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Stack Emissions Testing Report Commissioned by
BAE Systems Maritime - Submarines

Installation Name & Address
BAE Systems Maritime - Submarines
1st Floor
Main Shipyard Offices
Barrow-in-Furness
Cumbria
LA14 1AF

PPC Permit: PPC/B/05

Stack Reference
D16 E866 - RIF Spray Paint Enclosure

Dates of the Monitoring Campaign
26th July 2016

Job Reference Number
CAT-2864

Report Written by
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Report Date
28th July 2016

Version
Version 1

Signature of Report Approver

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Executive Summary

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MONITORING OBJECTIVES

BAE Systems Maritime - Submarines, Barrow-in-Furness

D16 E866 - RIF Spray Paint Enclosure

26th July 2016

Overall Aim of the Monitoring Campaign

Exova Catalyst were commissioned by BAE Systems Maritime - Submarines to carry out stack emissions testing on the D16 E866 - RIF Spray Paint Enclosure at Barrow-in-Furness.

The aim of the monitoring campaign was to demonstrate compliance with a set of emission limit values (ELVs) as specified in the Site's Permit.

Special Requirements

There were no special requirements.

Target Parameters

Total Particulate Matter |

Executive Summary

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MONITORING RESULTS

BAE Systems Maritime - Submarines, Barrow-in-Furness
D16 E866 - RIF Spray Paint Enclosure

where MU = Measurement Uncertainty associated with the Result

Parameter	Concentration				Mass Emission			
	Units	Result	MU +/-	Limit	Units	Result	MU +/-	Limit
Total Particulate Matter ¹	mg/m ³	2.0	0.31	50	g/hr	4.2	0.71	-
Water Vapour	% v/v	0.50	0.04					
Stack Gas Temperature	°C	22.9						
Stack Gas Velocity	m/s	8.9	0.34					
Volumetric Flow Rate (ACTUAL)	m ³ /hr	2278	135					
Volumetric Flow Rate (REF) ¹	m ³ /hr	2109	125					

NOTE: VOLUMETRIC FLOW RATE & VELOCITY DATA TAKEN FROM AN AVERAGE OF ALL OF THE ISOKINETIC RUNS.

¹ Reference Conditions (REF) are: 273K, 101.3kPa, without correction for water vapour content.

Executive Summary

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MONITORING DATE(S) & TIMES

BAE Systems Maritime - Submarines, Barrow-in-Furness
 D16 E866 - RIF Spray Paint Enclosure
 26th July 2016

Parameter	Units	Concentration	Units	Mass Emission	Sampling Date(s)	Sampling Times	Duration mins	
Total Particulate Matter	R1	mg/m ³	3.1	g/hr	6.6	26/07/2016	13:07 - 14:07	60
Total Particulate Matter	R2	mg/m ³	0.85	g/hr	1.8	26/07/2016	14:15 - 15:15	60
Velocity & Volumetric Flow Rate	R1					26/07/2016	12:45 - 12:50	

All results are expressed at the respective reference conditions.

Executive Summary

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PROCESS DETAILS

BAE Systems Maritime - Submarines, Barrow-in-Furness
 D16 E866 - RIF Spray Paint Enclosure
 26th July 2016

Standard Operating Conditions

Parameter	Value
Process Status	Normal Operation
Capacity (of 100%) and Tonnes / Hour	2 Large Submarine Parts
Continuous or Batch Process	Batch
Feedstock (if applicable)	Submarine Parts
Abatement System	Cartridge Filters
Abatement System Running Status	On
Fuel	N/A
Plume Appearance	No Visible Plume

Executive Summary

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MONITORING & ANALYTICAL METHODS

BAE Systems Maritime - Submarines, Barrow-in-Furness

D16 E866 - RIF Spray Paint Enclosure

26th July 2016

Parameter	Monitoring				Analysis				MCERTS Testing	LOD (Average)
	Standard	Technical Procedure	ISO 17025 Testing	Testing Lab	Analytical Procedure	Analytical Technique	ISO 17025 Analysis	Analysis Lab		
Total Particulate Matter	EN 13284-1	CAT-TP-01	Yes	CAT	CAT-TP-03	Gravimetric	Yes	CAT	Yes	0.12 mg/m ³
Water Vapour	EN 14790	CAT-TP-05	Yes	CAT	CAT-TP-05	Gravimetric	Yes	CAT	Yes	0.10 % v/v
Velocity & Vol. Flow Rate	EN 16911-1 (MID)	CAT-TP-41	Yes	CAT	Pitot Tube and Thermocouple				Yes	1.2 m/s

ANALYSIS LABORATORIES

(with short name reference as appears in the table above)

Exova Catalyst (CAT)	ISO 17025 Accreditation Number: 4279
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SUMMARY OF SAMPLING DEVIATIONS

Parameter	Run	Deviation
All Parameters	All	There are no deviations associated with the sampling employed.

