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Stack Emissions Testing Report Commissioned by
Air Tech Environmental Consultancy Services

Installation Name & Address
Federal Mogul Sintered Products Ltd
Holbrook Lane
Holbrooks
Coventry
CV6 4BG

PPC Permit: PPC/197

Stack Reference
Main Stack

Dates of the Monitoring Campaign
13th September 2018

Job Reference Number
CAT-4402

Report Written by
Ian Baggley Team Leader MCERTS Level 2 MM 05 653 TE1 TE2 TE3 TE4

Report Approved by
Matthew Pendlebury Team Leader MCERTS Level 2 MM 04 535 TE1 TE2 TE3 TE4

Report Date
19th October 2018

Version
Version 4

Signature of Report Approver
[redacted]

CONTENTS

Opinions and interpretations expressed herein are outside the scope of Exova Catalyst's ISO 17025 accreditation.

This version of the test report supersedes the previous version of the test report. Please destroy all previous versions to ensure no confusion arises from having multiple test reports in existence.

MONITORING OBJECTIVES

Federal Mogul Sintered Products Ltd, Coventry
Main Stack
13th September 2018

Overall Aim of the Monitoring Campaign

Exova Catalyst, in partnership with Air Tech Environmental Consultancy Services, were commissioned to carry out stack emissions testing on the Main Stack by Federal Mogul Sintered Products Ltd at Coventry.

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, Heavy Metals

Executive Summary

MONITORING RESULTS

Federal Mogul Sintered Products Ltd, Coventry

Main Stack

13th September 2018

where MU = Measurement Uncertainty associated with the Result

	Concentration				Mass Emission			
Parameter	**Units**	**Result**	**MU +/-**	**Limit**	**Units**	**Result**	**MU +/-**	**Limit**
Total Particulate Matter [1]	mg/m³	0.22	0.65	20	g/hr	0.89	2.56	-
Heavy Metals [1]	mg/m³	0.04	0.01	5	g/hr	0.14	0.05	-
Water Vapour	% v/v	0.91	0.06					
Stack Gas Temperature	°C	31.5						
Stack Gas Velocity	m/s	19.2	3.19					
Volumetric Flow Rate (ACTUAL)	m³/hr	4256	733					
Volumetric Flow Rate (REF) [1]	m³/hr	3949	680					

NOTE: VOLUMETRIC FLOW RATE & VELOCITY DATA TAKEN FROM THE PRELIMINARY VELOCITY TRAVERSE.

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

Executive Summary

MONITORING DATE(S) & TIMES

Federal Mogul Sintered Products Ltd, Coventry
Main Stack
13th September 2018

Parameter		Units	Concentration	Units	Mass Emission	Sampling Date(s)	Sampling Times	Duration mins
Total Particulate Matter	R1	mg/m³	0.22	g/hr	0.89	13/09/2018	10:06 - 11:06	60
Heavy Metals	R1	mg/m³	0.04	g/hr	0.14	13/09/2018	11:17 - 12:17	60
Velocity Traverse	R1					13/09/2018	09:55 - 10:01	

All results are expressed at the respective reference conditions.

PROCESS DETAILS

Federal Mogul Sintered Products Ltd, Coventry
Main Stack
13th September 2018

Standard Operating Conditions

Parameter	Value
Process Status	Normal Operation
Capacity (of 100%) and Tonnes / Hour	Standard Operating Capacity
Continuous or Batch Process	Induction Furnace and Mill Extraction
Feedstock (if applicable)	Aluminium Scrap
Abatement System	Bag Filter
Abatement System Running Status	On
Fuel	NA
Plume Appearance	None Visible

Executive Summary

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MONITORING & ANALYTICAL METHODS

Federal Mogul Sintered Products Ltd, Coventry
Main Stack
13th September 2018

	Monitoring				Analysis					
Parameter	**Standard**	**Technical Procedure**	**ISO 17025 Testing**	**Testing Lab**	**Analytical Procedure**	**Analytical Technique**	**ISO 17025 Analysis**	**Analysis Lab**	**MCERTS Testing**	**LOD (Average)**
Total Particulate Matter	EN 13284-1	CAT-TP-01	Yes	CAT	CAT-TP-03	Gravimetric	Yes	CAT	Yes	0.15 mg/m³
Heavy Metals	EN 14385	CAT-TP-06	Yes	CAT	Section 21	ICP-MS	Yes	CLS	Yes	0.01 mg/m³
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	1.8 m/s

ANALYSIS LABORATORIES

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

Exova Catalyst (CAT)	ISO 17025 Accreditation Number: 4279
Concept Life Sciences Ltd (CLS)	ISO 17025 Accreditation Number: 1549

SUMMARY OF SAMPLING DEVIATIONS

Parameter	Run	Deviation
Total Particulate Matter, Velocity & Vol. Flow Rate	1	In order to maintain isokinetic sampling, a nozzle size smaller than that specified in the Standard was used.

