mCERTS
THE ENVIRONMENT AGENCY'S MONITORING CERTIFICATION SCHEME

TEST REPORT

UKAS TESTING
1618

Report for the Periodic Monitoring of Emissions to Air **(Part 1)**

Operator: **Nationwide Crash Repair Centre**

Installation: **Coventry**
Spray Booth 1

Monitoring dates:	10th January 2006
Contract number:	Q0036117
Client Organisation:	Nationwide Crash Repair Centre
Address:	Stonybridge Trading Estate
	Rowley Drive
	Coventry
	CV3 4FG
Monitoring Organisation:	CPL Laboratories
Address:	Mill Lane
	Wingerworth
	Chesterfield
	S42 6NG
Date of Report:	10th February 2006
Report Approved by:	C. M. Greenaway
MCERTS Registration Number:	02 048
Function:	Team Leader
Signed:	[redacted]

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1.1 Monitoring Objectives

Mr Mark Rose of Nationwide Craft Repair Centre, requested CPL Laboratories to monitor emissions to air from Spray Booth 1.

The monitoring was carried out on the 10th January 2006, to determine compliance with specified emission limits. The substances requested for monitoring at each emission point are listed below.

Substances To be Monitored	**Emission Point Identification**
	Spray Booth 1
Total particulate matter (TPM)	

Special Requirements:	None

1.2 Monitoring Results

Emission point reference	**Spray Booth 1**
Substance to be monitored	**Total particulate matter (TPM)**
Emission limit value mg/m^3	10
Periodic monitoring results mg/m^3	<0.46 0.46
Uncertainty %	400 400
Monitoring Method reference	ISO 9096: 2003
Accreditation for use of method	UKAS MCERTS
Date of sampling	10/01/06
Start & end times	12:02 – 12:34 14:55 – 15:25
Reference conditions 273K, 101.3kPa	No correction for oxygen or moisture
Operating status	Normal

1.3 Operating Information

This process involves the paint spraying of automobiles within confined booths and extraction through a filter unit before outlet to air.

Emission point reference	Spray Booth 1
Date	10/01/06
Process type	Panel Spraying
Process duration	Approximately 30 to 60 mins
Fuel	Not Applicable
Feedstock	Paints
Abatement	Filters
Load	Automobiles

Comparison with Operator CEMs	
Operator CEMs Particulate matter mg/m^3	Not Applicable
Particulate matter mg/m^3 Periodic monitoring results	<0.46 0.46

1.4 Monitoring Deviations

Emission point reference	Spray Booth 1				
Substance deviations	None				
Monitoring deviations	Note 1	Note 2	Note 3	Note 4	Note 5
Other relevant issues	Note 6	Note 7	Note 8		

Notes

1. Nozzle diameter less than 6mm
2. Negative duct gas flows
3. Differential pressure at pitot tube less than 5 Pa
4. Ratio of maximum to minimum duct gas velocities greater than 3:1
5. Duct gas flow with regard to duct access greater than 15°
6. Less than 2 duct diameters straight length after the sampling plane
7. Less than 5 duct diameters straight length before the emission point
8. Weighing uncertainties greater than 5% of the LV

mCERTS
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TEST REPORT

UKAS TESTING
1618

Report for the Periodic Monitoring of Emissions to Air **(Part 2)**

Operator: **Nationwide Crash Repair Centre**

Installation: **Coventry**
Spray Booth 1

Monitoring dates:	10th January 2006
Contract number:	Q0036117
Client Organisation:	Nationwide Crash Repair Centre
Address:	Stonybridge Trading Estate Rowley Drive Coventry CV3 4FG
Monitoring Organisation:	CPL Laboratories
Address:	Mill Lane Wingerworth Chesterfield S42 6NG
Date of Report:	10th February 2006
Report Approved by:	C Greenaway
MCERTS Registration Number:	02 048
Function:	Team Leader
Signed:	[redacted]

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2 Part 2: Supporting Information

2.1 Appendix 1: General Information

2.1.1 Monitoring organisation staff details

Sampling Team Members

Name	MCert Status	MCert Registration No.	Responsibility
C M Greenaway	Level 2 With TE 1, 2, 3, 4	MM 02 048	Team Leader
D Martschenko	-	-	Technician

2.1.2 Monitoring organisation method details

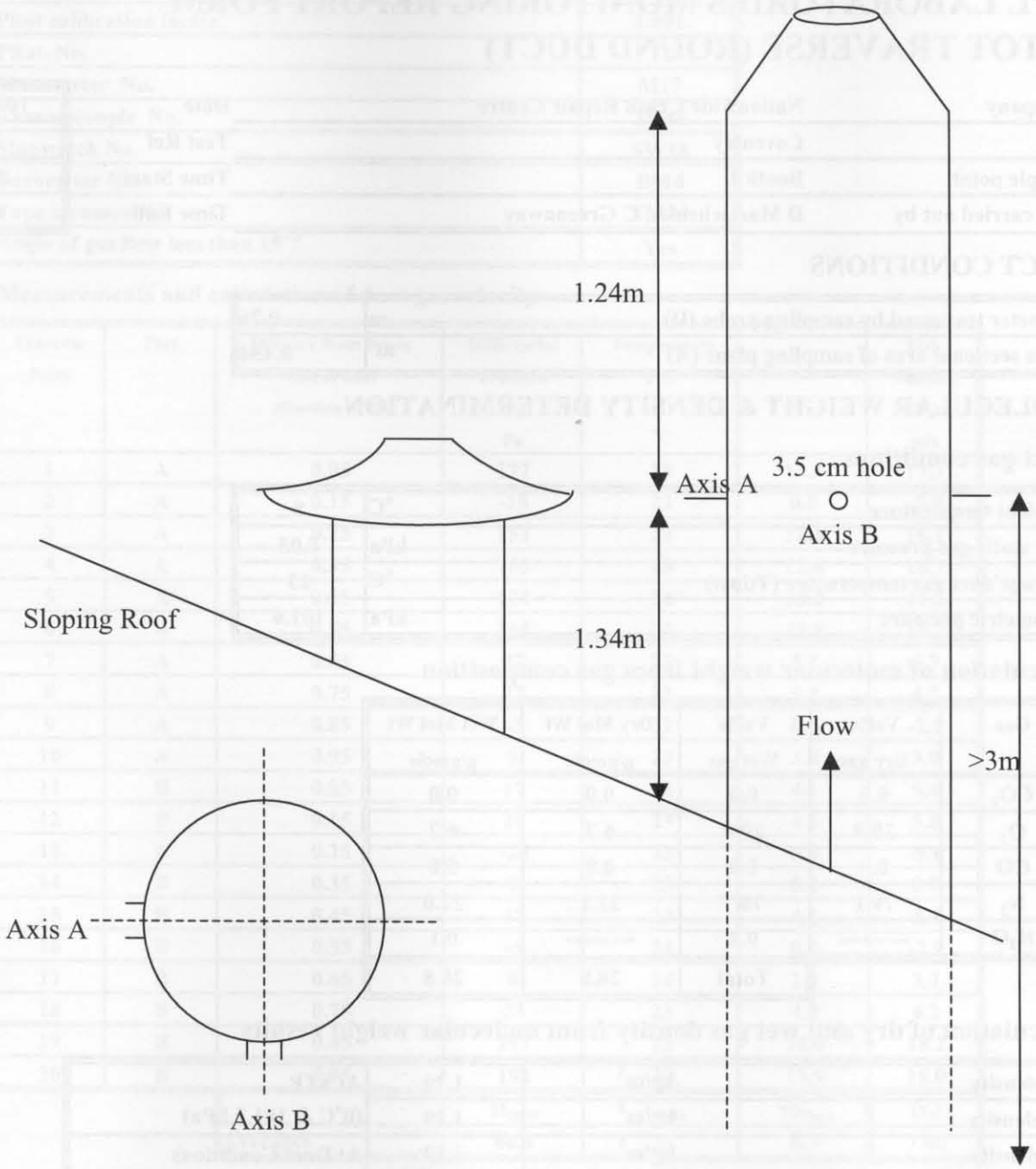
Pollutant	Measurement Method	No. tests / blanks
Total Particulate Matter (TPM)	ST 6 ISO 9096: 2003	2 / 1

2.1.3 Monitoring organisation equipment checklist

06/007	CL-081

2.2 Appendix 2

2.2.1 Diagram of Sampling Location and Position



2.2.2 Flow criteria and gas measurements

CPL LABORATORIES MONITORING REPORT FORM
PITOT TRAVERSE (ROUND DUCT)

Company	Nationwide Crash Repair Centre	Date	10-Jan-06
Site	Coventry	Test Ref	FL1
Sample point	Booth 1	Time Start	10:30
Test carried out by	D Martschenko, C Greenaway	Time End	10:34

DUCT CONDITIONS

Diameter traversed by sampling probe (D)	m	0.76
Cross sectional area of sampling plane (A)	m^2	0.454

MOLECULAR WEIGHT & DENSITY DETERMINATION

Duct gas conditions

Ambient temperature	°C	8
Duct static gas pressure	kPa	0.03
Average duct gas temperature (Tduct)	°C	23
Barometric pressure	kPa	101.6

Calculation of molecular weight from gas composition

Gas	Vol% Dry gas	Vol% Wet gas	Dry Mol Wt g/gmole	Wet Mol Wt g/gmole
CO_2	0.0	0.0	0.0	0.0
O_2	20.9	20.8	6.7	6.7
CO	0.0	0.0	0.0	0.0
N_2	79.1	78.7	22.1	22.0
H_2O	---------	0.4	---------	0.1
		Total	28.8	28.8

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	1.29	(0°C & 101.3 kPa)
Dry density	kg/m^3	1.19	At Duct Conditions
Wet density (ρ_a)	kg/m^3	1.19	(see above)
Wet specific gravity (sg)		0.994	

PITOT TRAVERSE

Details of measurement equipment and supplementary measurements

Pitot type ('L' or 'S' type)	L
Pitot calibration factor	1.001
Pitot No.	PT14
Manometer No.	M17
Thermocouple No.	TC44
Stopwatch No.	SW18
Barometer No.	BM4
Tape measure No.	TM21
Angle of gas flow less than 15°?	Yes

Measurements and calculation of duct gas velocity

Traverse Point	Port	Distance from inside wall of duct (fraction of D)	Differential Pressure (h) Pa	Temperature (T_s) °C	$\sqrt{h}$	Gas Velocity (V_s) m/s
1	A	0.05	177	23	13.3	17.3
2	A	0.15	-15	23	0.0	-5.0
3	A	0.25	153	23	12.4	16.1
4	A	0.35	165	23	12.8	16.7
5	A	0.45	174	24	13.2	17.2
6	A	0.55	165	24	12.8	16.7
7	A	0.65	27	23	5.2	6.7
8	A	0.75	27	23	5.2	6.7
9	A	0.85	-3	22	0.0	-2.2
10	A	0.95	9	23	3.0	3.9
11	B	0.05	17	23	4.1	5.4
12	B	0.15	20	23	4.5	5.8
13	B	0.25	-20	23	0.0	-5.8
14	B	0.35	0	23	0.0	0.0
15	B	0.45	17	23	4.1	5.4
16	B	0.55	-5	24	0.0	-2.9
17	B	0.65	8	24	2.8	3.7
18	B	0.75	23	23	4.8	6.2
19	B	0.85	197	23	14.0	18.2
20	B	0.95	192	22	13.9	18.0
			H_{Duct}	T_{Duct}	$\sqrt{h}_{Duct}$	(V_s)
		Averages	66.4	23	6.3	7.40

NOTE: Minimum pitot static reading less than 5 Pa (BS 3405:1983 Clause 6.3.2)

CALCULATION OF VELOCITY & FLOW RATE

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

where V_{Duct} = gas velocity at sampling point (m/s)

K_{pt} = pitot calibration factor (dimensionless)

$1-\varepsilon$ = compressibility correction (assumed constant at 0.995)

ρ_a = wet gas density under duct conditions (kg/m^3)

h = differential pressure (Pa)

Average gas velocity (V_{Ducta}) = **8.2** m/s

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

= **3.7** m^3/s

Conversion of actual duct gas flow to reference conditions

Actual Duct Flow Conditions			Reference Conditions		
Average temperature (T_{Duct})	°C	23	Temperature (T_{Ref})	°C	0
Total pressure (P_{Duct})	kPa	101.6	Pressure (P_{Ref})	kPa	101.3
Oxygen (O_{2Duct})	% vol,dry	20.9	Oxygen (O_{2Ref})	% vol, dry	20.9
Water vapour (H_2O_{Duct})	% vol	0.4	Water vapour (H_2O_{Ref})	% vol	0.4