Executive Summary

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SUITABILITY OF SAMPLING LOCATION

Duct Characteristics

Parameter	Units	Value
Type	-	Circular
Depth	m	0.30
Width	m	-
Area	m ²	0.07
Port Depth	cm	8
Orientation of Duct	-	Vertical
Sample Port Size	-	4" BSP

Location of Sampling Platform

General Platform Information	Value
Permanent / Temporary Platform	MEWP
Inside / Outside	Outside

Platform Details

EA Technical Guidance Note M1 / EN 15259 Platform Requirements	Value
Sufficient working area to manipulate probe and operate the measuring instruments	Yes
Platform has 2 levels of handrails (approx. 0.5m & 1.0m high)	Yes
Platform has vertical base boards (approx. 0.25m high)	Yes
Platform has chains / self closing gates at top of ladders	Yes
There are no obstructions present which hamper insertion of sampling equipment	Yes
Safe Access Available	Yes
Easy Access Available	Yes

Sampling Location / Platform Improvement Recommendations

The sampling location meets all the requirements specified in EA Guidance Note M1 and EN 15259, and therefore there are no improvement recommendations.

EN 15259 Homogeneity Test Requirements

There is no requirement to perform a EN 15259 Homogeneity Test on this Stack.

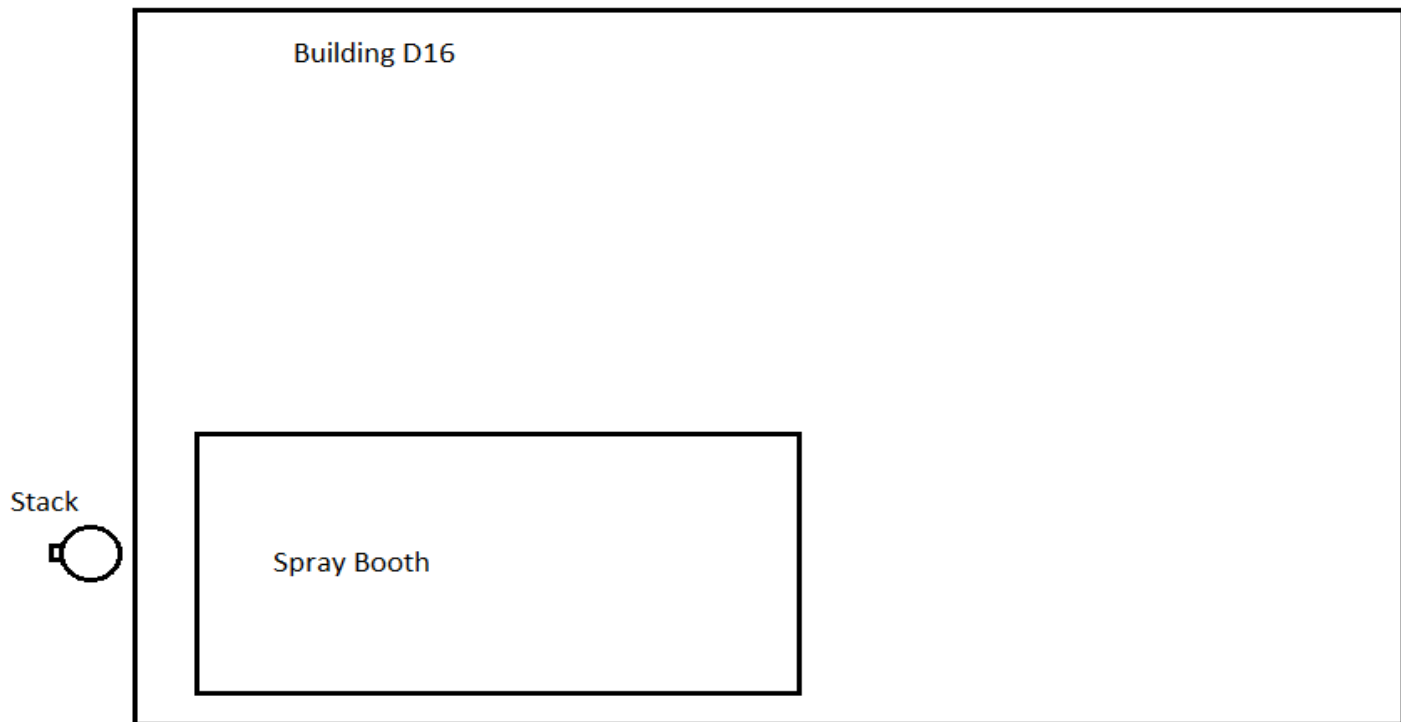
Sampling Plane Validation Criteria (from EN 15259)