SUITABILITY OF SAMPLING LOCATION

Duct Characteristics

Parameter	Units	Value
Type	-	Circular
Depth	m	0.28
Width	m	-
Area	m²	0.06
Port Depth	cm	9
Orientation of Duct	-	Vertical
Number of Ports	-	2
Sample Port Size	-	4" BSP

Location of Sampling Platform

General Platform Information	Value
Permanent / Temporary Platform	Permanent
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.

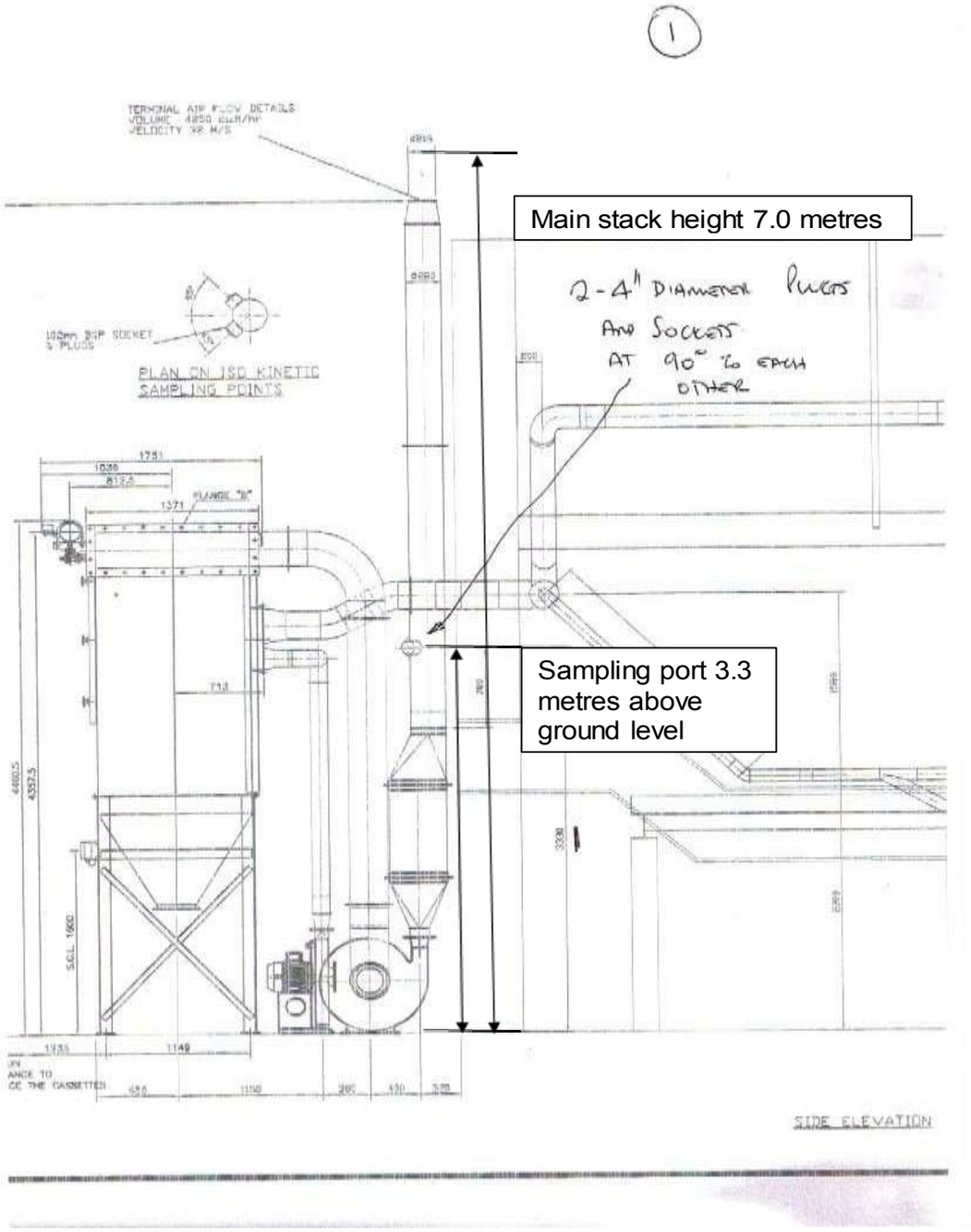
EN 15259 Homogeneity Test Requirements

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

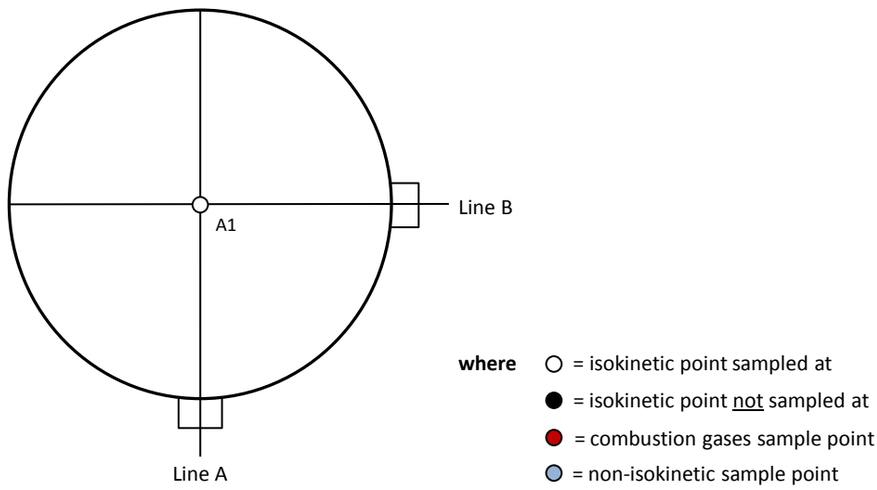
Sampling Plane Validation Criteria (from EN 15259)

Criteria in EN 15259	Units	Traverse 1	Required	Compliant
Lowest Differential Pressure	Pa	314	> 5 Pa	Yes
Mean Velocity	m/s	19.20	-	-
Lowest Gas Velocity	m/s	19.20	-	-
Highest Gas Velocity	m/s	19.20	-	-
Ratio of Above	: 1	1.00	< 3 : 1	Yes
Maximum Angle of Swirl	°	0	< 15°	Yes
No Local Negative Flow	-	Yes	-	Yes

PLANT PHOTOS / DIAGRAMS



SAMPLE POINTS



APPENDIX CONTENTS

STACK EMISSIONS MONITORING PERSONNEL

Position	Name	MCERTS Accreditation	MCERTS Number	Technical Endorsements
Team Leader	Ian Baggley	MCERTS Level 2	MM 05 653	TE1 TE2 TE3 TE4
Technician	Sean Kinahan	MCERTS Trainee	MM 18 1471	None

LIST OF EQUIPMENT

Extractive Sampling	
Equipment Type	**Equipment I.D.**
Control Box DGM (1)	CAT 7.5
Control Box DGM (2)	-
Box Thermocouples (1)	CAT 3.12
Box Thermocouples (2)	-
Umbilical (1)	CAT 3.12
Umbilical (2)	-
Oven Box (1)	CAT 12.36
