



2338

Title: Monitoring of Particulate Matter (PM) Emissions

Permit Number: PF/GYFMM/EPA
Operator: Pelagia (UK) Ltd
Installation: Meal Cooler MF01
Monitoring Dates: 17 July 2019

Reference Number: EI/8252

Client Organisation: Pelagia (UK) Ltd
Address: Gilbey Road
Grimsby
North East Lincolnshire
DN31 2SL

Monitoring Organisation: CES Environmental Instruments Ltd
Address: Bretby Business Park
Ashby Road
Burton on Trent
Staffordshire
DE15 0YZ

Date of Report: 29 July 2019

Report Prepared By: Martin Rodgers
MCERTS Registration Number: MM 04 531 (Level 2, TE1, TE2, TE3, TE4)

Signed:

Report Approved By: Robert Allen
MCERTS Registration Number: MM 02 009 (Level 2, TE1, TE2, TE3, TE4)

Signed:

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Part 1: Executive Summary

1.1 Monitoring Objectives

Pelaagia (UK) Ltd placed a contract with CES Environmental Instruments Ltd for the compliance check monitoring of emissions to air from the Meal Cooler MF01.

Meal Cooler MF01

Pelagia (UK) Ltd process fish and fish offal by the application of heat and drying to produce fish meal and fish oil for use in the animal feed industry, the hardened oil trade and other specialist outlets.

Raw material is heated in a cooker to enable oil extraction during pressing and pressed to remove as much body liquor as possible before drying. Solid material is removed from the liquor and directed to the dryer. Liquor is further treated to remove oil which is sent to storage.

Process emissions are directed through the foul air system which incorporates a waste heat evaporator; vapour condenser and boiler combustion plant.

The test work was undertaken on 17 July 2018⁹ by CES Environmental Instruments Ltd Engineers and carried out as part of CES Environmental Instruments Ltd job reference EI/8252

The substances monitored were:-

Particulate Matter

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

1.2 Monitoring Results

Emission Point Reference: Meal Cooler MF01

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	20	3.90	0.59	0.00*	mg/m ³	273K, 101.3kPa	0.0175 kg/hr	17 July 2019	09:00-11:20	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: Meal Cooler MF01

Process Type	Batch Sample Details	Fuel	Product	Load	Abatement
Continuous	-	-	Fish Meal	Normal Operation	None

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	20	3.90	0.59	mg/m ³	273K, 101.3kPa	17 July 2019	09:00-11:20	No Data Available

1.4 Monitoring Deviations

The sample plane does not comply upstream and downstream as per the requirements of BS EN 15259. The appropriate sample ports are not fitted 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
Martin Rodgers	Team Leader	MM 04 531		✓	✓	✓	✓	✓	T
				Dec 2019	June 2022	Mar 2024	Dec 2019	June 2023	
Adam Orme	Technician	MM 04 530	✓						✓
			Mar 2021						
Gordon Morse	Technician	MM 19 1523 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

Monitoring Equipment Used

Anderson CES Environmental Instruments Ltd Reference: C154

Appendix 2

Diagrams of Emission Point

Sampling Location

Dimensions	Cross Sectional Area	Orientation	Sample Ports Available/Used	Sampling Positions Per Plane	Standard
Dia=400mm	0.126m ²	Vertical	2/2	4	BS EN 15259
Comments:					
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 Tangential method for circular ducts					
Pitot Traverse					
Along lines A & B at positions consistent with BS EN 15259 these positions are: 14.6%, 85.4%					
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 4points (2 on each line) these positions are: 14.6%, 85.4%					
				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		✓

Diagram and Details

Stack Diameter 40 cm Circular Vertical



Appendix 3
Particulate Matter (Sampling Measurement & Results)