Criteria in EN 15259	Units	Traverse 1	Required	Compliant
Lowest Differential Pressure	Pa	67.0	> 5 Pa	Yes
Mean Velocity	m/s	8.94	-	-
Lowest Gas Velocity	m/s	8.94	-	-
Highest Gas Velocity	m/s	8.94	-	-
Ratio of Above	: 1	1.00	< 3 : 1	Yes
Maximum Angle of Swirl	°	5	< 15°	Yes
No Local Negative Flow	-	Yes	-	Yes

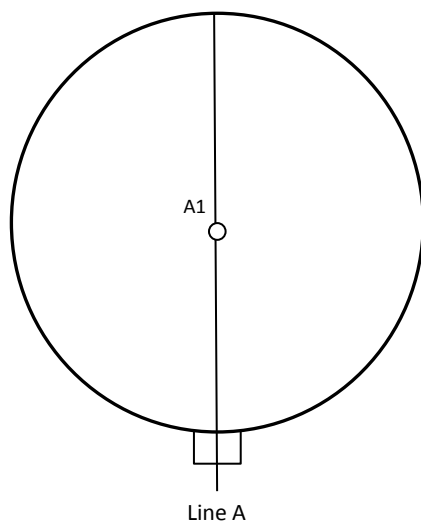
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PLANT LAYOUT



SAMPLE POINTS



- where
- = isokinetic point sampled at
 - = isokinetic point not sampled at
 - = combustion gases sample point
 - = non-isokinetic sample point



APPENDICES

APPENDIX CONTENTS

APPENDIX 1 - Stack Emissions Monitoring Personnel, List of Equipment & Methods and Technical Procedures Used

APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

STACK EMISSIONS MONITORING PERSONNEL

Position	Name	MCERTS Accreditation	MCERTS Number	Technical Endorsements
Team Leader	Brian Jacob	MCERTS Level 2	MM 06 693	TE1 TE2 TE3 TE4
Technician	Craig Macdonald	MCERTS Level 1	MM 11 1130	None

LIST OF EQUIPMENT

Extractive Sampling		Instrumental Analysers		Miscellaneous Items	
Equipment Type	Equipment I.D.	Equipment Type	Equipment I.D.	Equipment Type	Equipment I.D.
Control Box DGM (1)	CAT 7.39	Horiba PG-250	-	Digital Manometer (1)	CAT 3.25
Control Box DGM (2)	-	Horiba PG-250	-	Digital Manometer (2)	-
Box Thermocouples (1)	CAT 3.10	Servomex 4900	-	Digital Temperature Meter	CAT 3.25
Box Thermocouples (2)	-	Eco Physics CLD 822Mh	-	Stopwatch	CAT 14.53
Umbilical (1)	CAT 3.10	ABB AO2020-URAS26	-	Barometer	CAT 13.20
Umbilical (2)	-	Servomex 5200MP	-	Stack Thermocouple (1)	CAT 4.770
Oven Box (1)	-	JCT JCC P1 Cooler	-	Stack Thermocouple (2)	-
Oven Box (2)	-	Gasmet DX4000	-	Stack Thermocouple (3)	-
Heated Probe (1)	CAT 5.3	Gasmet Sampling System	-	1m Heated Line (1)	-
Heated Probe (2)	-	Bernath 3006 FID	-	1m Heated Line (2)	-
Heated Probe (3)	-	M&C PSS	-	1m Heated Line (3)	-
S-Pitot (1)	CAT 21p.43	Mass Flow Controller (1)	-	5m Heated Line (1)	-
S-Pitot (2)	-	Mass Flow Controller (2)	-	15m Heated Line (1)	-
L-Pitot	-	Mass View (1)	-	20m Heated Line (1)	-
Site Balance	CAT 17.13	Mass View (2)	-	20m Heated Line (2)	-
500g / 1Kg Check Weights	CAT 17.13	Easylogger EN-EL-12 Bit	-	Dual Channel Heater Controller	-
Last Impinger Arm	-	Easylogger EN-EL-12 Bit	-	Single Channel Heater Controller	-
Callipers	CAT 23.10	Bioaerosols Temperature Logger	-	Laboratory Balance	CAT 1.18 / 1.18a
Tubes Kit Thermocouple	-	Electronic Refrigerator	-	Tape Measure	CAT 16.14

