Title: Monitoring of Particulate Matter (PM) Emissions

Permit Number:	PPC/204
Operator:	Steel Construction Limited
Installation:	Spray Painting Area (LHS & RHS)
Monitoring Dates:	10 September 2020

Reference Number:	EI/8532
Client Organisation: Address:	Steel Construction Limited Bodmin Road Coventry CV2 5DB
Monitoring Organisation: Address:	CES Environmental Instruments Ltd Bretby Business Park Ashby Road Burton on Trent Staffordshire DE15 0YZ
Date of Report:	30 September 2020
Report Prepared By: MCERTS Registration Number:	Shane Elton MM 04 532 (Level 2, TE1, TE2, TE3, TE4)
Signed:	
Report Approved By: MCERTS Registration Number:	Robert Allen MM 02 009 (Level 2, TE1, TE2, TE3, TE4)
Signed:	

Contents

Part 1: Executive Summary

1.1 Monitoring Objectives

Steel Construction Limited placed a contract with CES Environmental Instruments Ltd for the compliance check monitoring of emissions to air from the Spray Painting Area (LHS & RHS).

Spray Painting Area (LHS & RHS)
Steel Construction Ltd operates a factory manufacturing steel parts for the construction industry at their Coventry site.

The metal products being sprayed arrive at the premises shot blasted and sometimes primed. The application of paints to steel beams, by airless spraying, occurs inside a wet wall spray booth. All emissions from the spray booth are released to atmosphere. The sludge from the wet filtration is removed and collected by a waste disposal company.

The test work was undertaken on 10 September 2020 by CES Environmental Instruments Ltd Engineers and carried out as part of CES Environmental Instruments Ltd job reference EI/8532.

The substances monitored were:-

Particulate Matter

On the day of testing there were no special requirements for the monitoring.

Amendments
Version 2

Version one of this report had the incorrect picture of the Spray Painting Area.

The following amendments have been made:
- Appendix 2: Photo amended

1.2 Monitoring Results

Emission Point Reference: Spray Painting Area (LHS)

Substance to be Monitored	Emission Limit Value	Periodic Monitoring Result	Uncertainty of Measurement (95% CI)	Blank Result	Units	Reference Conditions	Emission Rate	Date of Sampling	Start and End Times	Monitoring Method Reference	Accreditation for use of Method	Operating Status
Particulate Matter	50	0.11	0.71	0.14*	mg/m³	273K, 101.3kPa	0.001 kg/hr	10 September 2020	09:44-10:48	BS EN 13284-1	UKAS & MCERTS	Normal Operation

* Indicates where a value less than the limit of detection of the weighing procedure (0.21mg) has been reported, the value lies between the detection limit and zero. A value of half the limit of detection (0.21mg) has been used to calculate the concentration.

Emission Point Reference: Spray Painting Area (RHS)

Substance to be Monitored	Emission Limit Value	Periodic Monitoring Result	Uncertainty of Measurement (95% CI)	Blank Result	Units	Reference Conditions	Emission Rate	Date of Sampling	Start and End Times	Monitoring Method Reference	Accreditation for use of Method	Operating Status
Particulate Matter	50	1.27	0.61	0.13*	mg/m³	273K, 101.3kPa	0.016 kg/hr	10 September 2020	10:53-11:56	BS EN 13284-1	UKAS & MCERTS	Normal Operation

* Indicates where a value less than the limit of detection of the weighing procedure (0.21mg) has been reported, the value lies between the detection limit and zero. A value of half the limit of detection (0.21mg) has been used to calculate the concentration.