CES Environmental Instruments Ltd

Determination of Gas Flows By Pitot Tube, with Dalton Corrections		Client Job Number		Pelgia, Grimsby 8252		Date Test		17/07/2019 1				
Determination of Particulate Concentration		Site		Meal Cooler		Test Period		09:00-10:05				
Type of tube (E/S)	S	Metered Gas Reading (Start)	1292.4038 m ³	Metered Gas Reading (End)	1293.4924 m ³	Leak Correction 0.0000 m ³						
Pitot Factor, Cp	0.76	Metered Correction	0.9794	Metered Gas Volume VM _{meas}	1066.2 litres							
Duct Shape (Round/Rectangular)	Round	Meter Temperature TM _{meas}	21.4 °C	Meter Pressure PM _{meas}	760.5 mmHg							
Duct Diameter	0.400 m	Differential Meter Press (Pme)	0 mmH ₂ O	Barometric Pressure (Pb)	760.5 mmHg							
Duct Area	0.126 m ²	Differential Duct Press(Pd)	185.0 mmH ₂ O	Duct Pressure, Abs (Pda)	774.1 mmHg							
Nozzle Diameter	6.0 mm											
ΔH@	43.9756											
Velocity Traverse							Moisture Collection					
Line	A		B		A		B		Vessel	Wt on (g)	Wt off (g)	Δ W (g)
Traverse data (D %)	Δ p (mmH ₂ O)	Temp (°C)	Δ p (mmH ₂ O)	Temp (°C)	√h (mmH ₂ O)	√h (mmH ₂ O)						
25.0	12.5	48.0	12.1	49.0	3.536	3.479	Trap 1	652.7	682.3	29.6		
75.0	12.6	48.0	12.5	49.0	3.550	3.536	Trap 2	698.5	710.2	11.7		
							Trap 3			0.0		
							Trap 4			0.0		
							Trap 5			0.0		
							Trap 6			0.0		
							Trap 7			0.0		
Total Weight Gain (g) =										41.3		
H ₂ O Gas Vol @stp = ΔW/18 x 22.412										51.42 litres		
H ₂ O Vol =										51.42 litres		
Totals	25.10	96.00	24.60	98.00	7.085	7.014						
Line Mean	12.55	48.00	12.30	49.00	3.543	3.507	Metered Sample Vol @stp = V. 273 x Pm Tm + 273 760 Sample Vol @stp = 989.32 litres					
Overall Mean	h mean:	12.43	Temp mean:	48.50 °C	√h mean:	3.525						
Mean Flue Gas Temperature (in K) =		321.50		to		64.6		% moisture = $\frac{H_2O \text{ Gas Vol stp} \times 100}{\text{Vol stp} + H_2O \text{ (vol gas stp)}}$ = 4.94				
Permitted Gas Temperature Range (°C) =		32.4										
Highest Pitot-Static Reading (either sampling line) (in Pa) =		123.57										
Lowest Pitot-Static Reading (either sampling line) (in Pa) =		118.66										
Ratio Highest/Lowest =		1.0		(Maximum Permitted Ratio = 9 :1)								
Sampling Grid												
Line	A			B			A	B	K Factor	% Isokinetic		
Traverse data (D %)	Temp (°C)	Δ p (mmH ₂ O)	Δ H (mmH ₂ O)	Temp (°C)	Δ p (mmH ₂ O)	Δ H (mmH ₂ O)	Duration of Sampling (s)	Duration of Sampling (s)				
25.0	48.0	12.5	28.9	48.0	14.0	32.3	900	900	2.31	100.70		
75.0	48.0	12.5	28.9	49.0	14.0	32.3	900	900				
Gas Composition												
Gas Composition		MW	Mole Fraction = (1- H2O/100 x Dry%) x (MW Gas/100)									
Dry N ₂ % v/v	78.997	28.00	21.026									
Dry O ₂ % v/v	21.000	32.00	6.388									
Dry CO ₂ % v/v	0.003	44.00	0.001									
Total %	100.000											
Wet H ₂ O% v/v	4.941	18.00	0.889									
Molecular Weight of Wet Gas = Σ Mole Fraction (M) =		28.3049										
Molecular Weight of Dry Air =		28.8400										
Specific Gravity S = $\frac{\text{Molecular Wt Wet Gas}}{\text{Molecular Wt Dry Gas}}$		S = 0.9814										
Velocity and Volume Gas Flow												
Actual Gas Velocity =		$34.97 \sqrt{\frac{K}{M \times (Pb + Pd)}} \times \sqrt{h}$		x Cp		321.50 21910.871		0.014673 0.1211325				
Actual Gas Velocity =		11.35 m/s		Highest Gas Velocity =		11.4 m/s		Lowest Gas Velocity =		11.2 m/s		
				Ratio Highest/Lowest =		1.0		(Maximum Permitted Ratio = 3 :1)				
Gas Flow (actual) = Vel x Duct Area (m ³ /s)												
=		1.43 m ³ /s										
Gas Flow (ref wet) = Gas Flow (actual) x $\frac{273 \times \frac{Pb + Pd}{760}}{K}$		m ³ /s (760mmHg, 0°C and wet)										
=		1.234 m ³ /s (760mmHg, 0°C and wet)										
=		4441.8 m ³ /hr (760mmHg, 0°C and wet)										
Verified												