METHODS & TECHNICAL PROCEDURES USED

Parameter	Standard	Technical Procedure
Total Particulate Matter	EN 13284-1	CAT-TP-01
Water Vapour	EN 14790	CAT-TP-05
Velocity & Vol. Flow Rate	EN 16911-1 (MID)	CAT-TP-41

PRELIMINARY STACK SURVEY: CALCULATIONS

General Stack Details

Stack Details (from Traverse)	Units	Value
Stack Diameter / Depth, D	m	0.30
Stack Width, W	m	-
Stack Area, A	m ²	0.07
Average Stack Gas Temperature, T _a	°C	19.1
Average Stack Gas Pressure	Pa	67.0
Average Stack Static Pressure, P _{static}	kPa	0.011
Average Barometric Pressure, P _b	kPa	101.7
Average Pitot Tube Calibration Coefficient, C _p	-	0.85

Stack Gas Composition & Molecular Weights

Component	Conc ppm	Conc Dry % v/v	Conc Wet % v/v	Volume Fraction r	Molar Mass M	Density kg/m ³ ρ	Conc kg/m ³ ρ _i
CO ₂ (Estimated)	-	0.06	0.06	0.0006	44.01	1.9635	0.00118
O ₂ (Estimated)	-	20.80	20.70	0.2080	32.00	1.4277	0.29696
N ₂	-	79.14	78.75	0.7914	28.01	1.2498	0.98913
Moisture (H ₂ O)	-	-	0.50	0.0050	18.02	0.8037	0.00398

Where: $\rho = M / 22.41$
 $\rho_i = r \times \rho$

Calculation of Stack Gas Densities

Determinand	Units	Result
Dry Density (STP), P _{STD}	kg/m ³	1.287
Wet Density (STP), P _{STW}	kg/m ³	1.285
Dry Density (Actual), P _{Actual}	kg/m ³	1.208
Average Wet Density (Actual), P _{ActualW}	kg/m ³	1.206

Where: P_{STD} = sum of component concentrations, kg/m³ (not including water vapour)
P_{STW} = sum of all wet concentrations / 100 x density, kg/m³ (including water vapour)
 $P_{Actual} = P_{STD} \times (T_{STP} / (P_{STP})) \times ((P_{static} + P_b) / T_a)$
 $P_{ActualW} \text{ (at each sampling point)} = P_{STW} \times (T_s / P_s) \times (P_a / T_a)$

Calculation of Stack Gas Volumetric Flowrate, Q

Duct gas flow conditions	Units	Actual	REF ¹
Temperature	°C	19.1	0.0
Total Pressure	kPa	101.7	101.3
Moisture	%	0.50	0.50

Gas Volumetric Flowrate (from Traverse)	Units	Result
Gas Volumetric Flowrate (Actual)	m ³ /hr	2276
Gas Volumetric Flowrate (STP, Wet)	m ³ /hr	2136
Gas Volumetric Flowrate (STP, Dry)	m ³ /hr	2125
Gas Volumetric Flowrate REF ¹	m ³ /hr	2136

PRELIMINARY STACK SURVEY: VELOCITY TRAVERSE TO EN 16911-1 (MID)

(1 of 1)

Parameter	Units	Value
Date of Survey	-	26/07/2016
Time of Survey	-	12:45 - 12:50
Atmospheric Pressure	kPa	101.7
Average Stack Static Pressure	Pa	11
Result of Pitot Stagnation Test	-	Pass
Are Water Droplets Present?	-	No
Device Used	S-Type Pitot with KIMO MP 200 (500Pa)	

Parameter	Units	Value
Initial Pitot Leak Check	-	Pass
Final Pitot Leak Check	-	Pass
Orientation of Duct	-	Vertical
Pitot Tube, C_p	-	0.85
Number of Lines Available	-	1
Number of Lines Used	-	1

Sampling Line A						
Traverse Point	Depth m	ΔP Pa	Temp °C	Wet Density kg/m^3	Velocity m/s	Swirl °
<i>STATIC (Units: Pa)</i>		11.0				
Mean		67.0	19.1	1.206	8.94	
1	0.15	67.0	19.1	1.206	8.94	5.0