1.3 Operating Information

Emission Point Reference: Spray Painting Area (LHS)

Process Type	Batch Sample Details	Fuel	Product	Load	Abatement
Batch	Red Only – Manor Coating System Ltd ; Zinfos 490CT RAL 3020 Code 00260/ARYV2 (Solvant Based)	-	Steel Parts	4 Beams @ 15.2m Long	Bag Filter

Emission Point Reference: Spray Painting Area (RHS)

Process Type	Batch Sample Details	Fuel	Product	Load	Abatement
Batch	Red Only – Manor Coating System Ltd ; Zinfos 490CT RAL 3020 Code 00260/ARYV2 (Solvant Based)	-	Steel Parts	4 Beams @ 15.2m Long	Bag Filter

Comparison of Operator CEMS and Periodic Monitoring Results								
Substance to be Monitored	**Emission Limit Value**	**Periodic Monitoring Result**	**Uncertainty of Measurement (95% CI)**	**Units**	**Reference Conditions**	**Date of Sampling**	**Start and End Times**	**CEMS Results**
Particulate Matter (LHS)	50	0.11	0.71	mg/m³	273K, 101.3kPa	10 September 2020	09:44-10:48	No Data Available
Particulate Matter (RHS)	50	1.27	0.61	mg/m³	273K, 101.3kPa	10 September 2020	10:53-11:56	No Data Available

1.4 Monitoring Deviations

The sample plane does not comply downstream as per the requirements of BS EN 15259.

Part 2: Supporting Information

Appendix 1
General Information

CES Environmental Instruments Ltd staff details

Name	Role	MCERT Registration Number	Level 1	Level 2	TE1	TE2	TE3	TE4	At site
Derek Harvey	Team Leader	MM 06 686		✓					T
				June 2022	June 2022				
Richard Allen	Technician	MM 19 1561 Trainee							✓

T = Nominated Team Leader on Site

CES Environmental Instruments Ltd method details

Pollutant	Method	CES Procedure
Particulate Matter	BS EN 13284-1	WI 4/1
Moisture	BS EN 14790	WI 4/40

Monitoring Equipment Used

Gravimat & Probe CES Environmental Instruments Ltd Reference: C231

Appendix 2
Diagrams of Emission Point

Sampling Location

Dimensions	Cross Sectional Area	Orientation	Sample Ports Available/Used	Sampling Positions Per Plane	Standard
Dia =700mm	0.385m²	Vertical	1/1	3	BS EN 15259

Comments:
Sample ports: 2 off 4" BSP sockets bolted onto flanges

Sample times are calculated from the total sample time equally divided by the no. of sample positions per plane. The minimum sample time per position is 3 minutes.

Sample positions calculated using the General method for circular ducts

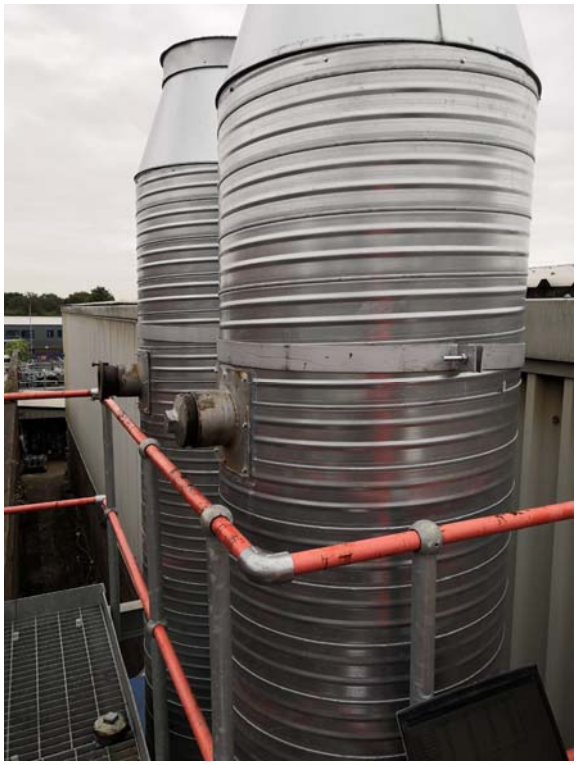
Pitot Traverse
Along lines A & B at positions consistent with BS EN 15259 these positions are:
6.7%, 50.0%, 90.80%