CES Environmental Instruments Ltd

Determination of Particulate Concentration	Client Pelgia, Grimsby Job Number 8252 Site Meal Cooler	Date 17/07/2019 Test 1 Test Period 09:00-10:05
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Inputs	Particulate Collected
Reference Temp T _{ref} 0.0 °C 273 K	Mass in Sample in mg
Reference Pressure P _{ref} 101.3 kPa	Mass on Filter 1 4.1 mg
Reference Oxygen O _{2ref} %	Mass on Filter 2 mg
Reference Moisture H ₂ O _{ref} 0.0 %	Mass on Filter 3 mg
Metered Gas Volume VM _{meas} 1066.2 litres	Mass on Filter 4 mg
Meter Temperature TM _{meas} 21.4 °C 294.4 K	Mass in Washings = 0.2 mg
Meter Pressure PM _{meas} 101.4 kPa	Mass on Blank 0.0 mg
Duct Oxygen O _{2meas} % v/v dry	Mass in Wash Blank = 0.0 mg
Duct Moisture H ₂ O _{meas} 4.9 % v/v	Filter ID F1
Duct Temperature T _{meas} 48.5 °C	
Duct Pressure, Abs (Pda) 103.2 kPa	
Calculated Actual Gas Flow 1.427 m ³ /s	
Calculated Reference Gas Flow Q _{ref} 1.234 m ³ /s (101.3kPa, 0°C and wet)	
4441.8 m ³ /hr (101.3kPa, 0°C and wet)	

Calculations
$\text{Meter Gas Vol } V_{ref} = VM_{meas} \times (T_{ref}/TM_{meas}) \times (PM_{meas}/P_{ref})$ $= 989.6 \text{ dm}^3$ $\text{Meter Gas Vol } V_{ref} = 0.9896 \text{ m}^3 \text{ (101.3kPa, 0°C and dry)}$
$\text{Total Net Mass Sampled} = \Sigma \text{Mass in Sample}$ $= 4.3 \text{ mg}$

Concentration of Particulate
$\text{Concentration} = \text{Total Net Mass Sampled} / \text{Gas Volume} \text{ mg/m}^3$
C1 @ Concentration Actual = 3.6 mg/m³
C2 @ 101.3kPa, 0°C and wet = C3 x (100-H₂O_{meas})/(100-H₂O_{ref}) $= 4.1 \text{ mg/m}^3$
C3 @ 101.3kPa, 0°C and dry = Total Net Mass Sampled / Meter Gas Vol Vref $= 4.3 \text{ mg/m}^3$
C4 @ 101.3kPa, 0°C, O_{2ref} and dry = C3 x (20.9-O_{2ref})/(20.9-O_{2meas}) $= 4.3 \text{ mg/m}^3$

Mass Emission Rate of Particulate
$\text{Emission Rate } E = \text{Conc @ ref temp \& press} \times \text{Gas Flow @ ref temp \& press}$
Emission Rate E = C2 x Q_{ref} x 10⁻⁶ x 3600 kg/hr $= 0.018 \text{ kg/hr}$
Verified

CES Environmental Instruments Ltd

Determination of Particulate Concentration	Client Pelgia, Grimsby Job Number 8252 Site Meal Cooler	Date 17/07/2019 Test Blank Test Period 09:00-10:05
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Inputs	Particulate Collected
Reference Temp T_{ref} 0.0 °C 273 K	Mass in Sample in mg
Reference Pressure P_{ref} 101.3 kPa	Mass on Filter 1 0.0 mg
Reference Oxygen O_{2ref} %	Mass on Filter 2 mg
Reference Moisture H_2O_{ref} 0.0 %	Mass on Filter 3 mg
Metered Gas Volume VM_{meas} 1066.2 litres	Mass on Filter 4 mg
Meter Temperature TM_{meas} 21.4 °C 294.4 K	Mass in Washings = 0.0 mg
Meter Pressure PM_{meas} 101.4 kPa	Mass on Blank 0.0 mg
Duct Oxygen O_{2meas} % v/v dry	Mass in Wash Blank = 0.0 mg
Duct Moisture H_2O_{meas} 4.9 % v/v	
Duct Temperature T_{meas} 48.5 °C	
Duct Pressure, Abs (Pda) 103.2 kPa	
Calculated Actual Gas Flow 1.427 m ³ /s	
Calculated Reference Gas Flow Q_{ref} 1.234 m ³ /s (101.3kPa, 0°C and wet)	
4441.8 m ³ /hr (101.3kPa, 0°C and wet)	

