 + u.W^2} + Corr_c$	3.05 %
Total relative uncertainty	$U = 1.96u$	5.97 %

Prepared by: M Davies Checked by: N Ford

BUREAU VERITAS MONITORING REPORT FORM
TOTAL PARTICULATE MATTER to BS EN 13284-1/BS ISO 9096

Company	Sarginsons Precision Components	Test Ref	DTPM/080507
Site	Coventry		
Sample point	Dry Arrestor exhaust		
Test carried out by	J Ward & T Davies		

SAMPLING TIMES

Determination		1
Date		22-May-08
Time Start		1400
Time End		1504
Duration	min	60

Duct conditions

Dimension traversed by sampling probe (D)	m	0.90
Cross sectional area of sampling plane (A)	m^2	0.81

Duct gas conditions

Determination		1
Ambient temperature (T_{Amb})	°C	18.0
Average duct gas temperature (T_{Duct})	°C	27.3
Duct static gas pressure (P_{Duct})	kPa	-0.04
Barometric pressure (P_{Baro})	kPa	98.60
Duct gas volume flowrate @ ref. conditions (Q_{Ref})	m^3/s	8.33
Gas compressibility correction (z)		0.995
Wet gas specific gravity (sg)		0.99
Exhaust gas conditions measurements		DFL1

Reference conditions

Determination		1
Actual Duct Flow Conditions		
Average temperature (T_{Duct})	°C	27.3
Total pressure (P_{Duct})	kPa	98.56
Oxygen (O_{2Duct})	% vol,dry	20.90
Water vapour (H_2O_{Duct})	% vol	1.27
Reference Conditions		
Temperature (T_{Ref})	°C	0
Pressure (P_{Ref})	kPa	101.3
Oxygen (O_{2Ref})	% vol, dry	20.9
Water vapour (H_2O_{Ref})	% vol	1.27

Sampling conditions

Determination		1
Nozzle diameter (d in mm or in)	in	0.252
Initial gas meter reading	m^3	1964.722
Final gas meter reading	m^3	1965.883
Sampled volume (SV_{Meter})	m^3	1.161

Calculation of sample gas volume at reference conditions, SV_{Ref}

$$SV_{Ref} = SV_{Meter} \times [273 + T_{Ref}]/[273 + T_{Meter}] \times P_{Baro}/P_{Ref} \times [100-H_2O_{Meter}]/[100-H_2O_{Ref}] \times [20.9-O_{2Duct}]/[20.9-O_{2Ref}]$$

Corrections
Temperature
Pressure
Water vapour
Oxygen

Determination		1
Sampled volume @ ref. conditions (SVR_{ef})	m^3	1.031

Prepared by: M Davies Checked by: N Ford

SAMPLING DATA 1

Distance from Duct Wall Fraction of D	Port	Time of Day h mm	Orifice ΔH in w.g. Desired (ΔH_d)	Orifice ΔH in w.g. Actual (ΔH_a)	Pitot Reading (h) in w.g.	Temperatures Sample Gas (T_{Sample}) °C	Temperatures Filter (T_{Filter}) °C	Temperatures Meter (T_{Meter}) Inlet °C	Temperatures Meter (T_{Meter}) Outlet °C	% isokinetic	Pitot Reading (h) " w.g.	Sampling Rate at meter l/min
0.063	B	1400	1.73	1.70	0.380	28	160	42.0	27.0	99.1	0.4	21.1
0.063	B	1404	1.69	1.70	0.370	28	160	42.0	27.0	100.3	0.4	20.9
0.188	B	1408	1.64	1.60	0.360	28	160	42.0	27.0	98.8	0.4	20.6
0.188	B	1412	1.69	1.70	0.370	28	160	42.0	28.0	100.3	0.4	20.9
0.313	B	1416	1.55	1.60	0.340	27	160	42.0	28.0	101.6	0.3	20.1
0.313	B	1420	1.46	1.50	0.320	27	160	41.0	28.0	101.4	0.3	19.4
0.438	B	1424	1.50	1.50	0.330	27	160	41.0	28.0	100.0	0.3	19.7
0.438	B	1428	1.55	1.60	0.340	27	160	41.0	28.0	101.6	0.3	20.0
0.563	B	1432	1.46	1.50	0.320	27	160	41.0	29.0	101.4	0.3	19.5
0.563	B	1436	1.46	1.50	0.320	27	160	41.0	29.0	101.4	0.3	19.5
0.688	B	1440	1.28	1.30	0.280	27	160	41.0	29.0	100.8	0.3	18.2
0.688	B	1444	1.23	1.20	0.280	27	160	41.0	29.0	98.8	0.3	18.2
0.813	B	1448	1.32	1.30	0.259	27	160	41.0	29.0	99.2	0.3	17.5
0.813	B	1452	1.32	1.30	0.290	27	160	41.0	29.0	99.2	0.3	18.5
0.938	B	1456	1.41	1.40	0.310	27	160	41.0	29.0	99.6	0.3	19.2
0.937	B	1500	1.41	1.40	0.310	27	160	41.0	29.0	99.6	0.3	19.2
	Averages				0.324	27.3	160.0	34.8		100.2	0.3	19.5

Equipment used

Item	File No.
Control box	P372
Meter coefficient	1.0155
Orifice units (in or mm w.g.)	in
Pitot differential units (in or mm w.g.)	in
Pitot	S
Probe liner thermocouple	P1016
Duct gas thermocouple	P988
Oven thermocouple	P710
Impinger bath thermocouple	P1212
Timer	P735
Field blank filter No.	011649
Sample filter No.	011652