PRELIMINARY STACK SURVEY: VELOCITY TRAVERSE TO EN 16911-1 (MID) - MEASUREMENT UNCERTAINTY

(1 of 1)

Performance characteristics (Uncertainty Components)	Uncertainty	Value	Units
Standard Uncertainty on the coefficient of the Pitot Tube	$u(k)$	0.005	-
Standard Uncertainty associated with the mean local dynamic pressures	$u(\Delta p_i)$	1.268	Pa
- Resolution	$u(res)$	0.00087	
- Calibration	$u(cal)$	0.467	
- Drift	$u(drift)$	0.083	
- Lack of Fit	$u(fit)$	0.056	
- Overall corrections to dynamic measurements	$u(C_f)$	0.608	
Standard uncertainty associated with the molar mass of the gas	$u(M)$	0.00003	-
- $\phi_{O_2,w}$	-	20.697	
- $\phi_{CO_2,w}$	-	0.060	
- Oxygen, dry	$u(\phi_{O_2,d})$	0.637	
- Carbon Dioxide, dry	$u(\phi_{CO_2,d})$	0.002	
- Water Vapour	$u(\phi_{H_2O})$	0.025	
- Oxygen, wet	$u(\phi_{O_2,w})$	0.634	
- Carbon Dioxide, wet	$u(\phi_{CO_2,w})$	0.002	
Standard uncertainty associated with the stack temperature	$u(T_c)$	1.490	K
Standard uncertainty associated with the absolute pressure in the duct	$u(p_c)$	175.697	Pa
- Atmospheric Pressure	$u(p_{atm})$	175.692	
- Static Pressure	$u(p_{stat})$	1.268	
Standard uncertainty associated with the density in the duct	$u(\rho)$	0.00649	-
Standard uncertainty associated with the local velocities	$u(v_i)$	0.176	Pa
Standard uncertainty associated with the mean velocity	$u(\bar{v})$	0.176	m/s
Standard uncertainty associated with the mean velocity (95% Confidence)	$U_c(v)$	0.344	m/s
Standard uncertainty associated with the mean velocity (95% Confidence), relative	$U_{c,rel}(v)$	3.85	%
Standard uncertainty associated with the volume flow rate (95% Confidence)	$U_c(qV,w)$	135.3	m ³ /hr
- $u^2(a)/a^2$	-	0.00053	
- $u^2(qV,w)/q^2V,w$	-	0.00092	
- $u^2(qV,w)$	-	4762	
- $u(qV,w)$	-	69.0	
Standard uncertainty associated with the volume flow rate (95% Confidence), relative	$U_{c,rel}(qV,w)$	5.94	%

TOTAL PARTICULATE MATTER: RESULTS SUMMARY

BAE Systems Maritime - Submarines, Barrow-in-Furness
D16 E866 - RIF Spray Paint Enclosure

Sample Runs

Parameter	Units	Run 1	Run 2	Mean
Concentration	mg/m ³	3.1	0.85	2.0
Uncertainty	±mg/m ³	0.33	0.29	0.31
Mass Emission	g/hr	6.6	1.8	4.2
Uncertainty	±g/hr	0.79	0.63	0.71

Parameter	Units	Run 1	Run 2	Mean
Water Vapour	% v/v	0.46	0.53	0.50
Uncertainty	±% v/v	0.03	0.04	0.04

Blank Runs

Parameter	Units	Blank 1	Maximum
Concentration	mg/m ³	0.14	0.14

General Sampling Information

Parameter	Value
Standard	EN 13284-1
Technical Procedure	CAT-TP-01
Probe Material	Titanium
Filter Housing Material	Titanium
Positioning of Filter	In Stack
Filter Size and Material	47mm Glass Fibre
Number of Sampling Lines Used	1 / 1
Number of Sampling Points Used	1 / 1
Sample Point I.D.'s	A1

FORMAT: Number Used / Number Required

FORMAT: Number Used / Number Required

Reference Conditions

Reference Conditions are: 273K, 101.3kPa, without correction for water vapour content.