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} = **3.4** 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 = **3.4** m^3/s

2.2.3 Water vapour measurements

CPL LABORATORIES MONITORING REPORT FORM
WATER VAPOUR (GRAVIMETRIC TECHNIQUE)

Company	Nationwide Crash Repair Centre	Date	10-Jan-06
Site	Coventry	Test Ref	H_20 1,2
Sample point	Booth 1	Prepared	D Martschenko
Test carried out by	D Martschenko, C Greenaway	Checked	G. Carroll

SAMPLING TIMES

Determination	1	2
Time Start	12:02	14:55
Time End	12:34	15:25

SAMPLING CONDITIONS

Determination		1	2
Gas meter temperature (T_{meter})	°C	9	10
Atmospheric pressure (P_{atm})	kPa	101.7	101.5
Final meter reading	m^3	218.468	218.696
Initial meter reading	m^3	218.284	218.469
Gas meter calibration factor		1.000	0.983
Volume of gas sampled (VG_{meter})	l	184.3	222.7

SAMPLE TUBE WEIGHTS

Determination		1	2
Tube			
Final weight (M_{fl})	g	140.6	142.0
Initial weight (M_{il})	g	140.5	140.6
Weight gain (M_{fl}-M_{il} = M_{gl})	g	0.1	1.4

Sample gas volume at STP, VG_{STP}

$VG_{STP} = VG_{meter} \times (273 \times P_{atm})/(101.3 \times (273 + T_{meter}))$

Determination		1	2
Volume of gas sampled (VG_{STP})	l, STP	179.0	215.7

Calculation of water vapour content in duct gas, C_g

C_g (% vol) = $100 \times (M_t \times MV_{STP} \div MW_{H2O}) \div (VG_{STP} + (M_t \times MV_{STP} \div MW_{H2O}))$

where MV_{STP} is the ideal gas molecular volume at STP (i.e. 22.412 m^3/kgmole)

MW_{H2O} is the molecular weight of water (i.e. 18 kg/kgmole)

WATER VAPOUR MEASUREMENTS

Determination		1	2
Water vapour content	%,vol	0.1	0.8
Mean water vapour content	%,vol	0.4	
Water vapour concentration	kg/m^3	0.001	0.007
Mean water vapour concentration	kg/m^3	0.004	

2.2.4 Sampling measurements

CPL LABORATORIES MONITORING REPORT FORM
TOTAL PARTICULATE

Company	Nationwide Crash Repair Centre	Date	10-Jan-06
Site	Coventry	Test Ref	TE1
Sample point	Booth 1	Time Start	12:02
Test carried out by	D Martschenko, C Greenaway	Time End	12:34

Duct conditions

Dimension traversed by sampling probe (D)	m	0.76
Cross sectional area of sampling plane (A)	m^2	0.454

Duct gas conditions

Ambient temperature (T_{Amb})	°C	9
Average duct gas temperature (T_{Duct})	°C	25
Duct static gas pressure (P_{Static})	kPa	0.03
Barometric pressure (P_{Baro})	kPa	101.7
Duct gas volume flowrate @ ref. conditions (Q_{Ref})	m^3/s	3.42
Gas compressibility correction (ε)		0.995
Wet gas specific gravity (sg)		0.99

Reference conditions

Actual Duct Flow Conditions			Reference Conditions		
Average temperature (T_{Duct})	°C	25	Temperature (T_{Ref})	°C	0
Total pressure (P_{Duct})	kPa	101.7	Pressure (P_{Ref})	kPa	101.3
Oxygen (O_{2Duct})	% vol,dry	20.9	Oxygen (O_{2Ref})	% vol, dry	20.9
Water vapour (H_2O_{Duct})	% vol	0.1	Water vapour (H_2O_{Ref})	% vol	0.1

Sampling conditions

Nozzle diameter (d)	mm	6.0
Initial gas meter reading	m^3	218.284
Final gas meter reading	m^3	218.468
Gas meter factor		1.000
Sampled volume (SV_{Meter})	m^3	0.184

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

Sampled volume @ ref. conditions (SVR_{ef})	m^3	0.179

Prepared by: D Martschenko **Checked by:** G. Carroll

CPL LABORATORIES MONITORING REPORT FORM
TOTAL PARTICULATE

Company	Nationwide Crash Repair Centre	Date	10-Jan-06
Site	Coventry	Test Ref	TE2
Sample point	Booth 1	Time Start	14:55
Test carried out by	D Martschenko, C Greenaway	Time End	15:25

Duct conditions

Dimension traversed by sampling probe (D)	m	0.76
Cross sectional area of sampling plane (A)	m^2	0.454

Duct gas conditions

Ambient temperature (T_{Amb})	°C	10
Average duct gas temperature (T_{Duct})	°C	27
Duct static gas pressure (P_{Static})	kPa	0.16
Barometric pressure (P_{Baro})	kPa	101.5
Duct gas volume flowrate @ ref. conditions (Q_{Ref})	m^3/s	3.42
Gas compressibility correction (E_1)		0.995
Wet gas specific gravity (sg)		0.99

Reference conditions

Actual Duct Flow Conditions			Reference Conditions		
Average temperature (T_{Duct})	°C	27	Temperature (T_{Ref})	°C	0
Total pressure (P_{Duct})	kPa	101.6	Pressure (P_{Ref})	kPa	101.3
Oxygen (O_{2Duct})	% vol,dry	20.9	Oxygen (O_{2Ref})	% vol, dry	20.9
Water vapour (H_2O_{Duct})	% vol	0.8	Water vapour (H_2O_{Ref})	% vol	0.8

Sampling conditions

Nozzle diameter (d)	mm	6.0
Initial gas meter reading	m^3	218.469
Final gas meter reading	m^3	218.696
Gas meter factor		0.983
Sampled volume (SV_{Meter})	m^3	0.223

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

Sampled volume @ ref. conditions (SV_{Ref})	m^3	0.217

Prepared by: D Martschenko **Checked by:** G. Carroll

Static pressure before gas meter	0	Pa	Pitot	1.001
Water Vapour Concentration	0.00	kg/m3	factor	
Moisture Content	0.4	%		

MEASUREMENT OF TOTAL PARTICULATE

Test 1

Time	Posn.	Pitot rdg. Pa	Duct temp. °C	Duct CO2 %	Duct O2 %	Meter temp. °C	Duct static Pa	Baro press. kPa	Nozzle dia. mm	Iso. rate l/min	Actual flow l/min	Vol.sampled m^3 meter	m^3 cum.	reqd. vol. m^3	Cum. dev. %
0	2	25	23	0.0	20.9	8	30	101.7	5.95	10.2	10.8	218.284	0.000	0.000	
4	4	1	24	0.0	20.9	8	30	101.7	5.95	2.0	2.1	218.327	0.043	0.041	5.4
8	7	12	24	0.0	20.9	9	30	101.7	5.95	7.1	7.0	218.335	0.052	0.049	4.9
12	9	12	24	0.0	20.9	9	30	101.7	5.95	7.1	7.2	218.363	0.080	0.078	2.5
16	2	8	24	0.0	20.9	10	30	101.7	5.95	5.8	5.6	218.392	0.108	0.106	2.2
20	4	1	25	0.0	20.9	10	30	101.7	5.95	2.1	2.0	218.415	0.131	0.129	1.0
24	7	4	26	0.0	20.9	10	30	101.6	5.95	4.1	3.9	218.422	0.139	0.138	0.7
28	9	15	26	0.0	20.9	10	30	101.6	5.95	8.0	7.5	218.438	0.154	0.154	0.0

MASS OF PARTICULATES COLLECTED

Filter no.	NCR8
Filter + particulates, g	0.5378
Filter, g	0.5378
Mass collected, g	0

Washing bottle no.	
Washing filter + particulates, g	0
Washing filter, g	0
Mass collected, g	0
Proportionalised weight	0

Total mass collected, g	0

OVERALL BLANK

Filter no.	NCR3
Filter + particulates, g	0.4682
Filter, g	0.4680
Mass Change, g	0.0002

Washing bottle no.	
Evaporating Basin + particulates, g	0
Evaporating Basin , g	0
Mass collected, g	0

TOTAL FIELD BLANK g 0.0002

CALCULATIONS

(Q_{duct}), Flow in the duct, at duct conditions, m^3/s	3.69740048
(Q_{ref}), Flow in the duct, at reference conditions, m^3/s	3.4188
(M), Mass flow at duct conditions, kg/h	0
(C), Concentration of particulate matter at reference conditions, mg/m^3	0

MEASUREMENT OF TOTAL PARTICULATE

Test 2

Time	Posn.	Pitot rdg. Pa	Duct temp. °C	Duct CO2 %	Duct O2 %	Meter temp. °C	Duct static Pa	Baro press. kPa	Nozzle dia. mm	Iso. rate l/min	Actual flow l/min	Vol.sampled m^3 meter	m^3 cum.	reqd. vol. m^3	Cum. dev. %
0	2	38	27	0.0	20.9	9	160	101.5	5.95	12.6	12.3	218.469	0.000	0.000	
4	4	1	27	0.0	20.9	10	160	101.5	5.95	2.0	2.0	218.518	0.049	0.050	-2.2
8	7	1	27	0.0	20.9	10	160	101.5	5.95	2.0	2.4	218.526	0.057	0.058	-2.4
12	9	24	27	0.0	20.9	10	160	101.5	5.95	10.0	10.0	218.536	0.067	0.067	-0.1
16	2	10	27	0.0	20.9	10	160	101.5	5.95	6.5	6.4	218.575	0.107	0.107	-0.3
20	4	17	27	0.0	20.9	10	160	101.5	5.95	8.4	8.5	218.601	0.132	0.133	-0.4
24	7	8	27	0.0	20.9	10	160	101.4	5.95	5.8	5.8	218.635	0.166	0.166	-0.1
28	9	21	27	0.0	20.9	10	160	101.5	5.95	9.4	9.3	218.658	0.190	0.190	0.0

MASS OF PARTICULATES COLLECTED

Filter no.	NCR4
Filter + particulates, g	0.5299
Filter, g	0.5298
Mass collected, g	1E-04

Washing bottle no.	
Washing filter + particulates, g	0
Washing filter, g	0
Mass collected, g	0
Proportionalised weight	0

Total mass collected, g	0.0001

OVERALL BLANK

Filter no.	NCR3
Filter + particulates, g	0.4682
Filter, g	0.4680
Mass Change, g	0.0002

Washing bottle no.	
Evaporating Basin + particulates, g	0
Evaporating Basin , g	0
Mass collected, g	0

TOTAL FIELD BLANK g 0.0002

CALCULATIONS

(Q_{duct}), Flow in the duct, at duct conditions, m^3/s	3.6974
(Q_{ref}), Flow in the duct, at reference conditions, m^3/s	3.4188
(M), Mass flow at duct conditions, kg/h	0.0062
(C), Concentration of particulate matter at reference conditions, mg/m^3	0.46

(M), Mass flow at duct conditions, kg/h = C x Q duct x 0.0036

(C), Concentration of particulate matter at reference conditions, mg/m^3 = Total mass collected, g / Sampled volume at ref conditions, m^3

2.2.5 Manual monitoring method results calculations

Formula 1 - Determination of Moisture Content

$$V_o = V_m.(273 \div T_m).(P_b \div 101.3)$$

$$\%\ H_20 = 100.(M_w \div 18) \div [(V_o \div 22.412) + (M_w \div 18)]$$

Where :

$\%H_20$	- Moisture content of the gas sampled, %
M_w	- Mass of water collected during the test, g
V_o	- Volume sampled at reference conditions, litres
V_m	- Volume sampled at meter conditions, litres
T_m	- Mean meter temperature during the test, K
P_b	- Mean meter conditions during test, kPa

Formula 2 - Determination of mean velocity

$$V = 0.0753.\sqrt{T}.\sqrt{h}$$

Where

V	- Mean velocity during test, m/s
$\sqrt{T}$	- Mean square root of temperatures before and after test, K
$\sqrt{h}$	- Mean square root of pitot-static readings before and after test, Pa