Calculations	
Sample Volumes	
Test 1 0.9896 m ³ (101.3kPa, 0°C and dry)	Meter Gas Vol $V_{ref} = VM_{meas} \times (T_{ref}/TM_{meas}) \times (PM_{meas}/P_{ref})$
Test 2 0.8910 m ³ (101.3kPa, 0°C and dry)	
Test 3 m ³ (101.3kPa, 0°C and dry)	
Test 4 m ³ (101.3kPa, 0°C and dry)	
Test 5 m ³ (101.3kPa, 0°C and dry)	
	Mean Meter Gas Vol $V_{ref} = 0.9403 \text{ m}^3$ (101.3kPa, 0°C and dry)
	Total Net Mass Sampled = Σ Mass in Sample
	= 0.0 mg

Concentration of Particulate	
Concentration = Total Net Mass Sampled / Gas Volume mg/m ³	
C1 @Concentration Actual =	0.0 mg/m³
C2 @ 101.3kPa, 0°C and wet = $C3 \times (100-H_2O_{meas})/(100-H_2O_{ref})$	= 0.0 mg/m³
C3 @ 101.3kPa, 0°C and dry = Total Net Mass Sampled / Meter Gas Vol V_{ref}	= 0.0 mg/m³
C4 @ 101.3kPa, 0°C, O_{2ref} and dry = $C3 \times (20.9-O_{2ref})/(20.9-O_{2meas})$	= 0.0 mg/m³

Mass Emission Rate of Particulate	
Emission Rate E = Conc @ ref temp & press x Gas Flow @ ref temp & press	
Emission Rate E = $C2 \times Q_{ref} \times 10^{-6} \times 3600 \text{ kg/hr}$	= 0 kg/hr