TOTAL PARTICULATE MATTER: ISOKINETIC SAMPLING CALCULATIONS

Test	Units	Run 1	Run 2	
Absolute pressure of stack gas, P_s				
Barometric pressure, P _b	mmHg	762.8	762.8	
Stack static pressure, P _{static}	mmH ₂ O	2.0	2.0	
P _s = (P _b + (P _{static} / 13.6))	mmHg	762.9	762.9	
Volume of water vapour collected, V_{wstd}				
Total mass collected in impingers (liquid trap)	g	2.7	2.8	
Total mass collected in impingers (silica trap)	g	1.6	2.1	
Total mass of liquid collected, V _{lc}	g	4.3	4.9	
V _{wstd} = (0.001246)(V _{lc})	m ³	0.0054	0.0061	
Volume of gas metered dry, V_{mstd}				
Volume of gas sample through gas meter, V _m	m ³	1.2460	1.2522	
Gas meter correction factor, Y _d	-	0.9900	0.9900	
Average dry gas meter temperature, T _m	°C	20.0	24.7	
Average pressure drop across orifice, ΔH	mmH ₂ O	45.5	44.3	
V _{mstd} = ((0.3592)(V _m)(P _b + (ΔH/13.6))(Y _d) / (T _m + 273))	m ³	1.1585	1.1459	
Moisture content, B_{w0} & R_{wv}				
B _{w0} = V _{wstd} / (V _{mstd} + V _{wstd})	m ³	0.0046	0.0053	
B _{w0} as a percentage	% v/v	0.46	0.53	
Reported Water Vapour, checked with Tables in EN 14790, R _{wv}	% v/v	0.46	0.53	
Volume of gas metered wet, V_{mstw}				
V _{mstw} = (V _{mstd})(100/(100 - R _{wv}))	m ³	1.1639	1.1520	
Volume of gas metered at Oxygen Reference Conditions, V_{mstd@X%O₂} & V_{mstw@X%O₂}				
IED & Incinerates Hazardous Material? (Yes = no positive O ₂ correction)	-	No	No	
% wet oxygen measured in gas stream, ACT%O _{2w}	% v/v	N/A	N/A	
% dry oxygen measured in gas stream, ACT%O _{2d}	% v/v	N/A	N/A	
% oxygen reference condition, REF%O ₂	% v/v	N/A	N/A	
O ₂ Reference Factor wet (O _{2REFw}) = (21 - REF%O ₂) / (21 - ACT%O _{2w})	-	N/A	N/A	
O ₂ Reference Factor dry (O _{2REFd}) = (21 - REF%O ₂) / (21 - ACT%O _{2d})	-	N/A	N/A	
V _{mstw@X%oxygen} = (V _{mstw}) / (O _{2REFw})	m ³	N/A	N/A	
V _{mstd@X%oxygen} = (V _{mstd}) / (O _{2REFd})	m ³	N/A	N/A	
Molecular weight of dry gas stream, M_d				
CO ₂ (Estimated)	% v/v	0.06	0.06	
O ₂ (Estimated)	% v/v	20.80	20.80	
Total	% v/v	20.86	20.86	
N ₂	% v/v	79.14	79.14	
M _d = 0.44(%CO ₂)+0.32(%O ₂)+0.28(%N ₂)	g/gmol	28.84	28.84	
Molecular weight of stack gas (wet), M_s				
M _s = M _d (1 - (R _{wv} /100)) + 18(R _{wv} /100)	g/gmol	28.79	28.78	
Velocity of stack gas, V_s				
Pitot tube velocity constant, K _p	-	34.97	34.97	
Velocity pressure coefficient, C _p	-	0.85	0.85	
Average of velocity heads, ΔP _{avg}	mmH ₂ O	6.86	6.60	
Average square root of velocity heads, √ΔP	√mmH ₂ O	2.62	2.57	
Average stack gas temperature, T _s	°C	22.3	23.5	
V _s = ((K _p)(C _p)(√ΔP)(√T _s + 273)) / (√(M _s)(P _s))	m/s	9.03	8.87	
Total flow of stack gas: Actual (Q_a), Wet (Q_{stw}), Dry (Q_{std}), Wet@O_{2REF} (Q_{stwO₂}), Dry@O_{2REF} (Q_{stdO₂})				
Area of stack, A _s	m ²	0.07	0.07	
Q _a = (60)(A _s)(V _s)	m ³ /min	38.3	37.6	
Conversion factor (K/mm.Hg), C _f	-	0.3592	0.3592	
Q _{stw} = ((Q _a)(P _s)(C _f) / ((T _s + 273))	m ³ /min	35.5	34.8	
Q _{std} = ((Q _a)(P _s)(C _f)(1 - (R _{wv} /100))) / ((T _s + 273))	m ³ /min	35.4	34.6	
Q _{stwO₂} = ((Q _a)(P _s)(C _f) / ((T _s + 273)) / (O _{2REFw})	m ³ /min	N/A	N/A	
Q _{stdO₂} = ((Q _a)(P _s)(C _f)(1 - (R _{wv} /100))) / ((T _s + 273)) / (O _{2REFd})	m ³ /min	N/A	N/A	
Percent isokinetic, %I				
Nozzle diameter, D _n	mm	6.98	6.98	
Nozzle area, A _n	mm ²	38.27	38.27	
Total sampling time, q	min	60	60	
%I = (4.6398E ⁹)(T _s +273)(V _{mstd}) / (P _s)(V _s)(A _n)(q)(1 - (R _{wv} /100))	%	100.9	102.0	