Formula 3 - Volume flow rate of duct gases, at duct temperatures

$$Q_{(duct)} = V.A$$

Where

$Q_{(duct)}$	- Volume flow rate of duct gases, m^3/s
V	- Mean velocity, m/s
A	- Area of duct (at the sampling plane), m^2

Formula 4 - Volume flow rate of duct gases, specified reference conditions

$$Q_o = Q_{(duct)}.(T_{ref} \div T_{duct}).(P_{duct} \div P_{ref}).[(100 - \%H_20) \div 100].[(20.9 - O_{2duct}) \div (20.9 - O_{2rel})]$$

Where

Q_o	- Volume flow rate at reference conditions, and relative O_2 and moisture correction, m^3/s
T_{ref}	- reference Temperature, K
T_{duct}	- Mean temperature across the duct, K
P_{duct}	- Relative static pressure in the duct, kPa
P_{ref}	- Reference pressure, kPa
$\%H_20$	- Water content, %
O_{2duct}	- Oxygen content as measured during the test, %*v/v*
O_{2rel}	- Relative Oxygen content for the process, %*v/v*

2.2.6 Uncertainty calculations

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

Test 1

Measurement Equation

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

Limit value	10	**mg.m^{-3}**	**Reference oxygen**	20.9	**% by volume**
Measured concentration	0.46	**mg.m^{-3}**			

Measured Quantities	**Symbol**	**Value**	**Standard uncertainty**		**Units**	**Uncertainty as percentage**	**Uncertainty at limit value**	**Requirement of standard**
Sampled Volume	V_m	0.18	uV_m	0.002	**m^3**	1.11		<=2%
Sampled gas Temperature	T_m	298	uTm	1	k	0.34		<=1%
Sampled gas Pressure	ρ_m	101.67	$u\rho_m$	0.1	**kPa**	0.10		<=1%
Sampled gas Humidity	H_m	0.1	uH_m	0.15	**% by volume**	150.00		<=1%
Oxygen content	$O_{2,m}$	20.9	$uO_{2,m}$	0	**% by volume**	0.00		<=5%
Mass particulate	m	0.1	um	0.2	**mg**	200.00	9.20	<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	UCM	0			**mg**	0.00		<=10%

Intermediate calculations						
Factor for std conds	fs	0.92				
uncertainty components	symbol	**sensitivity coeff**	**u (in units of fs)**		$f_s = \frac{(100 - H_m)}{100} \frac{273}{T_m} \frac{\rho_m}{101.3}$	
	ρ_m	0.009	0.001			
	H_m	0.009	0.001			
	T_m	0.003	0.003			
	ufs		0.003			0.38
Corrected volume	V	0.17	uV	0.002 **m^3**	$V = V_m f_s$	1.27
Factor for O2 correction	fc	1.00				
uncertainty components	symbol	**sensitivity coeff**	**u**		$f_c = \frac{21 - O_{2,ref}}{21 - O_{2,m}}$	
	$O_{2,m}$	10.00	0.000			
Factor for O2 Correction	ufc	1.00	0.000			0.00

Parameter	**Uncertainty, i**	**Value**	**Units**	**Sensitivity coeff**	**Uncertainty in Result**	**Uncertainty as %**
Volume(standard conditions)	V	0.17	m^3	2.78	0.01 mg.m^{-3}	1.27 %
Mass	m	0.10	mg	4.60	0.92 mg.m^{-3}	200.00
Factor for O2 Correction	fc	1.00		0.46	0.00 mg.m^{-3}	0.00 %
Leak	L	0.01	mg.m^{-3}	1.00	0.01 mg.m^{-3}	
Uncollected mass	UCM	0.00	mg	4.60	0.00 mg.m^{-3}	
Combined uncertainty					**0.92** mg.m^{-3}	

Expanded uncertainty	**expressed with a level of confidence of 95%**	**400.01**	**%**
Expanded uncertainty	**expressed with a level of confidence of 95%**	**1.84**	**mg.m^{-3}**

Test 2

Measurement Equation

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

Limit value	10	**mg.m^{-3}**	**Reference oxygen**	20.9	**% by volume**
Measured concentration	0.46	**mg.m^{-3}**			

Measured Quantities	**Symbol**	**Value**	**Standard uncertainty**		**Units**	**Uncertainty as percentage**	**Uncertainty at limit value**	**Requirement of standard**
Sampled Volume	V_m	0.216	uV_m	0.002	**m^3**	0.93		<=2%
Sampled gas Temperature	T_m	300	uTm	1	k	0.33		<=1%
Sampled gas Pressure	ρ_m	101.34	$u\rho_m$	0.1	**kPa**	0.10		<=1%
Sampled gas Humidity	H_m	0.8	uH_m	0.15	**% by volume**	18.75		<=1%
Oxygen content	$O_{2,m}$	20.9	$uO_{2,m}$	0	**% by volume**	0.00		<=5%
Mass particulate	m	0.1	um	0.2	**mg**	200.00	9.20	<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	UCM	0			**mg**	0.00		<=10%

Intermediate calculations						
Factor for std conds	fs	0.90				
uncertainty components	symbol	**sensitivity coeff**	**u (in units of fs)**		$f_s = \frac{(100 - H_m)}{100} \frac{273}{T_m} \frac{\rho_m}{101.3}$	
	ρ_m	0.009	0.001			
	H_m	0.009	0.001			
	T_m	0.003	0.003			
	ufs		0.003			0.38
Corrected volume	V	0.20	uV	0.002 **m^3**	$V = V_m f_s$	1.09
Factor for O2 correction	fc	1.00				
uncertainty components	symbol	**sensitivity coeff**	**u**		$f_c = \frac{21 - O_{2,ref}}{21 - O_{2,m}}$	
	$O_{2,m}$	10.00	0.000			
Factor for O2 Correction	ufc	1.00	0.000			0.00

Parameter	**Uncertainty, i**	**Value**	**Units**	**Sensitivity coeff**	**Uncertainty in Result**	**Uncertainty as %**
Volume(standard conditions)	V	0.20	m^3	2.36	0.01 mg.m^{-3}	1.09 %
Mass	m	0.10	mg	4.60	0.92 mg.m^{-3}	200.00
Factor for O2 Correction	fc	1.00		0.46	0.00 mg.m^{-3}	0.00 %
Leak	L	0.01	mg.m^{-3}	1.00	0.01 mg.m^{-3}	
Uncollected mass	UCM	0.00	mg	4.60	0.00 mg.m^{-3}	
Combined uncertainty					**0.92** mg.m^{-3}	

Expanded uncertainty	**expressed with a level of confidence of 95%**	**400.01**	**%**
Expanded uncertainty	**expressed with a level of confidence of 95%**	**1.84**	**mg.m^{-3}**

Appendix 3

Stack: **Spray Booth 1**

Equipment	Value	No X
Nozzle: internal diameter	>6 mm	X
Nozzle: uncertainty of area at nozzle entry	≤0%	✓
Nozzle: length with constant internal diameter	>10 mm	✓
Nozzle: change in diameter angle	<30°	✓
Nozzle: radius of the bend	.>1.5 times internal diameter	✓
Nozzle: straight length before the first bend	>30 mm	✓
Filter holder: distance to obstacles	>50mm	✓
Filter:		
Efficiency on test aerosol of 0.3 μm	>99.5 %	✓
Efficiency on test aerosol of 0.6 μm	>99.9%	✓
Filter: filter material	No reaction and no absorption of the components	✓
Condenser, drying tower: residual gas moisture	<10 gr/m^3	✓
Gas meter:		
Uncertainty of gas volume	<2%	✓
Uncertainty of absolute pressure	≤ %	✓
Uncertainty of absolute temperature	≤ %	✓
Angle of the nozzle with regard to gas flow Isokinetic rate	<10°	✓
Isokinetic rate	95% to 115%	✓
Leak rate	<2%	✓
Balance resolution	0.01 mg to 0.1 mg	✓
Weighing uncertainties	<5 % of the LV[a]	X
Weighing: temperature equilibrium duration	4h to l2h	✓
Overall blank value	<10%of the LV[a]	✓
Sampling location		
Duct gas flow: angle with regard to duct access	<15°	X
Duct gas flow: negative velocity	not permitted	X
Duct gas flow: differential pressure at Pitot tube	> 5 Pa	X
Duct gas flow: ratio of max. to min. velocity	<3:1	X
Straight length before the sampling plane	> 5 hydraulic diameters (recommended)	✓
Straight length after the sampling plane	> 2 hydraulic diameters (recommended)	X
Straight length before emission point	> 5 hydraulic diameters (recommended)	X
Correct number of sampling points for standard?		✓
Flue Gas Characteristics		
Flue gas density: uncertainty	0.05 kg/rn^3	✓
LV[a]: Limit Value set for the process	mg/m^3	10

---ooo0ooo---

End of Report

mCERTS
THE ENVIRONMENT AGENCY'S MONITORING CERTIFICATION SCHEME

TEST REPORT

UKAS TESTING
1618

Report for the Periodic Monitoring of Emissions to Air **(Part 1)**

Operator: **Nationwide Crash Repair Centre**

Installation: **Coventry**
Spray Booth 2

Monitoring dates:	11th January 2006
Contract number:	Q0036117
Client Organisation:	Nationwide Crash Repair Centre
Address:	Stonybridge Trading Estate
	Rowley Drive
	Coventry
	CV3 4FG
Monitoring Organisation:	CPL Laboratories
Address:	Mill Lane
	Wingerworth
	Chesterfield
	S42 6NG
Date of Report:	10th February 2006
Report Approved by:	C.M. Greenaway
MCERTS Registration Number:	02 048
Function:	Team Leader
Signed:	[redacted]

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Contents

1.1 Monitoring Objectives

Mr M. Rose of Nationwide Craft Repair Centre, requested CPL Laboratories to monitor emissions to air from Spray Booth 2.

The monitoring was carried out on the 11th January 2006, to determine compliance with specified emission limits. The substances requested for monitoring at each emission point are listed below.

Substances To be Monitored	**Emission Point Identification**
	Spray Booth 2
Total particulate matter (TPM)	

Special Requirements:	None

1.2 Monitoring Results

Emission point reference	**Spray Booth 2**
Substance to be monitored	**Total particulate matter (TPM)**
Emission limit value mg/m^3	10
Periodic monitoring results mg/m^3	0.51 <0.51
Uncertainty %	447 447
Monitoring Method reference	ISO 9096: 2003
Accreditation for use of method	UKAS MCERTS
Date of sampling	11/01/06
Start & end times	10:30 – 11:10 11:10 – 11:42
Reference conditions 273K, 101.3kPa	No correction for oxygen or moisture
Operating status	Normal

1.3 Operating Information

This process involves the paint spraying of automobiles within confined booths and extraction through a filter unit before outlet to air.