Verified

CES Environmental Instruments Ltd

Determination of Gas Flows By Pitot Tube, with Dalton Corrections		Client Job Number		Pelgia, Grimsby 8252		Date Test		17/07/2019 2				
Determination of Particulate Concentration		Site		Meal Cooler		Test Period		10:15-11:20				
Type of tube (E/S)	S	Metered Gas Reading (Start)	1293.5016 m ³	Metered Gas Reading (End)	1294.4864 m ³	Leak Correction 0.0000 m ³						
Pitot Factor, Cp	0.76	Metered Correction	0.9794	Metered Gas Volume VM _{meas}	964.5 litres							
Duct Shape (Round/Rectangular)	Round	Meter Temperature TM _{meas}	22.8 °C	Meter Pressure PM _{meas}	760.5 mmHg							
Duct Diameter	0.400 m	Differential Meter Press (Pme)	0 mmH ₂ O	Barometric Pressure (Pb)	760.5 mmHg							
Duct Area	0.126 m ²	Differential Duct Press(Pd)	185.0 mmH ₂ O	Duct Pressure, Abs (Pda)	774.1 mmHg							
Nozzle Diameter	6.0 mm											
ΔH@	43.9756											
Velocity Traverse							Moisture Collection					
Line	A		B		A		B		Vessel	Wt on (g)	Wt off (g)	Δ W (g)
Traverse data (D %)	Δ p (mmH ₂ O)	Temp (°C)	Δ p (mmH ₂ O)	Temp (°C)	√h (mmH ₂ O)	√h (mmH ₂ O)						
25.0	12.5	48.0	12.1	49.0	3.536	3.479	Trap 1	682.3	713.6	31.3		
75.0	12.6	48.0	12.5	49.0	3.550	3.536	Trap 2	710.2	720.6	10.4		
							Trap 3			0.0		
							Trap 4			0.0		
							Trap 5			0.0		
							Trap 6			0.0		
							Trap 7			0.0		
Total Weight Gain (g) =										41.7		
H ₂ O Gas Vol @stp = ΔW/18 x 22.412										5.12 litres		
H ₂ O Vol =										51.92 litres		
Totals	25.10	96.00	24.60	98.00	7.085	7.014						
Line Mean	12.55	48.00	12.30	49.00	3.543	3.507	Metered Sample Vol @stp = V. Tm + 273 760 Sample Vol @stp = 890.75 litres					
Overall Mean	h mean:	12.43	Temp mean:	48.50 °C	√h mean:	3.525						
Mean Flue Gas Temperature (in K) =		321.50		to		64.6		% moisture = $\frac{H_2O \text{ Gas Vol stp} \times 100}{\text{Vol stp} + H_2O \text{ (vol gas stp)}}$ = 5.51				
Permitted Gas Temperature Range (°C) =		32.4										
Highest Pitot-Static Reading (either sampling line) (in Pa) =		123.57										
Lowest Pitot-Static Reading (either sampling line) (in Pa) =		118.66										
Ratio Highest/Lowest =		1.0		(Maximum Permitted Ratio = 9 :1)								
Sampling Grid												
Line	A			B			A	B	K Factor	% Isokinetic		
Traverse data (D %)	Temp (°C)	Δ p (mmH ₂ O)	Δ H (mmH ₂ O)	Temp (°C)	Δ p (mmH ₂ O)	Δ H (mmH ₂ O)	Duration of Sampling (s)	Duration of Sampling (s)				
25.0	48.0	12.5	28.9	48.0	14.0	32.3	900	900	2.31	101.20		
75.0	48.0	12.5	28.9	49.0	14.0	32.3	900	900				
Gas Composition												
Gas Composition		MW	Mole Fraction = (1- H2O/100 x Dry%) x (MW Gas/100)									
Dry N ₂ % v/v		78.997	28.00	20.901								
Dry O ₂ % v/v		21.000	32.00	6.350								
Dry CO ₂ % v/v		0.003	44.00	0.001								
Total %		100.000										
Wet H ₂ O% v/v		5.508	18.00	0.991								
Molecular Weight of Wet Gas = Σ Mole Fraction (M) =			28.2434									
Molecular Weight of Dry Air =			28.8400									
Specific Gravity S = $\frac{\text{Molecular Wt Wet Gas}}{\text{Molecular Wt Dry Gas}}$			S = 0.9793									
Velocity and Volume Gas Flow												
Actual Gas Velocity =		$34.97 \sqrt{\frac{K}{M \times (Pb + Pd)}} \times \sqrt{h}$		x Cp		321.50 21863.301		0.014705 0.1212642				
Actual Gas Velocity =		11.36 m/s		Highest Gas Velocity =		11.4 m/s		Lowest Gas Velocity =		11.2 m/s		
				Ratio Highest/Lowest =		1.0		(Maximum Permitted Ratio = 3 :1)				
Gas Flow (actual) = Vel x Duct Area (m ³ /s)												
=		1.43 m ³ /s										
Gas Flow (ref wet) = Gas Flow (actual) x $\frac{273}{K} \times \frac{Pb + Pd}{760}$ m ³ /s (760mmHg, 0°C and wet)												
=		1.235 m ³ /s (760mmHg, 0°C and wet)										
=		4446.6 m ³ /hr (760mmHg, 0°C and wet)										
Verified												

CES Environmental Instruments Ltd

Determination of Particulate Concentration	Client Pelgia, Grimsby Job Number 8252 Site Meal Cooler	Date 17/07/2019 Test 2 Test Period 10:15-11:20
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Inputs	Particulate Collected
Reference Temp T _{ref} 0.0 °C 273 K	Mass in Sample in mg
Reference Pressure P _{ref} 101.3 kPa	Mass on Filter 1 3.4 mg
Reference Oxygen O _{2ref} %	Mass on Filter 2 mg
Reference Moisture H ₂ O _{ref} 0.0 %	Mass on Filter 3 mg
Metered Gas Volume VM _{meas} 964.5 litres	Mass on Filter 4 mg
Meter Temperature TM _{meas} 22.8 °C 295.8 K	Mass in Washings = 0.1 mg
Meter Pressure PM _{meas} 101.4 kPa	Mass on Blank 0.0 mg
Duct Oxygen O _{2meas} % v/v dry	Mass in Wash Blank = 0.0 mg
Duct Moisture H ₂ O _{meas} 5.5 % v/v	Filter ID F2
Duct Temperature T _{meas} 48.5 °C	
Duct Pressure, Abs (Pda) 103.2 kPa	
Calculated Actual Gas Flow 1.428 m ³ /s	
Calculated Reference Gas Flow Q _{ref} 1.235 m ³ /s (101.3kPa, 0°C and wet)	
4446.6 m ³ /hr (101.3kPa, 0°C and wet)	