TOTAL PARTICULATE MATTER: SAMPLING DETAILS

Sample Runs

Parameter	Units	Run 1	Run 2
Sampling Times	-	13:07 - 14:07	14:15 - 15:15
Sampling Dates	-	26/07/2016	26/07/2016
Sampling Device	-	ISO	ISO
Volume Sampled (REF)	m ³	1.1639	1.1520
Filter I.D. Number	-	47-33586	47-35093
Start Filter Mass	g	0.15433	0.14026
End Filter Mass	g	0.15750	0.14044
Total Mass on Filter	g	0.00317	0.00018
Probe Rinse I.D. Number	-	PR-47-33586	PR-47-35093
Start Probe Rinse Mass	g	2.93950	3.04468
End Probe Rinse Mass	g	2.93998	3.04548
Total Mass in Probe Rinse	g	0.00048	0.00080
Total Mass Collected	mg	3.64	0.98
Calculated Concentration	mg/m ³	3.13	0.85
Balance Uncertainty / LOD	mg/m ³	0.12	0.12

Where: ISO stands for Manual Isokinetic Sampling Train

Blank Runs

Parameter	Units	Blank 1
Blank Dates	-	26/07/2016
Average Volume Sampled (REF)	m ³	1.1580
Filter I.D. Number	-	47-31629
Start Filter Mass	g	0.14624
End Filter Mass	g	0.14640
Total Mass on Filter	g	0.00016
Probe Rinse I.D. Number	-	PR-47-31629
Start Probe Rinse Mass	g	2.90272
End Probe Rinse Mass	g	2.90273
Total Mass in Probe Rinse	g	0.00001
Total Mass Collected	mg	0.17
Calculated Concentration	mg/m ³	0.14
Balance Uncertainty / LOD	mg/m ³	0.12

TOTAL PARTICULATE MATTER: QUALITY ASSURANCE

(PAGE 1 OF 2)

Sample Runs

Leak Test Results	Units	Run 1	Run 2	
Mean Sampling Rate	l/min	20.56	20.66	
Pre-Sampling Leak Rate	l/min	0.10	0.08	
Post-Sampling Leak Rate	l/min	0.14	0.11	
Allowable Leak Rate	l/min	0.41	0.41	
Leak Test Acceptable	-	Yes	Yes	
Water Droplets	Units	Run 1	Run 2	
Are Water Droplets Present	-	No	No	
MU (Concurrent Water Vapour)	Units	Run 1	Run 2	
Measurement Uncertainty (MU)	%	7.5	7.0	
Allowable MU	%	20	20	
MU Acceptable	%	Yes	Yes	
Silica Gel (Concurrent Water Vapour)	Units	Run 1	Run 2	
Less than 50% Faded	%	Yes	Yes	
Isokinetic Criterion Compliance	Units	Run 1	Run 2	
Isokinetic Variation	%	100.9	102.0	
Allowable Isokinetic Range	%	95 - 115	95 - 115	
Isokineticity Acceptable	-	Yes	Yes	
Weighing Uncertainty Criteria	Units	Run 1	Run 2	
Overall Weighing Uncertainty	± mg	0.27	0.27	
Overall Weighing Uncertainty	± mg/m ³	0.23	0.23	
ELV [Daily ELV for IED]	mg/m ³	50.00	50.00	
Allowable Weighing Uncertainty	mg/m ³	2.50	2.50	
Weighing Uncertainty Acceptable	-	Yes	Yes	
Filter Temperatures	Units	Run 1	Run 2	
Pre-Conditioning Temperature	°C	180	180	
Post-Conditioning Temperature	°C	160	160	
Maximum Filter Temperature	°C	24	24	
Test Conditions	Units	Run 1	Run 2	
Ambient Temperature Recorded?	-	Yes	Yes	