Emission point reference	Spray Booth 2
Date	11/01/06
Process type	Panel Spraying
Process duration	Approximately 30 to 60 mins
Fuel	Not Applicable
Feedstock	Paints
Abatement	Filters
Load	Automobiles

Comparison with Operator CEMs	
Operator CEMs Particulate matter mg/m^3	Not Applicable
Particulate matter mg/m^3 Periodic monitoring results	0.51 <0.51

1.4 Monitoring Deviations

Emission point reference	Spray Booth 2	
Substance deviations	None	
Monitoring deviations	Note 1	Note 4
Other relevant issues	Note 2	Note 3

Notes

1. Nozzle diameter less than 6mm
2. Less than 2 duct diameters straight length after the sampling plane
3. Less than 5 duct diameters straight length before the emission point
4. Weighing uncertainties greater than 5% of the LV

TEST REPORT

1618

Report for the Periodic Monitoring of Emissions to Air **(Part 2)**

Operator: **Nationwide Crash Repair Centre**

Installation: **Coventry**
Spray Booth 2

Monitoring dates:	11th January 2006
Contract number:	Q0036117
Client Organisation:	Nationwide Crash Repair Centre
Address:	Stonybridge Trading Estate Rowley Drive Coventry CV3 4FG
Monitoring Organisation:	CPL Laboratories
Address:	Mill Lane Wingerworth Chesterfield S42 6NG
Date of Report:	10th February 2006
Report Approved by:	C Greenaway
MCERTS Registration Number:	02 048
Function:	Team Leader
Signed:	[redacted]

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Contents

2 Part 2: Supporting Information

2.1 Appendix 1: General Information

2.1.1 Monitoring organisation staff details

Sampling Team Members

Name	MCert Status	MCert Registration No.	Responsibility
C M Greenaway	Level 2 With TE 1, 2, 3, 4	MM 02 048	Team Leader
D Martschenko	-	-	Technician

2.1.2 Monitoring organisation method details

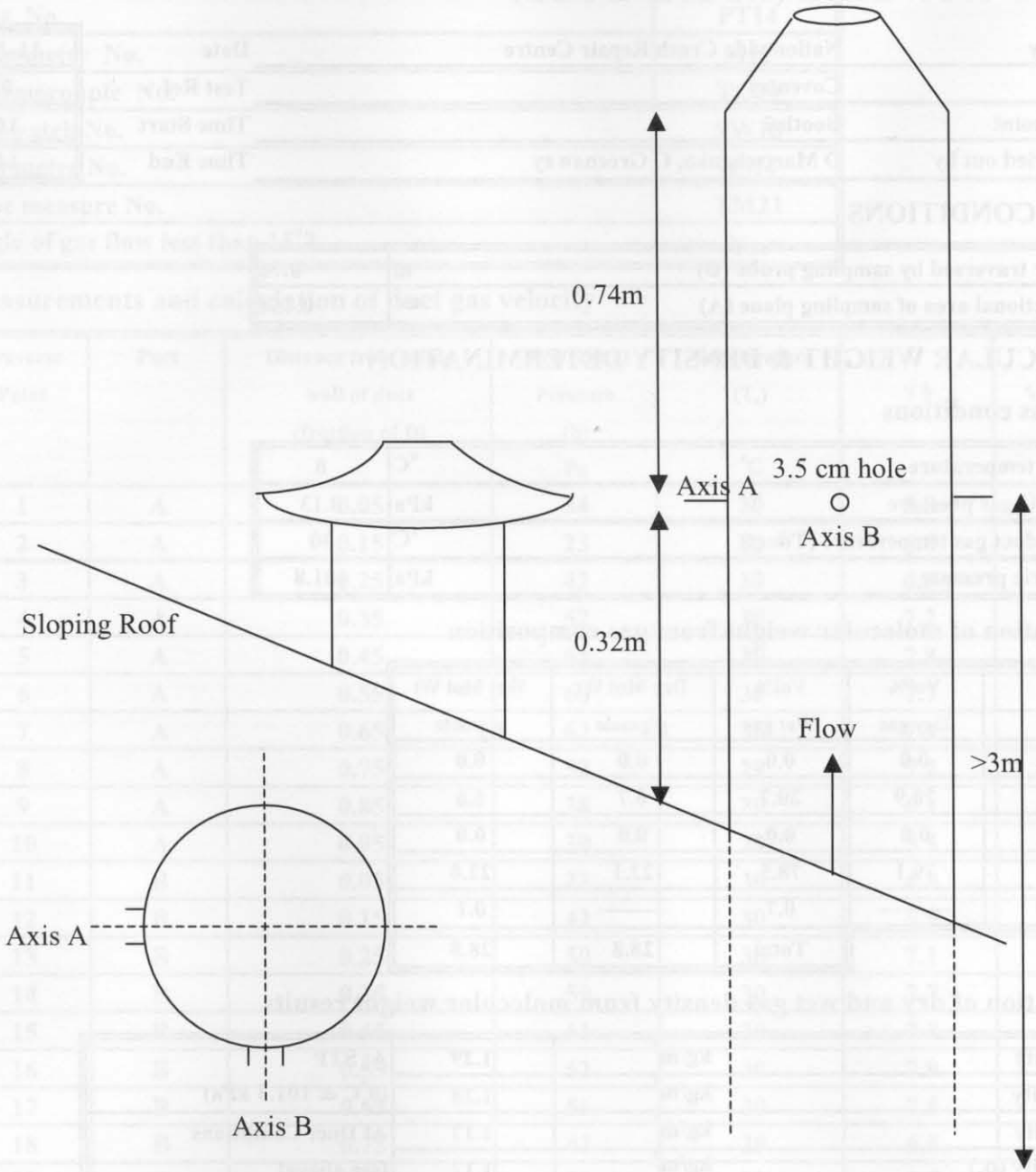
Pollutant	Measurement Method	No. tests / blanks
Total Particulate Matter (TPM)	ST 6 ISO 9096: 2003	2 / 1

2.1.3 Monitoring organisation equipment checklist

06/007	CL-081

2.2 Appendix 2

2.2.1 Diagram of Sampling Location and Position



CPL LABORATORIES MONITORING REPORT FORM
PITOT TRAVERSE (ROUND DUCT)

Company	Nationwide Crash Repair Centre	Date	11-Jan-06
Site	Coventry	Test Ref	FL1
Sample point	Booth 2	Time Start	14:45
Test carried out by	D Martschenko, C Greenaway	Time End	14:49

DUCT CONDITIONS

Diameter traversed by sampling probe (D)	m	0.76
Cross sectional area of sampling plane (A)	m^2	0.454

MOLECULAR WEIGHT & DENSITY DETERMINATION

Duct gas conditions

Ambient temperature	°C	8
Duct static gas pressure	kPa	0.13
Average duct gas temperature (Tduct)	°C	30
Barometric pressure	kPa	101.8

Calculation of molecular weight from gas composition

Gas	Vol% Dry gas	Vol% Wet gas	Dry Mol Wt g/gmole	Wet Mol Wt g/gmole
CO_2	0.0	0.0	0.0	0.0
O_2	20.9	20.7	6.7	6.6
CO	0.0	0.0	0.0	0.0
N_2	79.1	78.5	22.1	22.0
H_2O	---------	0.7	---------	0.1
		Total	28.8	28.8

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	1.17	At Duct Conditions
Wet density (ρ_a)	kg/m^3	1.17	(see above)
Wet specific gravity (sg)		0.993	

PITOT TRAVERSE

Details of measurement equipment and supplementary measurements

Pitot type ('L' or 'S' type)	L
Pitot calibration factor	1.001
Pitot No.	PT14
Manometer No.	M17
Thermocouple No.	TC44
Stopwatch No.	SW18
Barometer No.	BM4
Tape measure No.	TM21
Angle of gas flow less than 15°?	Yes

Measurements and calculation of duct gas velocity

Traverse Point	Port	Distance from inside wall of duct (fraction of D)	Differential Pressure (h) Pa	Temperature (T_s) °C	$\sqrt{h}$	Gas Velocity (V_s) m/s
1	A	0.05	34	30	5.8	7.7
2	A	0.15	23	30	4.8	6.3
3	A	0.25	42	30	6.5	8.5
4	A	0.35	52	30	7.2	9.5
5	A	0.45	61	30	7.8	10.3
6	A	0.55	60	30	7.7	10.2
7	A	0.65	62	30	7.9	10.3
8	A	0.75	52	29	7.2	9.5
9	A	0.85	38	29	6.2	8.1
10	A	0.95	30	29	5.5	7.2
11	B	0.05	23	30	4.8	6.3
12	B	0.15	42	30	6.5	8.5
13	B	0.25	50	30	7.1	9.3
14	B	0.35	59	30	7.7	10.1
15	B	0.45	61	30	7.8	10.3
16	B	0.55	62	30	7.9	10.3
17	B	0.65	56	30	7.5	9.8
18	B	0.75	42	29	6.5	8.5
19	B	0.85	32	29	5.7	7.4
20	B	0.95	42	29	6.5	8.5

	H_{Duct}	T_{Duct}	$\sqrt{h}_{Duct}$	(V_s)
Averages	46.2	30	6.7	8.82

CALCULATION OF VELOCITY & FLOW RATE

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

where V_{Duct} = gas velocity at sampling point (m/s)

K_{pt} = pitot calibration factor (dimensionless)

$1-\varepsilon$ = compressibility correction (assumed constant at 0.995)

ρ_a = wet gas density under duct conditions (kg/m^3)

h = differential pressure (Pa)

Average gas velocity (V_{Ducta}) = **8.8 m/s**

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

= **4.0 m^3/s**

Conversion of actual duct gas flow to reference conditions

Actual Duct Flow Conditions			Reference Conditions		
Average temperature (T_{Duct})	°C	30	Temperature (T_{Ref})	°C	0.0
Total pressure (P_{Duct})	kPa	101.9	Pressure (P_{Ref})	kPa	101.3
Oxygen (O_{2Duct})	% vol,dry	20.9	Oxygen (O_{2Ref})	% vol, dry	20.9
Water vapour (H_2O_{Duct})	% vol	0.7	Water vapour (H_2O_{Ref})	% vol	0.7

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} = **3.6 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 = **3.6 m^3/s**

2.2.3 Water vapour measurements

CPL LABORATORIES MONITORING REPORT FORM
WATER VAPOUR (GRAVIMETRIC TECHNIQUE)

Company	Nationwide Crash Repair Centre	Date	11-Jan-06
Site	Coventry	Test Ref	H_20 1,2
Sample point	Booth 2	Prepared	D Martschenko
Test carried out by	D Martschenko, C Greenaway	Checked	G. Carroll

SAMPLING TIMES

Determination	1	2
Time Start	10:30	11:10
Time End	11:06	11:42

SAMPLING CONDITIONS

Determination		1	2
Gas meter temperature (T_{meter})	°C	10	12
Atmospheric pressure (P_{atm})	kPa	101.8	101.8
Final meter reading	m^3	218.898	219.092
Initial meter reading	m^3	218.696	218.899
Gas meter calibration factor		0.983	0.983
Volume of gas sampled (VG_{meter})	l	198.5	189.8

SAMPLE TUBE WEIGHTS

Determination		1	2
Tube			
Final weight (M_{fl})	g	145.6	129.1
Initial weight (M_{il})	g	144.7	127.8
Weight gain (M_{fl}-M_{il} = M_{gl})	g	0.9	1.3

Sample gas volume at STP, VG_{STP}

$VG_{STP} = VG_{meter} \times (273 \times P_{atm})/(101.3 \times (273 + T_{meter}))$

Determination		1	2
Volume of gas sampled (VG_{STP})	l, STP	192.3	183.0

Calculation of water vapour content in duct gas, C_g

C_g (% vol) = $100 \times (M_t \times MV_{STP} \div MW_{H2O}) \div (VG_{STP} + (M_t \times MV_{STP} \div MW_{H2O}))$

where MV_{STP} is the ideal gas molecular volume at STP (i.e. 22.412 m^3/kgmole)

MW_{H2O} is the molecular weight of water (i.e. 18 kg/kgmole)

WATER VAPOUR MEASUREMENTS

Determination		1	2
Water vapour content	%,vol	0.6	0.9
Mean water vapour content	%,vol	0.7	
Water vapour concentration	kg/m^3	0.005	0.007
Mean water vapour concentration	kg/m^3	0.006	

2.2.4 Sampling measurements

CPL LABORATORIES MONITORING REPORT FORM
TOTAL PARTICULATE

Company	Nationwide Crash Repair Centre	Date	11-Jan-06
Site	Coventry	Test Ref	TE1
Sample point	Booth 2	Time Start	10:30
Test carried out by	D Martschenko, C Greenaway	Time End	11:06

Duct conditions

Dimension traversed by sampling probe (D)	m	0.76
Cross sectional area of sampling plane (A)	m^2	0.454

Duct gas conditions

Ambient temperature (T_{Amb})	°C	9
Average duct gas temperature (T_{Duct})	°C	32
Duct static gas pressure (P_{Static})	kPa	0.13
Barometric pressure (P_{Baro})	kPa	101.8
Duct gas volume flowrate @ ref. conditions (Q_{Ref})	m^3/s	3.61
Gas compressibility correction (ε)		0.995
Wet gas specific gravity (sg)		0.99

Reference conditions

Actual Duct Flow Conditions			Reference Conditions		
Average temperature (T_{Duct})	°C	32	Temperature (T_{Ref})	°C	0
Total pressure (P_{Duct})	kPa	101.9	Pressure (P_{Ref})	kPa	101.3
Oxygen (O_{2Duct})	% vol,dry	20.9	Oxygen (O_{2Ref})	% vol, dry	20.9
Water vapour (H_2O_{Duct})	% vol	0.6	Water vapour (H_2O_{Ref})	% vol	0.6

Sampling conditions

Nozzle diameter (d)	mm	3.99
Initial gas meter reading	m^3	218.696
Final gas meter reading	m^3	218.898
Gas meter factor		0.983
Sampled volume (SV_{Meter})	m^3	0.198