Measurements from other tests

Determinand	Test Reference
Duct gas conditions	DFL1

Leak check

		Start	End
Start Time		1331	1507
End Time		1333	1508
Initial meter reading	m^3	4.412	5.8831
Final meter reading	m^3	4.4124	5.8834
Duration of leak test	min	2	1
Pump vacuum	"Hg	15	15
Leak rate	l/min	0.2	0.3
Less than 2% of normal sampling rate?		Yes	Yes

PARTICULATE WEIGHINGS

Filters

Determination		Method Blank	Field Blank	1
Filter No.			011649	011652
Pre-sampling conditioning temperature (±5°C)	°C	180	180	180
Post-sampling conditioning temperature (±5°C)	°C	160	160	160
Diameter	mm	110	110	110
Material		Quartz	Quartz	Quartz
Pre-sampling weights				
after 1 min	g		0.7824	0.7764
after 2 min	g		0.7825	0.7763
after 3 min	g		0.7825	0.7763
Weight extrapolated to zero time (M_{f0})	g		0.7824	0.7764
Post-sampling weights				
after 1 min	g		0.7789	0.7757
after 2 min	g		0.7795	0.7756
after 3 min	g		0.7797	0.7756
Weight extrapolated to zero time (M_{f0})	g		0.7786	0.7757

Rinsings

Pre-sampling conditioning temperature (±5°C)	°C	180	180	180
Post-sampling conditioning temperature (±5°C)	°C	160	160	160
Pre-sampling weights (container only)				
after 1 min	g		72.1609	73.1381
after 2 min	g		72.1609	73.1381
after 3 min	g		72.1609	73.1380
Weight extrapolated to zero time (M_{r0})	g		72.1609	73.1382
Post-sampling weights (container and evaporated rinsings)				
after 1 min	g		72.1612	73.1448
after 2 min	g		72.1611	73.1447
after 3 min	g		72.1610	73.1447
Weight extrapolated to zero time (M_{r0})	g		72.1613	73.1448

Summary

Determination		Method Blank (M_{mb})	Field Blank	1
Mass collected on filter ($M_f = (M_{f0} - M_{f0} - M_{fmb})$)	g	0.0000	-0.0038	-0.0007
Mass collected in rinsings ($M_r = (M_{r0} - M_{r0} - M_{rmb})$)	g	0.0000	0.0004	0.0067
Total mass collected ($M = M_f + M_r$)	g	0.0000	-0.0034	0.0060

Uncertainty Calculation Parameters

Standard uncertainty for gas volume measurement (U6)	2.9 %
Standard uncertainty for filter weighing (U17)	0.57 mg
Standard uncertainty for washings weighing (U17)	0.50 mg
Limit of detection for filter weighing (U17)	0.50 mg
Limit of detecion for washings weighing (U17)	0.50 mg
Standard uncertainty for oxygen correction (U11)	0.95 %
Standard uncertainty for gas flow measurement (U14)	5.7 %

Emission Limit Value

Emission limit value (ELV) at reference conditions	mg/m^3

SUMMARY OF MEASUREMENTS

Calculation of Particulate Concentration and Discharge Rate

Particulate concentration (C), mg/m^3 = M x 1000/ SVRef

Discharge rate, kg/h = C x Qref x 0.0036

Determination		Field Blank	1
Particulate concentration at reference conditions	mg/m^3	-3.30	5.79
Uncertainty	mg/m^3	-3.30	1.91
Particulate concentration at duct conditions (raw)	mg/m^3	-2.92	5.12
Particulate discharge rate	kg/h	-0.10	0.17
Uncertainty	kg/h	-0.32	0.06

Note: Field blank results based on average sampling conditions

COMPLIANCE WITH BS EN 13248-1:2002/BS ISO 9096 CONDITIONS

Standard	EN 13284-1
Determination	1
Angle of gas flow less than 15°	Yes
No local negative gas flow	Yes
Minimum differential pressure greater than 5 Pa	Yes
Ratio of highest to lowest local gas velocites less than 3:1	Yes

Determination 1 BS EN 13284-1

Blank value is less than 10% of ELV (Clause 4f)
Nozzle diameter greater than 6 mm (Clause 6.2.4)
Average sampling rate was outside the isokinetic limits (Clause 8.4)
Leak rate is within 2% of sample rate (Clause 8.4)

Uncertainty budget

Uncertainties		Field Blank	1
Volume measurement (m_{vol})	mg	-0.10	0.17
Filter weighings (m_f)	mg	-3.80	-0.70
Rinsings weighings (m_w)	mg	-3.80	-0.70
Total for uncorrected measurement (U_u)	mg	5.37	1.00
Correction to reference conditions (m_{corr})	mg	0.00	0.00
Total for corrected measurement (U_c)	mg	5.37	1.00
Concentration at 95% confidence interval (U_{95c})	mg/m^3	-3.30	1.91

Based on Procedure 55 and Uncertainty Policies 11 & 17
(in accordance with requirements of BS EN ISO 14956:2002 and ENV 13005 (GUM))

$U_u = \sqrt{m_{vol}^2 + m_f^2 + m_w^2}$

$U_c = \sqrt{U_u^2 + m_{corr}^2}$

$U_{95c} = 1.96 \times U_c / SV_{ref}$

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END OF REPORT