Calculations
$\text{Meter Gas Vol } V_{ref} = VM_{meas} \times (T_{ref}/TM_{meas}) \times (PM_{meas}/P_{ref})$ $= 891.0 \text{ dm}^3$ $\text{Meter Gas Vol } V_{ref} = 0.8910 \text{ m}^3 \text{ (101.3kPa, 0°C and dry)}$
$\text{Total Net Mass Sampled} = \Sigma \text{Mass in Sample}$ $= 3.5 \text{ mg}$

Concentration of Particulate
$\text{Concentration} = \text{Total Net Mass Sampled} / \text{Gas Volume} \text{ mg/m}^3$
C1 @Concentration Actual = 3.2 mg/m³
C2 @ 101.3kPa, 0°C and wet = C3 x (100-H₂O_{meas})/(100-H₂O_{ref}) $= 3.7 \text{ mg/m}^3$
C3 @ 101.3kPa, 0°C and dry = Total Net Mass Sampled / Meter Gas Vol Vref $= 3.9 \text{ mg/m}^3$
C4 @ 101.3kPa, 0°C, O_{2ref} and dry = C3 x (20.9-O_{2ref})/(20.9-O_{2meas}) $= 3.9 \text{ mg/m}^3$

Mass Emission Rate of Particulate
$\text{Emission Rate } E = \text{Conc @ ref temp \& press} \times \text{Gas Flow @ ref temp \& press}$
Emission Rate E = C2 x Q_{ref} x 10⁻⁶ x 3600 kg/hr $= 0.017 \text{ kg/hr}$
Verified

Appendix 4 Calibration Certificates

Certificate of Calibration

Date of Issue: 07 January 2019

Certificate No. CES1716

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



Certified By

Instrument Details

Instrument Type	Manual Sample Train
Instrument Make	Andersen
Instrument Serial No.	90637
Dry Gas Meter Serial No.	102928
Quality No.	C154
Calibration Date	07/01/2019
Calibrated By Name	A.Orme

Ambient Conditions

Air Temperature (°C)	27
Relative Humidity (%)	42
Barometric Pressure P _b	762.1 mm Hg 1016 mbar

Instruments used to undertake calibration

Manometer Type FC012	UKAS Certificate No. 16522	(Qu. No. C082)
Manometer Type FC012	UKAS Certificate No. 16521	(Qu. No. C081)
Barometer Type 104	UKAS Certificate No. U93363-18	(Qu. No. C138)
RIS Supercal XT	UKAS Certificate No. 263185001	(Qu. No. C014)
Gallus Dry Gas Meter	UKAS Certificate No. N024109	(Qu. No. C333)

Pressure Measurement

The instrument under test provides an indication by means of a liquid manometer corresponding to an applied pressure. The liquid manometer was calibrated against a FCO12 Digital Micromanometer whose calibration is traceable to UKAS standards. The readings of the reference instrument and the instrument under test were taken simultaneously and compared.

Dry Gas Meter Calibration

A calibrated dry gas meter was connected to the sampling inlet of the Control Unit. 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 dry gas meter contained within the control unit.

Temperature Calibration

The instrument under test provides an indication by means of an Electronic Display corresponding to an applied simulated temperature. The Display was calibrated against a reference temperature instrument whose calibration is traceable to UKAS standards. The readings of the reference instrument and the instrument under test were taken simultaneously and compared.

Certificate of Calibration

Date of Issue: 07 January 2019

Certificate No. CES1716
page 2 of 2

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



Certified By

Instrument Details

Instrument Type: Manual Sample Train
Instrument Make: Andersen
Instrument Serial No.: 90637
Dry Gas Meter Serial No.: 102928
Quality No.: C154
Calibration Date: 07/01/2019

Ambient Conditions

Air Temperature (°C): 27
Relative Humidity (%): 42
Barometric Pressure (P₀): 762.1 mm Hg
1016 mBar

Calibration Details

Orifice manometer setting	Calibrated Dry Gas Meter ΔH	Dry Gas Meter (UUT) Volume	Temperatures				Time min
			Calibrated Gas Meter	Dry Gas Meter			
				Inlet t _i	Outlet t _o	Average	
0.3	39.0	40.9	25.0	31.0	30.0	30.5	20.0
15	260.4	274.4	24.0	37.0	33.0	35.0	20.0
25	337.1	348.4	23.0	36.0	32.0	34.0	20.0
50	457.9	474.6	27.0	36.0	30.0	33.0	20.0
100	646.8	635.9	29.0	31.0	27.0	29.0	20.0