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

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

Corrections
Temperature
Pressure
Water vapour
Oxygen

Sampled volume @ ref. conditions (SV_{Ref})	m^3	0.194

Prepared by: D Martschenko **Checked by:** G. Carroll

CPL LABORATORIES MONITORING REPORT FORM
TOTAL PARTICULATE

Company	Nationwide Crash Repair Centre	Date	11-Jan-06
Site	Coventry	Test Ref	TE2
Sample point	Booth 2	Time Start	11:10
Test carried out by	D Martschenko, C Greenaway	Time End	11:42

Duct conditions

Dimension traversed by sampling probe (D)	m	0.76
Cross sectional area of sampling plane (A)	m^2	0.454

Duct gas conditions

Ambient temperature (T_{Amb})	°C	12
Average duct gas temperature (T_{Duct})	°C	30
Duct static gas pressure (P_{Static})	kPa	0.13
Barometric pressure (P_{Baro})	kPa	101.8
Duct gas volume flowrate @ ref. conditions (Q_{Ref})	m^3/s	3.61
Gas compressibility correction (ε)		0.995
Wet gas specific gravity (sg)		0.99

Reference conditions

Actual Duct Flow Conditions			Reference Conditions		
Average temperature (T_{Duct})	°C	30	Temperature (T_{Ref})	°C	0
Total pressure (P_{Duct})	kPa	101.9	Pressure (P_{Ref})	kPa	101.3
Oxygen (O_{2Duct})	% vol,dry	20.9	Oxygen (O_{2Ref})	% vol, dry	20.9
Water vapour (H_2O_{Duct})	% vol	0.9	Water vapour (H_2O_{Ref})	% vol	0.7

Sampling conditions

Nozzle diameter (d)	mm	4.0
Initial gas meter reading	m^3	218.899
Final gas meter reading	m^3	219.092
Gas meter factor		0.983
Sampled volume (SV_{Meter})	m^3	0.190

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

Sampled volume @ ref. conditions (SVR_{ef})	m^3	0.184

Prepared by: D Martschenko **Checked by:** G. Carroll

Static pressure before gas meter	0	Pa	Pitot factor	1.001	
Water Vapour Concentration	0.01	kg/m3			
Moisture Content	0.7	%			

MEASUREMENT OF TOTAL PARTICULATE

Test 1

Time	Posn.	Pitot rdg. Pa	Duct temp. °C	Duct CO2 %	Duct O2 %	Meter temp. °C	Duct static Pa	Baro press. kPa	Nozzle dia. mm	Iso. rate l/min	Actual flow l/min	Vol.sampled m^3 meter	m^3 cum.	reqd. vol. m^3	Cum. dev. %
0	2	47	29	0.0	20.9	8	130	101.7	3.99	6.2	6.2	218.696	0.000	0.000	
4	4	55	29	0.0	20.9	8	130	101.7	3.99	6.7	6.8	218.721	0.025	0.025	-0.1
8	7	68	29	0.0	20.9	9	130	101.7	3.99	7.5	7.6	218.749	0.052	0.052	0.4
12	9	20	34	0.0	20.9	9	130	101.7	3.99	4.0	4.1	218.779	0.083	0.082	0.7
16	2	38	35	0.0	20.9	10	130	101.8	3.99	5.6	5.6	218.795	0.099	0.098	0.8
20	4	68	35	0.0	20.9	10	130	101.8	3.99	7.5	7.6	218.818	0.121	0.121	0.7
24	7	64	32	0.0	20.9	10	130	101.8	3.99	7.3	7.4	218.848	0.152	0.150	1.0
28	9	30	31	0.0	20.9	10	130	101.8	3.99	5.0	5.1	218.878	0.182	0.180	1.2

MASS OF PARTICULATES COLLECTED

Filter no.	NCR6
Filter + particulates, g	0.5277
Filter, g	0.5276
Mass collected, g	1E-04

Washing bottle no.	
Washing filter + particulates, g	0
Washing filter, g	0
Mass collected, g	0
Proportionalised weight	0

Total mass collected, g	0.0001

OVERALL BLANK

Filter no.	NCR3
Filter + particulates, g	0.4682
Filter, g	0.4680
Mass Change, g	0.0002

Washing bottle no.	
Evaporating Basin + particulates, g	0
Evaporating Basin , g	0
Mass collected, g	0

TOTAL FIELD BLANK g 0.0002

CALCULATIONS

(Q_{duct}), Flow in the duct, at duct conditions, m^3/s	3.97869515
(Q_{ref}), Flow in the duct, at reference conditions, m^3/s	3.6096
(M), Mass flow at duct conditions, kg/h	0.0074
(C), Concentration of particulate matter at reference conditions, mg/m^3	0.51

MEASUREMENT OF TOTAL PARTICULATE

Test 2

Time	Posn.	Pitot rdg. Pa	Duct temp. °C	Duct CO2 %	Duct O2 %	Meter temp. °C	Duct static Pa	Baro press. kPa	Nozzle dia. mm	Iso. rate l/min	Actual flow l/min	Vol.sampled m^3 meter	m^3 cum.	reqd. vol. m^3	Cum. dev. %
0	2	44	30	0.0	20.9	11	130	101.8	3.99	6.1	6.0	218.899	0.000	0.000	
4	4	56	31	0.0	20.9	12	130	101.8	3.99	6.9	7.1	218.923	0.024	0.024	-1.0
8	7	56	30	0.0	20.9	12	130	101.8	3.99	6.9	7.0	218.951	0.052	0.052	1.1
12	9	36	31	0.0	20.9	12	130	101.8	3.99	5.5	5.8	218.979	0.080	0.079	1.0
16	2	15	31	0.0	20.9	12	130	101.8	3.99	3.6	3.6	219.002	0.103	0.101	1.9
20	4	58	30	0.0	20.9	12	130	101.8	3.99	7.0	7.0	219.017	0.118	0.116	1.7
24	7	70	30	0.0	20.9	12	130	101.8	3.99	7.7	7.9	219.044	0.146	0.144	1.3
28	9	18	30	0.0	20.9	12	130	101.8	3.99	3.9	4.0	219.076	0.177	0.175	1.5

MASS OF PARTICULATES COLLECTED

Filter no.	NCR7
Filter + particulates, g	0.5254
Filter, g	0.5254
Mass collected, g	0

Washing bottle no.	
Washing filter + particulates, g	0
Washing filter, g	0
Mass collected, g	0
Proportionalised weight	0

Total mass collected, g	0

OVERALL BLANK

Filter no.	NCR3
Filter + particulates, g	0.4682
Filter, g	0.4680
Mass Change, g	0.0002

Washing bottle no.	
Evaporating Basin + particulates, g	0
Evaporating Basin , g	0
Mass collected, g	0

TOTAL FIELD BLANK g 0.0002

CALCULATIONS

(Q_{duct}), Flow in the duct, at duct conditions, m^3/s	3.97869515
(Q_{ref}), Flow in the duct, at reference conditions, m^3/s	3.6096
(M), Mass flow at duct conditions, kg/h	0
(C), Concentration of particulate matter at reference conditions, mg/m^3	0

(M), Mass flow at duct conditions, kg/h = C x Q duct x 0.0036

(C), Concentration of particulate matter at reference conditions, mg/m^3 = Total mass collected, g / Sampled volume at ref conditions, m^3

2.2.5 Manual monitoring method results calculations

Formula 1 - Determination of Moisture Content

$$V_o = V_m.(273 \div T_m).(P_b \div 101.3)$$

$$\%\ H_20 = 100.(M_w \div 18) \div [(V_o \div 22.412) + (M_w \div 18)]$$

Where :

$\%H_20$	- Moisture content of the gas sampled, %
M_w	- Mass of water collected during the test, g
V_o	- Volume sampled at reference conditions, litres
V_m	- Volume sampled at meter conditions, litres
T_m	- Mean meter temperature during the test, K
P_b	- Mean meter conditions during test, kPa

Formula 2 - Determination of mean velocity

$$V = 0.0753.\sqrt{T}.\sqrt{h}$$

Where

V	- Mean velocity during test, m/s
$\sqrt{T}$	- Mean square root of temperatures before and after test, K
$\sqrt{h}$	- Mean square root of pitot-static readings before and after test, Pa

Formula 3 - Volume flow rate of duct gases, at duct temperatures

$$Q_{(duct)} = V.A$$

Where

$Q_{(duct)}$	- Volume flow rate of duct gases, m^3/s
V	- Mean velocity, m/s
A	- Area of duct (at the sampling plane), m^2

Formula 4 - Volume flow rate of duct gases, specified reference conditions

$$Q_o = Q_{(duct)}.(T_{ref} \div T_{duct}).(P_{duct} \div P_{ref}).[(100 - \%H_20) \div 100].[(20.9 - O_{2duct}) \div (20.9 - O_{2rel})]$$

Where

Q_o	- Volume flow rate at reference conditions, and relative O_2 and moisture correction, m^3/s
T_{ref}	- reference Temperature, K
T_{duct}	- Mean temperature across the duct, K
P_{duct}	- Relative static pressure in the duct, kPa
P_{ref}	- Reference pressure, kPa
$\%H_20$	- Water content, %
O_{2duct}	- Oxygen content as measured during the test, *%v/v*
O_{2rel}	- Relative Oxygen content for the process, *%v/v*

2.2.6 Uncertainty calculations

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

Test 1

Limit value	10	**mg.m^{-3}**	**Reference oxygen**	20.9	**% by volume**
Measured concentration	0.51	**mg.m^{-3}**			

Measurement Equation

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

Measured Quantities	**Symbol**	**Value**	**Standard uncertainty**		**Units**	**Uncertainty as percentage**	**Uncertainty at limit value**	**Requirement of standard**
Sampled Volume	V_m	0.194	uV_m	0.002	**m^3**	1.03		<=2%
Sampled gas Temperature	T_m	305	uTm	1	k	0.33		<=1%
Sampled gas Pressure	ρ_m	101.67	$u\rho_m$	0.1	**kPa**	0.10		<=1%
Sampled gas Humidity	H_m	0.6	uH_m	0.15	**% by volume**	25.00		<=1%
Oxygen content	$O_{2,m}$	20.9	$uO_{2,m}$	0.1	**% by volume**	0.48		<=5%
Mass particulate	m	0.1	um	0.2	**mg**	200.00	10.20	<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	UCM	0			**mg**	0.00		<=10%

Intermediate calculations						
Factor for std conds	fs	0.89				
uncertainty components	symbol	**sensitivity coeff**	**u (in units of fs)**			
	ρ_m	0.009	0.001			
	H_m	0.009	0.001		$f_s = \frac{(100 - H_m)}{100} \frac{273}{T_m} \frac{\rho_m}{101.3}$	
	T_m	0.003	0.003			
	ufs		0.003			0.37
Corrected volume	V	0.17	uV	0.002 **m^3**	$V = V_m f_s$	1.21
Factor for O2 correction	fc	1.00				
uncertainty components	symbol	**sensitivity coeff**	**u**		$f_c = \frac{21 - O_{2,ref}}{21 - O_{2,m}}$	
	$O_{2,m}$	10.00	1.000			
Factor for O2 Correction	ufc	1.00	1.000			100.00

Parameter	**Uncertainty, i**	**Value**	**Units**	**Sensitivity coeff**	**Uncertainty in Result**	**Uncertainty as %**
Volume(standard conditions)	V	0.17	m^3	2.94	0.01 mg.m^{-3}	1.21 %
Mass	m	0.10	mg	5.10	1.02 mg.m^{-3}	200.00
Factor for O2 Correction	fc	1.00		0.51	0.51 mg.m^{-3}	100.00 %
Leak	L	0.01	mg.m^{-3}	1.00	0.01 mg.m^{-3}	
Uncollected mass	UCM	0.00	mg	5.10	0.00 mg.m^{-3}	
Combined uncertainty					**1.14** mg.m^{-3}	

Expanded uncertainty	**expressed with a level of confidence of 95%**	**447.23**	**%**
Expanded uncertainty	**expressed with a level of confidence of 95%**	**2.28**	**mg.m^{-3}**

Test 2

Limit value	10	**mg.m^{-3}**	**Reference oxygen**	20.9	**% by volume**
Measured concentration	0.54	**mg.m^{-3}**			