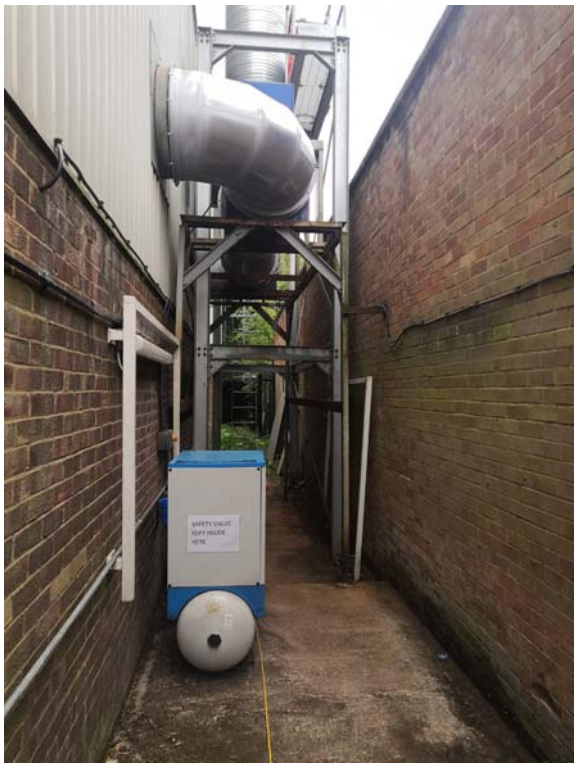
Sample Positions
Along lines A & B at as many of the positions required within the standard method as can be achieved given the clearance limitations behind each socket. BS EN 15259 requires sampling at 3 points (3 on one line) these positions are:
6.7%, 50.0%, 90.80%

	Yes	No
Has homogeneity test been carried out?		✓
If Yes - Is stack gas homogenous?		

Any physical or regulatory restrictions regarding usage of equipment?
N/A

Compliance with BS EN 15259 / EA TGN M1	Yes	No
Does the sample plane comply upstream?	✓	
Does the sample plane comply downstream?		✓
Are the appropriate sample ports fitted?	✓	
Do the stack gas velocity / temperature profiles comply?	✓	
Minimum platform area >5m²	✓	





Appendix 3
Particulate Matter (Sampling Measurement & Results)

Site : **Steel Construction Limited**
Date : **10 September 2020**
Plant : **Spray Painting Area (LHS)**
File Ref. **8532**

Mean Particulate Results

Filter	Time	mg/m³	m³/hr	mg/Nm³	Nm³/hr	kg/hr
		(Actual Conditions)		(Reference Conditions)		
801031	09:44-10:15	0.09	11642	**0.09**	**11092.0**	**0.001**
801177	10:17-10:48	0.12	11781	**0.12**	**11224.0**	**0.001**
	Mean	**0.11**	**11712**	**0.11**	**11158.00**	**0.001**

Control Blank Filter

Filter	Volume (m³)
801031	**0.728**
801177	**0.734**
Mean	**0.731**

(Reference Conditions with no correction for Oxygen)

Filter **522025**

Tare Weight	**17681.51 mg**	
Gross Weight	**17681.62 mg**	*
Gain	**0.10 mg**	
Measured Oxygen	**%**	
Concentration	**0.14 mg/Nm³**	

Results Correct to

Temperature		Pressure		Oxygen		Gas	
°C/K	0/273	**mbar/kPa**	1013/101.3	**%**		**Wet/Dry**	Wet

* Indicates where a value less than the limit of detection of the weighing procedure (0.21mg) has been reported, the value lies somewhere between the detection limit and zero. A value of half the limit of detection (0.21mg) has been used to calculate the concentration.

protocol simultaneous isokinetic extraction measurement

10/09/2020 09:44
10/09/2020 10:15

collector-no. 1031

engineer	DH, RA
plant name	Spray painting area (LHS)
place	Steel Construction, Coventry
remarks	Normal Operations Diameter = 700mm Test 1

operating parameter

normal density humid	[kg / m³]	:	1.27
water vapour	[%Vol]	:	3
ambient pressure	[mbar]	:	1016
duct cross-section	[m²]	:	0.385

extraction parameter

change of meas. point	[h:m:s]	:	00:10:00
points / axis		:	3
nozzles diameter	[mm]	:	8
isokinetic factor		:	1
tare weight	[mg]	:	18857.21
gross weight	[mg]	:	18857.28