ΔH setting mm H2O @	Y		ΔH@	
	V _w P ₀ (t _m + 273)	[P ₀ + (ΔH + 13.6)] (t _w + 273)	1170 ΔH P ₀ (t ₀ + 273)	(T _w + 273) Q ² V _w
0.3	0.9711			35.8893
15	0.9831			39.5898
25	1.0011			39.2364
50	0.9794			43.9756
100	1.0074			45.1165
Average	0.9884			40.7615
As Found	0.8952			47.8862

Manometer 1 (ΔH)				Manometer 2 (ΔP)			
Required Pressure mmH ₂ O/Pa	Reference Pressure Pa	Reference Pressure mmH ₂ O	Display Pressure mmH ₂ O (ΔH)	Required Pressure mmH ₂ O/Pa	Reference Pressure Pa	Reference Pressure mmH ₂ O	Display Pressure mmH ₂ O (ΔP)
0.0 / 0.0	0.0	0.0	0.0	0.0 / 0.0	0.0	0.0	0.0
5.0 / 49.0	49.0	5.0	5.0	5.0 / 49.0	49.0	5.0	5.0
10.0 / 98.1	98.1	10.0	10.0	10.0 / 98.1	98.1	10.0	10.0
15.0 / 147.1	147.1	15.0	15.0	15.0 / 147.1	147.1	15.0	15.0
20.0 / 196.1	196.1	20.0	20.0	20.0 / 196.1	196.1	20.0	20.0
25.0 / 245.2	245.2	25.0	25.0	25.0 / 245.2	245.2	25.0	25.0
50.0 / 490.3	490.3	50.0	50.0	50.0 / 490.3	490.3	50.0	50.0
100.0 / 980.1	980.1	100.0	100.0	100.0 / 980.1	980.1	99.9	100.0
150.0 / 1471.0	1471.0	150.0	150.0	150.0 / 1471.0	1471.0	150.0	150.0
200.0 / 1961.3	1961.3	200.0	200.0	200.0 / 1961.3	1961.3	200.0	200.0
250.0 / 2451.1	2451.1	250.0	250.0	250.0 / 2451.1	2451.1	250.0	250.0

Test Temperature °C	Display 1 °C	Display 2 °C	Display 3 °C	Display 4 °C	Display 5 °C	Display 6 °C	Display 7 °C
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0
100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
200.0	200.0	200.0	200.0	200.0	200.0	200.0	200.0
300.0	300.0	300.0	300.0	300.0	300.0	300.0	300.0
700.0	700.0	700.0	700.0	700.0	700.0	700.0	700.0

Appendix 5 Uncertainty Calculations

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

Limit value (ELV)	20 mg.m ⁻³	Reference oxygen	% by volume
Measured concentration	4.14 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	0.9896	uV _m	0.001 m ³	0.10		<=2%
Sampled gas Temperature	T _m	273	uT _m	2 k	0.73		<=1%
Sampled gas Pressure	ρ _m	101.3	uρ _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	4.1	um	0.26 mg	6.34	1.31	<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	0.2		mg	4.87804878		<=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	$f_s = \frac{(100 - H_m) 273 \rho_m}{100 T_m 101.3}$
	H _m	0.010	0.010	
	T _m	0.004	0.007	
	ufs		0.012	
Corrected volume	V	0.99	uV	0.012 m ³
				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	0.99 m ³	4.19	0.05 mg.m ⁻³	1.25 %
Mass	m	4.10 mg	1.01	0.26 mg.m ⁻³	6.34 %
Factor for O2 Correction	fc	1.00	4.14	0.02 mg.m ⁻³	0.48 %
Leak	L	0.05 mg.m ⁻³	1.00	0.05 mg.m ⁻³	1.15 %
Uncollected mass	UCM	0.12 mg	1.01	0.12 mg.m ⁻³	2.82 %
Combined measurement uncertainty				0.30 mg.m⁻³	
Expanded uncertainty as percentage of measured value		14.32	% measured of value	expressed with a level of confidence of 95% (Using a coverage factor k=2)	
Expanded uncertainty in units of measurement		0.59	mg.m ⁻³		
Expanded uncertainty as percentage of limit value		2.97	% ELV		

Verified