Measurement Equation

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

Measured Quantities	**Symbol**	**Value**	**Standard uncertainty**		**Units**	**Uncertainty as percentage**	**Uncertainty at limit value**	**Requirement of standard**
Sampled Volume	V_m	0.184	uV_m	0.002	**m^3**	1.09		<=2%
Sampled gas Temperature	T_m	303	uTm	1	k	0.33		<=1%
Sampled gas Pressure	ρ_m	101.67	$u\rho_m$	0.1	**kPa**	0.10		<=1%
Sampled gas Humidity	H_m	0.9	uH_m	0.15	**% by volume**	16.67		<=1%
Oxygen content	$O_{2,m}$	20.9	$uO_{2,m}$	0.1	**% by volume**	0.48		<=5%
Mass particulate	m	0.1	um	0.2	**mg**	200.00	10.80	<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	UCM	0			**mg**	0.00		<=10%

Intermediate calculations						
Factor for std conds	fs	0.90				
uncertainty components	symbol	**sensitivity coeff**	**u (in units of fs)**			
	ρ_m	0.009	0.001			
	H_m	0.009	0.001		$f_s = \frac{(100 - H_m)}{100} \frac{273}{T_m} \frac{\rho_m}{101.3}$	
	T_m	0.003	0.003			
	ufs		0.003			0.38
Corrected volume	V	0.16	uV	0.002 **m^3**	$V = V_m f_s$	1.27
Factor for O2 correction	fc	1.00				
uncertainty components	symbol	**sensitivity coeff**	**u**		$f_c = \frac{21 - O_{2,ref}}{21 - O_{2,m}}$	
	$O_{2,m}$	10.00	1.000			
Factor for O2 Correction	ufc	1.00	1.000			100.00

Parameter	**Uncertainty, i**	**Value**	**Units**	**Sensitivity coeff**	**Uncertainty in Result**	**Uncertainty as %**
Volume(standard conditions)	V	0.16	m^3	3.27	0.01 mg.m^{-3}	1.27 %
Mass	m	0.10	mg	5.40	1.08 mg.m^{-3}	200.00
Factor for O2 Correction	fc	1.00		0.54	0.54 mg.m^{-3}	100.00 %
Leak	L	0.01	mg.m^{-3}	1.00	0.01 mg.m^{-3}	
Uncollected mass	UCM	0.00	mg	5.40	0.00 mg.m^{-3}	
Combined uncertainty					**1.21** mg.m^{-3}	

Expanded uncertainty	**expressed with a level of confidence of 95%**	**447.23**	**%**
Expanded uncertainty	**expressed with a level of confidence of 95%**	**2.42**	**mg.m^{-3}**

Appendix 3

Stack: **Spray Booth 2**

Equipment	Value	No X
Nozzle: internal diameter	>6 mm	X
Nozzle: uncertainty of area at nozzle entry	⩽0%	✓
Nozzle: length with constant internal diameter	>10 mm	✓
Nozzle: change in diameter angle	<30°	✓
Nozzle: radius of the bend	.>1.5 times internal diameter	✓
Nozzle: straight length before the first bend	>30 mm	✓
Filter holder: distance to obstacles	>50mm	✓
Filter:		
Efficiency on test aerosol of 0.3 μm	>99.5 %	✓
Efficiency on test aerosol of 0.6 μm	>99.9%	✓
Filter: filter material	No reaction and no absorption of the components	✓
Condenser, drying tower: residual gas moisture	<10 gr/m^3	✓
Gas meter:		
Uncertainty of gas volume	<2%	✓
Uncertainty of absolute pressure	⩽ %	✓
Uncertainty of absolute temperature	⩽ %	✓
Angle of the nozzle with regard to gas flow Isokinetic rate	<10°	✓
Isokinetic rate	95% to 115%	✓
Leak rate	<2%	✓
Balance resolution	0.01 mg to 0.1 mg	✓
Weighing uncertainties	<5 % of the LV a	X
Weighing: temperature equilibrium duration	4h to l2h	✓
Overall blank value	<10%of the LV a	✓
Sampling location		
Duct gas flow: angle with regard to duct access	<15°	✓
Duct gas flow: negative velocity	not permitted	✓
Duct gas flow: differential pressure at Pitot tube	> 5 Pa	✓
Duct gas flow: ratio of max. to min. velocity	<3:1	✓
Straight length before the sampling plane	> 5 hydraulic diameters (recommended)	✓
Straight length after the sampling plane	> 2 hydraulic diameters (recommended)	X
Straight length before emission point	> 5 hydraulic diameters (recommended)	X
Correct number of sampling points for standard?		✓
Flue Gas Characteristics		
Flue gas density: uncertainty	0.05 kg/rn^3	✓
LV[a]: Limit Value set for the process	mg/m^3	10

---ooo0ooo---

End of Report

mCERTS
THE ENVIRONMENT AGENCY'S MONITORING CERTIFICATION SCHEME

TEST REPORT

UKAS TESTING
1618

Report for the Periodic Monitoring of Emissions to Air **(Part 1)**

Operator: **Nationwide Crash Repair Centre**

Installation: **Coventry**
Spray Booth 3

Monitoring dates:	11-12th January 2006
Contract number:	Q0036117
Client Organisation:	Nationwide Crash Repair Centre
Address:	Stonybridge Trading Estate
	Rowley Drive
	Coventry
	CV3 4FG
Monitoring Organisation:	CPL Laboratories
Address:	Mill Lane
	Wingerworth
	Chesterfield
	S42 6NG
Date of Report:	10th February 2006
Report Approved by:	C. M. Greenaway
MCERTS Registration Number:	02 048
Function:	Team Leader
Signed:	[redacted]

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Contents

1.1 Monitoring Objectives

Mr M. Rose of Nationwide Craft Repair Centre, requested CPL Laboratories to monitor emissions to air from Spray Booth 3.

The monitoring was carried out on the 11-12th January 2006, to determine compliance with specified emission limits. The substances requested for monitoring at each emission point are listed below.

Substances To be Monitored	**Emission Point Identification**
	Spray Booth 3
Total particulate matter (TPM)	

Special Requirements:	None

1.2 Monitoring Results

Emission point reference	**Spray Booth 3**	
Substance to be monitored	**Total particulate matter (TPM)**	
Emission limit value mg/m^3	10	
Periodic monitoring results mg/m^3	<0.52	<0.56
Uncertainty %	400	400
Monitoring Method reference	ISO 9096: 2003	
Accreditation for use of method	UKAS MCERTS	
Date of sampling	11/01/06	12/01/06
Start & end times	13:57 – 14:27	9:05 – 9:37
Reference conditions 273K, 101.3kPa	No correction for oxygen or moisture	
Operating status	Normal	

1.3 Operating Information

This process involves the paint spraying of automobiles within confined booths and extraction through a filter unit before outlet to air.

Emission point reference	Spray Booth 3
Date	11-12/01/06
Process type	Panel Spraying
Process duration	Approximately 30 to 60 mins
Fuel	Not Applicable
Feedstock	Paints
Abatement	Filters
Load	Automobiles

Comparison with Operator CEMs	
Operator CEMs Particulate matter mg/m^3	Not Applicable
Particulate matter mg/m^3 Periodic monitoring results	<0.52 <0.56

1.4 Monitoring Deviations

Emission point reference	Spray Booth 3	
Substance deviations	None	
Monitoring deviations	Note 1	Note 4
Other relevant issues	Note 2	Note 3

Notes

1. Nozzle diameter less than 6mm
2. Less than 2 duct diameters straight length after the sampling plane
3. Less than 5 duct diameters straight length before the emission point
4. Weighing uncertainties greater than 5% of the LV

TEST REPORT

1618

Report for the Periodic Monitoring of Emissions to Air **(Part 2)**

Operator: **Nationwide Crash Repair Centre**

Installation: **Coventry**
Spray Booth 3

Monitoring dates: 11-12th January 2006
Contract number: Q0036117
Client Organisation: Nationwide Crash Repair Centre
Address: Stonybridge Trading Estate
Rowley Drive
Coventry
CV3 4FG

Monitoring Organisation: CPL Laboratories
Address: Mill Lane
Wingerworth
Chesterfield
S42 6NG

Date of Report: 10th February 2006
Report Approved by: C Greenaway
MCERTS Registration Number: 02 048
Function: Team Leader
Signed: [redacted]

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Contents

2 Part 2: Supporting Information

2.1 Appendix 1: General Information

2.1.1 Monitoring organisation staff details

Sampling Team Members

Name	MCert Status	MCert Registration No.	Responsibility
C M Greenaway	Level 2 With TE 1, 2, 3, 4	MM 02 048	Team Leader
D Martschenko	-	-	Technician

2.1.2 Monitoring organisation method details

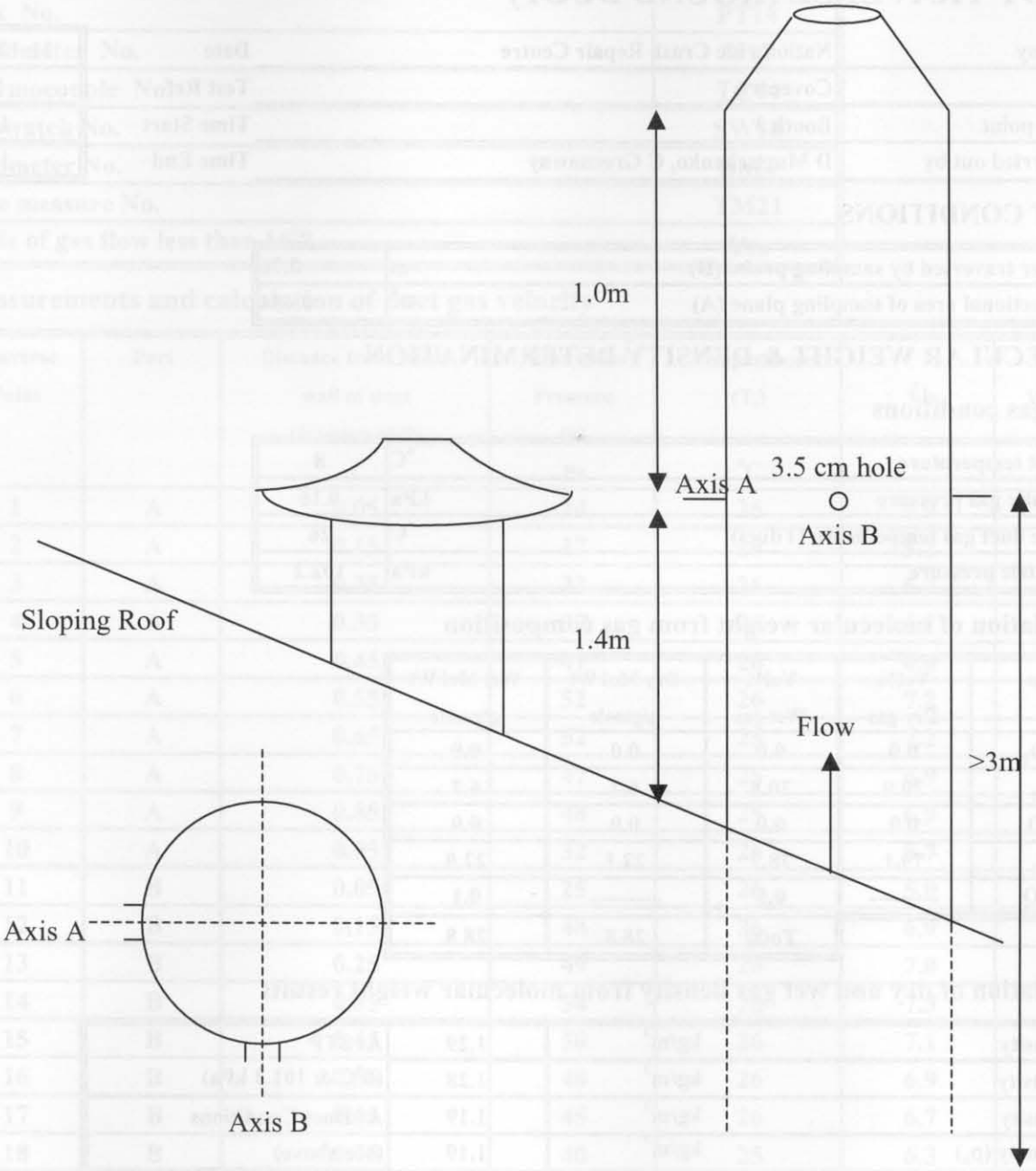
Pollutant	Measurement Method	No. tests / blanks
Total Particulate Matter (TPM)	ST 6 ISO 9096: 2003	2 / 1