evaluation

meas. time	[h:m:s]	:	00:30:00
dust weight	[mg]	:	0.07
extracted partial volume			
actual conditions	[m³]	:	0.764
in norm wet	[Nm³]	:	0.728
in norm dry	[Nm³]	:	0.706
volume flow in duct			
actual conditions	[m³/h]	:	11642
in norm wet	[Nm³/h]	:	11092
in norm dry	[Nm³/h]	:	10760
dust concentration			
actual conditions	[mg/m³]	:	0.09
in norm wet	[mg/Nm³]	:	0.09
in norm dry	[mg/Nm³]	:	0.10

protocol simultaneous isokinetic extraction measurement 10/09/2020 09:44
10/09/2020 10:15

measured values table

axis	depth	T_probe [°C]	v_duct [m/s]	angle [grd]	Q_act. [m³/h]	volume [m³]	meas. time [H:M:S]	p10 [mbar]	p40 [mbar]
1	1	14	9.1	1.9	1.67	0.279	00:10:00	2.00	-40
1	2	14	8.4	0.3	1.53	0.254	00:10:00	2.00	-36
1	3	15	7.7	0.0	1.39	0.231	00:10:00	2.00	-33
		14	8.4	0.7	1.53	0.255		2.00	-36

protocol simultaneous isokinetic extraction measurement

10/09/2020 10:17
10/09/2020 10:48

collector-no. 1177

engineer	DH, RA
plant name	Spray painting area (LHS)
place	Steel Construction, Coventry
remarks	Normal Operations Diameter = 700mm Test 2

operating parameter

normal density humid	[kg / m³]	:	1.27
water vapour	[%Vol]	:	3
ambient pressure	[mbar]	:	1016
duct cross-section	[m²]	:	0.385

extraction parameter

change of meas. point	[h:m:s]	:	00:10:00
points / axis		:	3
nozzles diameter	[mm]	:	8
isokinetic factor		:	1
tare weight	[mg]	:	18135.15
gross weight	[mg]	:	18135.24

evaluation

meas. time	[h:m:s]	:	00:30:00
dust weight	[mg]	:	0.09
extracted partial volume			
actual conditions	[m³]	:	0.770
in norm wet	[Nm³]	:	0.734
in norm dry	[Nm³]	:	0.712
volume flow in duct			
actual conditions	[m³/h]	:	11781
in norm wet	[Nm³/h]	:	11224
in norm dry	[Nm³/h]	:	10888
dust concentration			
actual conditions	[mg/m³]	:	0.12
in norm wet	[mg/Nm³]	:	0.12
in norm dry	[mg/Nm³]	:	0.13

protocol simultaneous isokinetic extraction measurement 10/09/2020 10:17
10/09/2020 10:48

measured values table

axis	depth	T_probe [°C]	v_duct [m/s]	angle [grd]	Q_act. [m³/h]	volume [m³]	meas. time [H:M:S]	p10 [mbar]	p40 [mbar]
1	1	15	9.0	-0.6	1.63	0.271	00:10:00	2.00	-40
1	2	15	8.7	0.5	1.58	0.264	00:10:00	2.00	-40
1	3	15	7.8	1.3	1.41	0.235	00:10:00	2.00	-36
		15	8.5	0.4	1.54	0.257		2.00	-39

Site : **Steel Construction Limited**
Date : **10 September 2020**
Plant : **Spray Painting Area (RHS)**
File Ref. **8532**

Mean Particulate Results

Filter	Time	mg/m³	m³/hr	mg/Nm³	Nm³/hr	kg/hr
		(Actual Conditions)		(Reference Conditions)		
802048	10:53-11:24	0.82	12335	**0.86**	**11753.0**	**0.010**
80908	11:25-11:56	1.60	14045	**1.68**	**13381.0**	**0.022**
	Mean	**1.21**	**13190**	**1.27**	**12567.00**	**0.016**

Control Blank Filter

Filter	Volume (m³)
802048	**0.770**
80908	**0.871**
Mean	**0.821** (Reference Conditions with no correction for Oxygen)