TOTAL PARTICULATE MATTER: QUALITY ASSURANCE

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Blank Runs

Leak Test Results	Units	Blank 1	
Expected Sampling Rate	l/min	20.00	
Pre-Sampling Leak Rate	l/min	0.10	
Post-Sampling Leak Rate	l/min	0.10	
Allowable Leak Rate	l/min	0.40	
Leak Test Acceptable	-	Yes	

Validity of Blank vs ELV	Units	Blank 1	
Allowable Blank	mg/m ³	5.0	
Blank Acceptable	-	Yes	

Acetone / Water Rinse Blank	Units	Blank
Acetone / Water Rinse Value	mg/l	2.7
Allowable Blank	mg/l	10
Blank Acceptable	-	Yes

Method Deviations

Nature of Deviation	Run Number		
	1	2	
(x = deviation applies to the associated run, wx = deviation also applies to the concurrent water vapour run)			
There are no deviations associated with the sampling employed.	wx	wx	

TOTAL PARTICULATE MATTER: MEASUREMENT UNCERTAINTY CALCULATIONS

Measured Quantities	Value				Standard uncertainty				
	Symbol	Run 1	Run 2		Symbol	Units	Run 1	Run 2	
Sampled Volume (Actual)	V _m	1.2460	1.2522		uV _m	m ³	0.0249	0.0250	
Sampled Gas Temperature	T _m	293.0	297.7		uT _m	K	2.0	2.0	
Sampled Gas Pressure	p _m	101.7	101.7		uρ _m	kPa	0.5	0.5	
Sampled Gas Humidity	H _m	0.0	0.0		uH _m	% v/v	1.0	1.0	
Leak	L	0.68	0.53		uL	%	-	-	
Mass of Particulate	m	3.64	0.98		um	mg	0.14	0.14	
Uncollected Mass	UCM	0.17	0.17		uUCM	mg	-	-	

Measured Quantities	Uncertainty as a Percentage				Requirement of Standard
	Units	Run 1	Run 2		
Sampled Volume (Actual)	%	2.00	2.00		≤2%
Sampled Gas Temperature	%	0.68	0.67		≤1%
Sampled Gas Pressure	%	0.49	0.49		≤1%
Sampled Gas Humidity	%	1.00	1.00		≤1%
Leak	%	0.68	0.53		≤2%
Mass of Particulate	%	0.24	0.24		<5% of ELV
Uncollected Mass	%	-	-		-

Measured Quantities	Uncertainty in Measurement Units					Sensitivity Coefficient		
	Symbol	Units	Run 1	Run 2		Run 1	Run 2	
Sampled Volume (STP)	V _m	m ³	1.1585	1.1459		2.70	0.74	
Leak	L	mg/m ³	0.012	0.003		1.00	1.00	
Mass of Particulate	L _r	mg	3.643	0.983		0.86	0.87	
Uncollected Mass	UCM	mg	0.10	0.10		0.86	0.87	

Measured Quantities	Uncertainty in Result			
	Units	Run 1	Run 2	
Sampled Volume (STP)	mg/m ³	0.079	0.022	
Leak	mg/m ³	0.0123	0.0026	
Mass of Particulate	mg/m ³	0.1203	0.1215	
Uncollected Mass	mg/m ³	0.0827	0.0835	

Measured Quantities	Oxygen Correction Part of MU Budget			
	Units	Run 1	Run 2	
O ₂ Correction Factor	-	N/A	N/A	
Stack Gas O ₂ Content	% v/v	N/A	N/A	
MU for O ₂ Correction	-	N/A	N/A	
Overall MU For O ₂ Measurement	%	N/A	N/A	

Parameter	Units	Run 1	Run 2	
Combined uncertainty	mg/m ³	0.17	0.15	
Expanded uncertainty (95% confidence), without Oxygen Correction	mg/m ³	0.33	0.29	
Expanded uncertainty (95% confidence), with Oxygen Correction	mg/m ³	N/A	N/A	
Expanded uncertainty (95% confidence), estimated with Method Deviations	mg/m ³	0.33	0.29	
Reported Uncertainty	mg/m ³	0.33	0.29	
Expanded uncertainty (95% confidence), without Oxygen Correction	%	10.4	34.2	
Expanded uncertainty (95% confidence), with Oxygen Correction	%	N/A	N/A	
Expanded uncertainty (95% confidence), estimated with Method Deviations	%	10.4	34.2	
Reported Uncertainty	%	10.4	34.2	