2.1.3 Monitoring organisation equipment checklist

06/007	CL-081

2.2 Appendix 2

2.2.1 Diagram of Sampling Location and Position



2.2.2 Flow criteria and gas measurements

CPL LABORATORIES MONITORING REPORT FORM
PITOT TRAVERSE (ROUND DUCT)

Company	Nationwide Crash Repair Centre	Date	11-12/01/2006
Site	Coventry	Test Ref	FL1
Sample point	Booth 3	Time Start	14:45
Test carried out by	D Martschenko, C Greenaway	Time End	14:49

DUCT CONDITIONS

Diameter traversed by sampling probe (D)	m	0.76
Cross sectional area of sampling plane (A)	m^2	0.454

MOLECULAR WEIGHT & DENSITY DETERMINATION

Duct gas conditions

Ambient temperature	^oC	8
Duct static gas pressure	kPa	0.16
Average duct gas temperature (Tduct)	^oC	26
Barometric pressure	kPa	102.2

Calculation of molecular weight from gas composition

Gas	Vol% Dry gas	Vol% Wet gas	Dry Mol Wt g/gmole	Wet Mol Wt g/gmole
CO_2	0.0	0.0	0.0	0.0
O_2	20.9	20.8	6.7	6.7
CO	0.0	0.0	0.0	0.0
N_2	79.1	78.7	22.1	22.0
H_2O	---------	0.5	---------	0.1
		Total	28.8	28.8

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^oC & 101.3 kPa)
Dry density	kg/m^3	1.19	At Duct Conditions
Wet density (ρ_a)	kg/m^3	1.19	(see above)
Wet specific gravity (sg)		0.994	

PITOT TRAVERSE

Details of measurement equipment and supplementary measurements

Pitot type ('L' or 'S' type)	L
Pitot calibration factor	1.001
Pitot No.	PT14
Manometer No.	M17
Thermocouple No.	TC44
Stopwatch No.	SW18
Barometer No.	BM4
Tape measure No.	TM21
Angle of gas flow less than 15°?	Yes

Measurements and calculation of duct gas velocity

Traverse Point	Port	Distance from inside wall of duct (fraction of D)	Differential Pressure (h) Pa	Temperature (T_s) °C	√ h	Gas Velocity (V_s) m/s
1	A	0.05	24	26	4.9	6.4
2	A	0.15	27	26	5.2	6.8
3	A	0.25	32	26	5.7	7.4
4	A	0.35	37	26	6.1	7.9
5	A	0.45	41	26	6.4	8.3
6	A	0.55	52	26	7.2	9.4
7	A	0.65	52	25	7.2	9.4
8	A	0.75	47	25	6.9	8.9
9	A	0.85	48	25	6.9	9.0
10	A	0.95	32	26	5.7	7.4
11	B	0.05	25	26	5.0	6.5
12	B	0.15	48	26	6.9	9.0
13	B	0.25	49	26	7.0	9.1
14	B	0.35	54	26	7.3	9.6
15	B	0.45	50	26	7.1	9.2
16	B	0.55	48	26	6.9	9.0
17	B	0.65	45	26	6.7	8.7
18	B	0.75	40	25	6.3	8.2
19	B	0.85	27	25	5.2	6.8
20	B	0.95	22	25	4.7	6.1

	H_{Duct}	T_{Duct}	$\sqrt{h}_{Duct}$	(V_s)
Averages	40.0	26	6.3	8.15

CALCULATION OF VELOCITY & FLOW RATE

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

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

Average gas velocity (V_{Ducta}) = 8.1 m/s

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

= 3.7 m^3/s

Conversion of actual duct gas flow to reference conditions

Actual Duct Flow Conditions			Reference Conditions		
Average temperature (T_{Duct})	°C	26	Temperature (T_{Ref})	°C	0
Total pressure (P_{Duct})	kPa	102.4	Pressure (P_{Ref})	kPa	101.3
Oxygen (O_{2Duct})	% vol,dry	20.9	Oxygen (O_{2Ref})	% vol, dry	20.9
Water vapour (H_2O_{Duct})	% vol	0.5	Water vapour (H_2O_{Ref})	% vol	0.5

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} = 3.4 m^3/s

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

				Corrections
Q_{Ref}	=	Q_{Duct} x	$[273 + T_{Ref}]/[273 + T_{Duct}]$	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 = 3.4 m^3/s

2.2.3 Water vapour measurements

CPL LABORATORIES MONITORING REPORT FORM
WATER VAPOUR (GRAVIMETRIC TECHNIQUE)

Company	Nationwide Crash Repair Centre	Date	11-12/01/2006
Site	Coventry	Test Ref	H_20 1,2
Sample point	Booth 3	Prepared	D Martschenko
Test carried out by	D Martschenko, C Greenaway	Checked	G. Carroll

SAMPLING TIMES

Determination	1	2
Time Start	13:57	09:05
Time End	14:27	09:37

SAMPLING CONDITIONS

Determination		1	2
Gas meter temperature (T_{meter})	°C	12	4
Atmospheric pressure (P_{atm})	kPa	102.1	102.4
Final meter reading	m^3	219.293	219.576
Initial meter reading	m^3	219.092	219.393
Gas meter calibration factor		0.983	0.983
Volume of gas sampled (VG_{meter})	l	196.7	179.8

SAMPLE TUBE WEIGHTS

Determination		1	2
Tube			
Final weight (M_{fl})	g	146.2	130.3
Initial weight (M_{il})	g	145.6	129.3
Weight gain (M_{fl}-M_{il} = M_{gl})	g	0.6	1.0

Sample gas volume at STP, VG_{STP}

$VG_{STP} = VG_{meter} \times (273 \times P_{atm})/(101.3 \times (273 + T_{meter}))$

Determination		1	2
Volume of gas sampled (VG_{STP})	l, STP	190.1	179.4

Calculation of water vapour content in duct gas, C_g

C_g (% vol) = $100 \times (M_t \times MV_{STP} + MW_{H2O}) + (VG_{STP} + (M_t \times MV_{STP} + MW_{H2O}))$

where MV_{STP} is the ideal gas molecular volume at STP (i.e. 22.412 m^3/kgmole)

MW_{H2O} is the molecular weight of water (i.e. 18 kg/kgmole)

WATER VAPOUR MEASUREMENTS

Determination		1	2
Water vapour content	%,vol	0.4	0.7
Mean water vapour content	%,vol	0.5	
Water vapour concentration	kg/m^3	0.003	0.006
Mean water vapour concentration	kg/m^3	0.004	

2.2.4 Sampling measurements

CPL LABORATORIES MONITORING REPORT FORM
TOTAL PARTICULATE

Company	Nationwide Crash Repair Centre	Date	11-Jan-06
Site	Coventry	Test Ref	TE1
Sample point	Booth 3	Time Start	13:57
Test carried out by	D Martschenko, C Greenaway	Time End	14:27

Duct conditions

Dimension traversed by sampling probe (D)	m	0.76
Cross sectional area of sampling plane (A)	m^2	0.454

Duct gas conditions

Ambient temperature (T_{Amb})	°C	11
Average duct gas temperature (T_{Duct})	°C	32
Duct static gas pressure (P_{Static})	kPa	0.16
Barometric pressure (P_{Baro})	kPa	102.0
Duct gas volume flowrate @ ref. conditions (Q_{Ref})	m^3/s	3.39
Gas compressibility correction (K)		0.995
Wet gas specific gravity (sg)		0.99

Reference conditions

Actual Duct Flow Conditions			Reference Conditions		
Average temperature (T_{Duct})	°C	32	Temperature (T_{Ref})	°C	0
Total pressure (P_{Duct})	kPa	102.2	Pressure (P_{Ref})	kPa	101.3
Oxygen (O_{2Duct})	% vol,dry	20.9	Oxygen (O_{2Ref})	% vol, dry	20.9
Water vapour (H_2O_{Duct})	% vol	0.4	Water vapour (H_2O_{Ref})	% vol	0.4

Sampling conditions

Nozzle diameter (d)	mm	3.99
Initial gas meter reading	m^3	219.092
Final gas meter reading	m^3	219.293
Gas meter factor		0.983
Sampled volume (SV_{Meter})	m^3	0.197

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

Sampled volume @ ref. conditions (SV_{Ref})	m^3	0.192

Prepared by: D Martschenko **Checked by:** G. Carroll

CPL LABORATORIES MONITORING REPORT FORM
TOTAL PARTICULATE

Company	Nationwide Crash Repair Centre	Date	12-Jan-06
Site	Coventry	Test Ref	TE2
Sample point	Booth 3	Time Start	09:05
Test carried out by	D Martschenko, C Greenaway	Time End	09:37

Duct conditions

Dimension traversed by sampling probe (D)	m	0.76
Cross sectional area of sampling plane (A)	m^2	0.454

Duct gas conditions

Ambient temperature (T_{Amb})	°C	4
Average duct gas temperature (T_{Duct})	°C	34
Duct static gas pressure (P_{Static})	kPa	0.16
Barometric pressure (P_{Baro})	kPa	102.3
Duct gas volume flowrate @ ref. conditions (Q_{Ref})	m^3/s	3.39
Gas compressibility correction (ε)		0.995
Wet gas specific gravity (sg)		0.99

Reference conditions

Actual Duct Flow Conditions			Reference Conditions		
Average temperature (T_{Duct})	°C	34	Temperature (T_{Ref})	°C	0
Total pressure (P_{Duct})	kPa	102.5	Pressure (P_{Ref})	kPa	101.3
Oxygen (O_{2Duct})	% vol,dry	20.9	Oxygen (O_{2Ref})	% vol, dry	20.9
Water vapour (H_2O_{Duct})	% vol	0.7	Water vapour (H_2O_{Ref})	% vol	0.7

Sampling conditions

Nozzle diameter (d)	mm	4.0
Initial gas meter reading	m^3	219.393
Final gas meter reading	m^3	219.576
Gas meter factor		0.983
Sampled volume (SV_{Meter})	m^3	0.180

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

Sampled volume @ ref. conditions (SVR_{ef})	m^3	0.180

Prepared by: D Martschenko **Checked by:** G. Carroll

Static pressure before gas meter	0	Pa	Pitot factor	1.001
Water Vapour Concentration	0.00	kg/m3		
Moisture Content	0.5	%		

MEASUREMENT OF TOTAL PARTICULATE

Test 1

Time	Posn.	Pitot rdg. Pa	Duct temp. °C	Duct CO2 %	Duct O2 %	Meter temp. °C	Duct static Pa	Baro press. kPa	Nozzle dia. mm	Iso. rate l/min	Actual flow l/min	Vol.sampled m^3 meter	m^3 cum.	reqd. vol. m^3	Cum. dev. %
0	2	30	31	0.0	20.9	10	160	102.0	3.99	5.0	4.9	219.092	0.000	0.000	
4	4	62	31	0.0	20.9	10	160	102.0	3.99	7.2	7.1	219.112	0.020	0.020	-2.1
8	7	57	32	0.0	20.9	10	160	102.0	3.99	6.9	7.1	219.141	0.048	0.049	-1.4
12	9	42	32	0.0	20.9	10	160	102.0	3.99	5.9	6.0	219.169	0.077	0.076	0.4
16	2	35	31	0.0	20.9	11	160	102.0	3.99	5.4	5.5	219.193	0.101	0.100	0.8
20	4	68	32	0.0	20.9	11	160	102.0	3.99	7.5	7.5	219.215	0.123	0.122	1.0
24	7	48	32	0.0	20.9	11	160	102.0	3.99	6.3	6.6	219.245	0.153	0.152	0.8
28	9	32	32	0.0	20.9	11	160	102.1	3.99	5.2	5.2	219.272	0.179	0.177	1.1

MASS OF PARTICULATES COLLECTED

Filter no.	NCR1
Filter + particulates, g	0.486
Filter, g	0.486
Mass collected, g	0

Washing bottle no.	
Washing filter + particulates, g	0
Washing filter, g	0
Mass collected, g	0
Proportionalised weight	0

Total mass collected, g	0

OVERALL BLANK

Filter no.	NCR3
Filter + particulates, g	0.4682
Filter, g	0.4680
Mass Change, g	0.0002

Washing bottle no.	
Evaporating Basin + particulates, g	0
Evaporating Basin , g	0
Mass collected, g	0