Filter **522028**

Tare Weight	**17623.46**	**mg**	
Gross Weight	**17623.57**	**mg**	*
Gain	**0.10**	**mg**	
Measured Oxygen		**%**	
Concentration	**0.13**	**mg/Nm³**	

Results Correct to

Temperature		Pressure		Oxygen		Gas	
°C/K	0/273	mbar/kPa	1013/101.3	%		Wet/Dry	Wet

* Indicates where a value less than the limit of detection of the weighing procedure (0.21mg) has been reported, the value lies somewhere between the detection limit and zero. A value of half the limit of detection (0.21mg) has been used to calculate the concentration.

protocol simultaneous isokinetic extraction measurement

10/09/2020 10:53
10/09/2020 11:24

collector-no. 2048

engineer	DH, RA
plant name	Spray painting area (RHS)
place	Steel Construction, Coventry
remarks	Normal Operations Diameter = 700mm Test 1

operating parameter

normal density humid	[kg / m³]	:	1.27
water vapour	[%Vol]	:	3
ambient pressure	[mbar]	:	1016
duct cross-section	[m²]	:	0.385

extraction parameter

change of meas. point	[h:m:s]	:	00:10:00
points / axis		:	3
nozzles diameter	[mm]	:	8
isokinetic factor		:	1
tare weight	[mg]	:	18469.33
gross weight	[mg]	:	18469.99

evaluation

meas. time	[h:m:s]	:	00:30:00
dust weight	[mg]	:	0.66
extracted partial volume			
actual conditions	[m³]	:	0.808
in norm wet	[Nm³]	:	0.770
in norm dry	[Nm³]	:	0.747
volume flow in duct			
actual conditions	[m³/h]	:	12335
in norm wet	[Nm³/h]	:	11753
in norm dry	[Nm³/h]	:	11400
dust concentration			
actual conditions	[mg/m³]	:	0.82
in norm wet	[mg/Nm³]	:	0.86
in norm dry	[mg/Nm³]	:	0.88

protocol simultaneous isokinetic extraction measurement 10/09/2020 10:53
10/09/2020 11:24

measured values table

axis	depth	T_probe [°C]	v_duct [m/s]	angle [grd]	Q_act. [m³/h]	volume [m³]	meas. time [H:M:S]	p10 [mbar]	p40 [mbar]
1	1	15	10.6	-0.1	1.91	0.319	00:10:00	2.00	-49
1	2	15	8.9	-1.3	1.63	0.271	00:10:00	2.00	-42
1	3	15	7.2	0.3	1.31	0.218	00:10:00	2.00	-33
		15	8.9	-0.4	1.62	0.269		2.00	-41

protocol simultaneous isokinetic extraction measurement

10/09/2020 11:25
10/09/2020 11:56

collector-no. 908

engineer	DH, RA
plant name	Spray painting area (RHS)
place	Steel Construction, Coventry
remarks	Normal Operations Diameter = 700mm Test 2

operating parameter

normal density humid	[kg / m³]	:	1.27
water vapour	[%Vol]	:	3
ambient pressure	[mbar]	:	1016
duct cross-section	[m²]	:	0.385

extraction parameter

change of meas. point	[h:m:s]	:	00:10:00
points / axis		:	3
nozzles diameter	[mm]	:	8
isokinetic factor		:	1
tare weight	[mg]	:	17568.58
gross weight	[mg]	:	17570.04

evaluation

meas. time	[h:m:s]	:	00:30:00
dust weight	[mg]	:	1.46
extracted partial volume			
actual conditions	[m³]	:	0.914
in norm wet	[Nm³]	:	0.871
in norm dry	[Nm³]	:	0.845
volume flow in duct			
actual conditions	[m³/h]	:	14045
in norm wet	[Nm³/h]	:	13381
in norm dry	[Nm³/h]	:	12980
dust concentration			
actual conditions	[mg/m³]	:	1.60
in norm wet	[mg/Nm³]	:	1.68
in norm dry	[mg/Nm³]	:	1.73

protocol simultaneous isokinetic extraction measurement 10/09/2020 11:25
10/09/2020 11:56

measured values table

axis	depth	T_probe [°C]	v_duct [m/s]	angle [grd]	Q_act. [m³/h]	volume [m³]	meas. time [H:M:S]	p10 [mbar]	p40 [mbar]
1	1	15	10.5	-0.9	1.88	0.315	00:10:00	2.00	-46
1	2	15	9.3	0.1	1.69	0.281	00:10:00	2.00	-42
1	3	15	10.6	-0.7	1.91	0.318	00:10:00	2.00	-50
		15	10.1	-0.5	1.83	0.305		2.00	-46

Appendix 4
Calibration Certificates

Certificate of Calibration

Date of Issue: 21st December 2019

Certificate No. CES1857
page 1 of 2

CES Environmental Instruments Ltd
Bretby Business Park, Ashby Road
Burton-on-Trent, Staffordshire, DE15 0YZ
Tel: 01283 216334 Fax: 01283 550939

Instrument Details

Instrument Type	Gravimat SHC-502
Instrument Make	Erwin Sick
Instrument Serial No.	6118714
Quality No.	C231
Calibration Date	21/12/19
Calibrated By Name	S.Cashmore

Ambient Conditions

Air Temperature (°C)	24
Barometric Pressure (mbar)	986
Relative Humidity (%)	50

Instruments used to undertake calibration

E Type Pitot	UKAS Certificate No.K43616V	(Qu. No. C136)
Manometer Type FC012	UKAS Certificate No. 18379	(Qu. No. C082)
Manometer Type FC012	UKAS Certificate No. 18378	(Qu. No. C081)
Barometer Type 104	UKAS Certificate No. U98488-19	(Qu. No. C138)
Gallus Dry Gas Meter	UKAS Certificate No.N026250	(Qu. No. C333)
RIS Supercal XT	UKAS Certificate No. 2928640001	(Qu. No. C014)

Flow and Extraction

The reference pitot was placed in a wind tunnel located at Bretby Business Park. The Gravimat SHC-5 Sampling Probe under test was mounted within the same wind tunnel in close proximity to the reference pitot. The wind tunnel was operated to generate a differential pressure across each pitot, a direct comparison was made. The differential pressures measured were in the region of the caibration points of the reference pitot. Correction factors were applied to the reference pitot and compared to the differential pressure shown for the pitot under test. The extraction system of the unit was operated for a period of one minute.

Volume Flow

A calibrated dry gas meter was connected to the sampling nozzel ot the Gravimat SCH-5. A volume of air is pulled through the sampling system. The measured value shown on the calibrated dry gas meter is then compared to the indicated value on the Gravimat SCH-5 display.

Barometric Pressure

The barometric pressure was measured using a calibrated barometer. The indicated pressure was compared to the Gravimat SHC-5 display.

Temperature

The probe thermocouple was placed in a thermpcouple oven and heated. The temperature was measured using a calibrated thermocouple and temperature indicator. The resultant temperature was compared to the Gravimat SCH-5 display.

Current

A mA current source was injected into the Gravimat SCH-5 using a mA current generator. The injected current was compared to the Gravimat SCH-5 display.

Certificate of Calibration

Date of Issue: 21st December 2019

Certificate No CES1857

CES Environmental Instruments Ltd
Bretby Business Park, Ashby Road
Burton-on-Trent, Staffordshire, DE15 0YZ
Tel: 01283 216334 Fax: 01283 550939

Instrument Details

Instrument Type	Gravimat SHC-502
Instrument Make	Erwin Sick
Instrument Serial No	6118714
Quality No	C231
Calibration Date	21/12/19

Ambient Conditions

Air Temperature (°C)	24
Barometric Pressure (mbar)	986
Relative Humidity (%)	50
Air Density @ 0°C (kg/m³)	1 277
Corrected Air Density (kg/m³)	1 1638