TOTAL FIELD BLANK g 0.0002

CALCULATIONS

(Q_{duct}), Flow in the duct, at duct conditions, m^3/s	3.6751
(Q_{ref}), Flow in the duct, at reference conditions, m^3/s	3.3927
(M), Mass flow at duct conditions, kg/h	0
(C), Concentration of particulate matter at reference conditions, mg/m^3	0

MEASUREMENT OF TOTAL PARTICULATE

Test 2

Time	Posn.	Pitot rdg. Pa	Duct temp. °C	Duct CO2 %	Duct O2 %	Meter temp. °C	Duct static Pa	Baro press. kPa	Nozzle dia. mm	Iso. rate l/min	Actual flow l/min	Vol.sampled m^3 meter	m^3 cum.	reqd. vol. m^3	Cum. dev. %
0	2	25	32	0.0	20.9	3	160	102.4	3.99	4.4	4.4	219.393	0.000	0.000	
4	4	50	33	0.0	20.9	3	160	102.4	3.99	6.3	6.4	219.411	0.017	0.018	-1.6
8	7	50	34	0.0	20.9	4	160	102.3	3.99	6.3	6.3	219.436	0.043	0.043	0.4
12	9	40	34	0.0	20.9	4	160	102.3	3.99	5.6	5.7	219.462	0.068	0.068	0.2
16	2	25	33	0.0	20.9	4	160	102.3	3.99	4.5	4.5	219.484	0.091	0.091	0.3
20	4	55	34	0.0	20.9	4	160	102.3	3.99	6.6	6.8	219.502	0.109	0.108	0.5
24	7	53	34	0.0	20.9	4	160	102.3	3.99	6.5	6.4	219.529	0.136	0.135	0.8
28	9	35	35	0.0	20.9	4	160	102.4	3.99	5.3	5.3	219.555	0.161	0.161	0.5

MASS OF PARTICULATES COLLECTED

Filter no.	NCR2
Filter + particulates, g	0.551
Filter, g	0.551
Mass collected, g	0

Washing bottle no.	
Washing filter + particulates, g	0
Washing filter, g	0
Mass collected, g	0
Proportionalised weight	0

Total mass collected, g	0

OVERALL BLANK

Filter no.	NCR3
Filter + particulates, g	0.4682
Filter, g	0.4680
Mass Change, g	0.0002

Washing bottle no.	
Evaporating Basin + particulates, g	0
Evaporating Basin , g	0
Mass collected, g	0

TOTAL FIELD BLANK g 0.0002

CALCULATIONS

(Q_{duct}), Flow in the duct, at duct conditions, m^3/s	3.6751
(Q_{ref}), Flow in the duct, at reference conditions, m^3/s	3.3927
(M), Mass flow at duct conditions, kg/h	0
(C), Concentration of particulate matter at reference conditions, mg/m^3	0

(M), Mass flow at duct conditions, kg/h = C x Q duct x 0.0036

(C), Concentration of particulate matter at reference conditions, mg/m^3 = Total mass collected, g / Sampled volume at ref conditions, m^3

2.2.5 Manual monitoring method results calculations

Formula 1 - Determination of Moisture Content

$$V_o = V_m.(273 \div T_m).(P_b \div 101.3)$$

$$\% H_20 = 100.(M_w \div 18) \div [(V_o \div 22.412) + (M_w \div 18)]$$

Where :

$\%H_20$	- Moisture content of the gas sampled, %
M_w	- Mass of water collected during the test, g
V_o	- Volume sampled at reference conditions, litres
V_m	- Volume sampled at meter conditions, litres
T_m	- Mean meter temperature during the test, K
P_b	- Mean meter conditions during test, kPa

Formula 2 - Determination of mean velocity

$$V = 0.0753.\sqrt{T}.\sqrt{h}$$

Where

V	- Mean velocity during test, m/s
$\sqrt{T}$	- Mean square root of temperatures before and after test, K
$\sqrt{h}$	- Mean square root of pitot-static readings before and after test, Pa

Formula 3 - Volume flow rate of duct gases, at duct temperatures

$$Q_{(duct)} = V.A$$

Where

$Q_{(duct)}$	- Volume flow rate of duct gases, m^3/s
V	- Mean velocity, m/s
A	- Area of duct (at the sampling plane), m^2

Formula 4 - Volume flow rate of duct gases, specified reference conditions

$$Q_o = Q_{(duct)}.(T_{ref} \div T_{duct}).(P_{duct} \div P_{ref}).[(100 - \%H_20) \div 100].[(20.9 - O_{2duct}) \div (20.9 - O_{2rel})]$$

Where

Q_o	- Volume flow rate at reference conditions, and relative O_2 and moisture correction, m^3/s
T_{ref}	- reference Temperature, K
T_{duct}	- Mean temperature across the duct, K
P_{duct}	- Relative static pressure in the duct, kPa
P_{ref}	- Reference pressure, kPa
$\%H_20$	- Water content, %
O_{2duct}	- Oxygen content as measured during the test, *%v/v*
O_{2rel}	- Relative Oxygen content for the process, *%v/v*

2.2.6 Uncertainty calculations

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

Test 1

Measurement Equation

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

Limit value	10	mg.m^{-3}	Reference oxygen	20.9	% by volume
Measured concentration	0.52	mg.m^{-3}			

Measured Quantities	Symbol	Value	Standard uncertainty		Units	Uncertainty as percentage	Uncertainty at limit value	Requirement of standard
Sampled Volume	V_m	0.192	uV_m	0.002	m^3	1.04		<=2%
Sampled gas Temperature	T_m	305	uTm	1	k	0.33		<=1%
Sampled gas Pressure	ρ_m	101.84	$u\rho_m$	0.1	kPa	0.10		<=1%
Sampled gas Humidity	H_m	0.4	uH_m	0.15	% by volume	37.50		<=1%
Oxygen content	$O_{2,m}$	20.9	$uO_{2,m}$	0	% by volume	0.00		<=5%
Mass particulate	m	0.1	um	0.2	mg	200.00	10.40	<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	UCM	0			mg	0.00		<=10%

Intermediate calculations						
Factor for std conds	fs	0.90				
uncertainty components	symbol	sensitivity coeff	u (in units of fs)		$f_s = \frac{(100-H_m)}{100}\frac{273}{T_m}\frac{\rho_m}{101.3}$	
	ρ_m	0.009	0.001			
	H_m	0.009	0.001			
	T_m	0.003	0.003			
	ufs		0.003			0.37
Corrected volume	V	0.17	uV	0.002 m^3	$V = V_m f_s$	1.22
Factor for O2 correction	fc	1.00				
uncertainty components	symbol	sensitivity coeff	u		$f_c = \frac{21 - O_{2,ref}}{21 - O_{2,m}}$	
	$O_{2,m}$	10.00	0.000			
Factor for O2 Correction	ufc	1.00	0.000			0.00

Parameter	Uncertainty, i	Value	Units	Sensitivity coeff	Uncertainty in Result	Uncertainty as %
Volume(standard conditions)	V	0.17	m^3	3.02	0.01 mg.m^{-3}	1.22 %
Mass	m	0.10	mg	5.20	1.04 mg.m^{-3}	200.00
Factor for O2 Correction	fc	1.00		0.52	0.00 mg.m^{-3}	0.00 %
Leak	L	0.01	mg.m^{-3}	1.00	0.01 mg.m^{-3}	
Uncollected mass	UCM	0.00	mg	5.20	0.00 mg.m^{-3}	
Combined uncertainty					**1.04** mg.m^{-3}	

Expanded uncertainty	expressed with a level of confidence of 95%	**400.01**	%
Expanded uncertainty	expressed with a level of confidence of 95%	**2.08**	mg.m^{-3}

Test 2

Measurement Equation

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

Limit value	10	mg.m^{-3}	Reference oxygen	20.9	% by volume
Measured concentration	0.56	mg.m^{-3}			

Measured Quantities	Symbol	Value	Standard uncertainty		Units	Uncertainty as percentage	Uncertainty at limit value	Requirement of standard
Sampled Volume	V_m	0.18	uV_m	0.002	m^3	1.11		<=2%
Sampled gas Temperature	T_m	307	uTm	1	k	0.33		<=1%
Sampled gas Pressure	ρ_m	102.14	$u\rho_m$	0.1	kPa	0.10		<=1%
Sampled gas Humidity	H_m	0.7	uH_m	0.15	% by volume	21.43		<=1%
Oxygen content	$O_{2,m}$	20.9	$uO_{2,m}$	0	% by volume	0.00		<=5%
Mass particulate	m	0.1	um	0.2	mg	200.00	11.20	<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	UCM	0			mg	0.00		<=10%

Intermediate calculations						
Factor for std conds	fs	0.89				
uncertainty components	symbol	sensitivity coeff	u (in units of fs)		$f_s = \frac{(100-H_m)}{100}\frac{273}{T_m}\frac{\rho_m}{101.3}$	
	ρ_m	0.009	0.001			
	H_m	0.009	0.001			
	T_m	0.003	0.003			
	ufs		0.003			0.37
Corrected volume	V	0.16	uV	0.002 m^3	$V = V_m f_s$	1.30
Factor for O2 correction	fc	1.00				
uncertainty components	symbol	sensitivity coeff	u		$f_c = \frac{21 - O_{2,ref}}{21 - O_{2,m}}$	
	$O_{2,m}$	10.00	0.000			
Factor for O2 Correction	ufc	1.00	0.000			0.00

Parameter	Uncertainty, i	Value	Units	Sensitivity coeff	Uncertainty in Result	Uncertainty as %
Volume(standard conditions)	V	0.16	m^3	3.49	0.01 mg.m^{-3}	1.30 %
Mass	m	0.10	mg	5.60	1.12 mg.m^{-3}	200.00
Factor for O2 Correction	fc	1.00		0.56	0.00 mg.m^{-3}	0.00 %
Leak	L	0.01	mg.m^{-3}	1.00	0.01 mg.m^{-3}	
Uncollected mass	UCM	0.00	mg	5.60	0.00 mg.m^{-3}	
Combined uncertainty					**1.12** mg.m^{-3}	

Expanded uncertainty	expressed with a level of confidence of 95%	**400.02**	%
Expanded uncertainty	expressed with a level of confidence of 95%	**2.24**	mg.m^{-3}

Appendix 3

Stack: Spray Booth 3

Equipment	Value	No X
Nozzle: internal diameter	>6 mm	X
Nozzle: uncertainty of area at nozzle entry	≤0%	✓
Nozzle: length with constant internal diameter	>10 mm	✓
Nozzle: change in diameter angle	<30°	✓
Nozzle: radius of the bend	.>1.5 times internal diameter	✓
Nozzle: straight length before the first bend	>30 mm	✓
Filter holder: distance to obstacles	>50mm	✓
Filter:		
Efficiency on test aerosol of 0.3 µm	>99.5 %	✓
Efficiency on test aerosol of 0.6 µm	>99.9%	✓
Filter: filter material	No reaction and no absorption of the components	✓
Condenser, drying tower: residual gas moisture	<10 gr/m^3	✓
Gas meter:		
Uncertainty of gas volume	<2%	✓
Uncertainty of absolute pressure	≤ %	✓
Uncertainty of absolute temperature	≤ %	✓
Angle of the nozzle with regard to gas flow Isokinetic rate	<10°	✓
Isokinetic rate	95% to 115%	✓
Leak rate	<2%	✓
Balance resolution	0.01 mg to 0.1 mg	✓
Weighing uncertainties	<5 % of the LV a	X
Weighing: temperature equilibrium duration	4h to l2h	✓
Overall blank value	<10%of the LV a	✓
Sampling location		
Duct gas flow: angle with regard to duct access	<15°	✓
Duct gas flow: negative velocity	not permitted	✓
Duct gas flow: differential pressure at Pitot tube	> 5 Pa	✓
Duct gas flow: ratio of max. to min. velocity	<3:1	✓
Straight length before the sampling plane	> 5 hydraulic diameters (recommended)	✓
Straight length after the sampling plane	> 2 hydraulic diameters (recommended)	X
Straight length before emission point	> 5 hydraulic diameters (recommended)	X
Correct number of sampling points for standard?		✓
Flue Gas Characteristics		
Flue gas density: uncertainty	0.05 kg/rn^3	✓
LV[a]: Limit Value set for the process	mg/m^3	10

---ooo0ooo---

End of Report