Calibration Details

Flow and Extraction

	Pitot Correction	Applied Pressure Corrected (Pa)	SHC502 (Calculated) (Pa)	Pressure Factor	Calculated Velocity (m/s)	SHC502 Velocity (m/s)	Velocity Factor
5.4	0.988	5.3	5.2	**1.02**	3.028	3.000	**1.01**
40.6	0.988	40.1	39.1	**1.03**	8.303	8.200	**1.01**
86.5	0.990	85.6	83.8	**1.02**	12.131	12.000	**1.01**
171.1	0.990	169.4	166.2	**1.02**	17.061	16.900	**1.01**
231.6	0.988	228.8	223.5	**1.02**	19.830	19.600	**1.01**
Mean (excluding 4.0Pa)				**1.02**			**1.01**

Volume Flow

Nominal Flow Rate l/min	Actual Flow Rate l/min	Actual Flow Rate m³/hr	Orifice Constant
10.0	9.855	0.591	12.706
15.0	14.979	0.899	12.810
20.0	19.947	1.197	12.826
25.0	24.380	1.463	12.828
30.0	30.148	1.809	12.870
nent Orifice Constant(@1.5m³/hr) =			**12.828**

Barometric Pressure

Pressure Input	
Required Value (mbar)	**Indicated Value (mbar)**
995.0	995.0
1001.0	1001.0
1014.0	1014.0

Temperature

Temperature Input	
Required Value (°C)	**Indicated Value (°C)**
25.0	25.1
50.0	50.1
100.0	99.8
150.0	150.2
250.0	250.4
300.0	300.0

Current

Current Value	
Required Value (mA)	**Indicated Value (mA)**
0	0.0
5	5.0
10	10.0
15	15.0
20	20.0

Time

Time Period mins	Required Value mins	Within Limit
3.00	2:59 → 3.01	Yes
5:00	4:59 → 5:01	Yes
10:00	9:59 → 10:01	Yes

Appendix 5
Uncertainty Calculations

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

Limit value (ELV)	50	**mg.m^{-3}**	**Reference oxygen**		**% by volume**
Measured concentration	0.12	**mg.m^{-3} (at reference conditions)**			

Measurement Equation

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

Measured Quantities	**Symbol**	**Value**	**Standard uncertainty**		**Units**	**Uncertainty as percentage**	**Uncertainty at lv**	**Requirement of std**
Sampled Volume	V_m	0.734	uV_m	0.001	**m^3**	0.14		<=2%
Sampled gas Temperature	T_m	273	uTm	2	k	0.73		<=1%
Sampled gas Pressure	ρ_m	101.3	$u\rho_m$	0.1	**kPa**	0.10		<=1%
Sampled gas Humidity	H_m	0	uH_m	1	**% by volume**	1.00		<=1%
Oxygen content	$O_{2,m}$		$uO_{2,m}$	0.1	**% by volume**	#DIV/0!		<=5%
Mass particulate	m	0.09	um	0.26	**mg**	288.89	0.71	<5% of limit value
Note - Sampled gas humidity, temperature and pressure are values at the gas meter								
Leak	L	2			**%**	2.00		<=2%
Uncollected Mass (Instack filter - no rinse)	UCM	0.009			**mg**	10		<=10%

Intermediate calculations						
Factor for std conds	fs	1.00			$f_s = \frac{(100 - H_m)}{100} \frac{273}{T_m} \frac{\rho_m}{101.3}$	
uncertainty components	symbol	**sensitivity coeff**	**u (in units of fs)**			
	ρ_m	0.010	0.001			
	H_m	0.010	0.010			
	T_m	0.004	0.007			
	ufs		0.012			1.24
Corrected volume	V	0.73	uV	0.009 **m^3**	$V = V_m f_s$	1.25
Factor for O2 correction	fc	1.00				
uncertainty components	symbol	**sensitivity coeff**	**u**		$f_c = \frac{21 - O_{2,ref}}{21 - O_{2,m}}$	
	$O_{2,m}$	0.05	0.005			
Factor for O2 Correction	ufc	1.00	0.005			0.48

Parameter		**Value**	**Units**	**Sensitivity coeff**	**Uncertainty contribution**	**Uncertainty as %**
Corrected Volume (standard cc	V	0.73	m^3	0.17	0.00 mg.m^{-3}	1.25 %
Mass	m	0.09	mg	1.36	0.35 mg.m^{-3}	288.89 %
Factor for O2 Correction	fc	1.00		0.12	0.00 mg.m^{-3}	0.48 %
Leak	L	0.00	mg.m^{-3}	1.00	0.00 mg.m^{-3}	1.15 %
Uncollected mass	UCM	0.01	mg	1.36	0.01 mg.m^{-3}	5.77 %
Combined measurement uncertainty					**0.35** mg.m^{-3}	

Expanded uncertainty as percentage of measured value	**577.90**	**% measured of value**	**expressed with a level of confidence of 95%**
			(Using a coverage factor k=2)
Expanded uncertainty in units of measurement	**0.71**	**mg.m^{-3}**	
Expanded uncertainty as percentage of limit value	**1.42**	**% ELV**	

Verified

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

Limit value (ELV)	50	**mg.m^{-3}**	**Reference oxygen**	**% by volume**
Measured concentration	1.68	**mg.m^{-3} (at reference conditions)**		

Measurement Equation

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

Measured Quantities	**Symbol**	**Value**	**Standard uncertainty**		**Units**	**Uncertainty as percentage**	**Uncertainty at lv**	**Requirement of std**
Sampled Volume	V_m	0.871	uV_m	0.001	**m^3**	0.11		<=2%
Sampled gas Temperature	T_m	273	uTm	2	k	0.73		<=1%
Sampled gas Pressure	ρ_m	101.3	$u\rho_m$	0.1	**kPa**	0.10		<=1%
Sampled gas Humidity	H_m	0	uH_m	1	**% by volume**	1.00		<=1%
Oxygen content	$O_{2,m}$		$uO_{2,m}$	0.1	**% by volume**	#DIV/0!		<=5%
Mass particulate	m	1.46	um	0.26	**mg**	17.81	0.60	<5% of limit value
Note - Sampled gas humidity, temperature and pressure are values at the gas meter								
Leak	L	2			**%**	2.00		<=2%
Uncollected Mass (Instack filter - no rinse)	UCM	0.1			**mg**	6.849315068		<=10%

Intermediate calculations						
Factor for std conds	fs	1.00				
uncertainty components	symbol	**sensitivity coeff**	**u (in units of fs)**			
	ρ_m	0.010	0.001			
	H_m	0.010	0.010	$f_s = \frac{(100 - H_m)}{100} \frac{273}{T_m} \frac{\rho_m}{101.3}$		
	T_m	0.004	0.007			
	ufs		0.012			1.24
Corrected volume	V	0.87	uV 0.011	**m^3**	$V = V_m f_s$	1.25
Factor for O2 correction	fc	1.00				
uncertainty components	symbol	**sensitivity coeff**	**u**			
	$O_{2,m}$	0.05	0.005	$f_c = \frac{21 - O_{2,ref}}{21 - O_{2,m}}$		
Factor for O2 Correction	ufc	1.00	0.005			0.48

Parameter		**Value**	**Units**	**Sensitivity coeff**	**Uncertainty contribution**	**Uncertainty as %**
Corrected Volume (standard cc	V	0.87	m^3	1.92	0.02 mg.m^{-3}	1.25 %
Mass	m	1.46	mg	1.15	0.30 mg.m^{-3}	17.81 %
Factor for O2 Correction	fc	1.00		1.68	0.01 mg.m^{-3}	0.48 %
Leak	L	0.02	mg.m^{-3}	1.00	0.02 mg.m^{-3}	1.15 %
Uncollected mass	UCM	0.06	mg	1.15	0.07 mg.m^{-3}	3.95 %
Combined measurement uncertainty					**0.31** mg.m^{-3}	

Expanded uncertainty as percentage of measured value	**36.65**	**% measured of value**	**expressed with a level of confidence of 95%**
			(Using a coverage factor k=2)
Expanded uncertainty in units of measurement	**0.61**	**mg.m^{-3}**	
Expanded uncertainty as percentage of limit value	**1.23**	**% ELV**	

Verified