Oven Box (2)	-
Heated Probe (1)	CAT 5.19
Heated Probe (2)	CAT 5.20
Heated Probe (3)	-
S-Pitot (1)	CAT 21P.79
S-Pitot (2)	CAT 21.P20
L-Pitot	-
Site Balance	CAT 17.20
500g / 1Kg Check Weights	CAT 17.20
Last Impinger Arm	-
Callipers	CAT 23.7
Tubes Kit Thermocouple	-

Instrumental Analysers	
Equipment Type	**Equipment I.D.**
Horiba PG-250	-
Horiba PG-350E	-
Servomex 5200 MP	-
Eco Physics CLD 822Mh	-
ABB AO2020-URAS26	-
Testo 350 XL	-
JCT JCC P1 Cooler	-
Gasmet DX4000	-
Gasmet Sampling System	-
Bernath 3006 FID	-
M&C PSS	-
Mass Flow Controller (1)	-
Mass Flow Controller (2)	-
Mass View (1)	-
Mass View (2)	-
Hioki 5043 (V)	-
Easylogger EN-EL-12 Bit	-
Bioaerosols Temperature Logger	-
Electronic Refrigerator	-

Miscellaneous Items	
Equipment Type	**Equipment I.D.**
Digital Manometer (1)	CAT 3.124
Digital Manometer (2)	-
Digital Temperature Meter	CAT 3.124
Stopwatch	-
Barometer	CAT 13.29
Stack Thermocouple (1)	CAT 4.1064
Stack Thermocouple (2)	CAT 4.1202
Stack Thermocouple (3)	-
1m Heated Line (1)	-
1m Heated Line (2)	-
1m Heated Line (3)	-
5m Heated Line (1)	-
15m Heated Line (1)	-
20m Heated Line (1)	-
20m Heated Line (2)	-
Dual Channel Heater Controller	CAT 3.18
Single Channel Heater Controller	-
Laboratory Balance	CAT 1.18 / 1.18a
Tape Measure	CAT 16.26

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	0.28
Stack Width, W	m	-
Stack Area, A	m^2	0.06
Average Stack Gas Temperature, T_a	°C	21.0
Average Stack Gas Pressure	mmH_2O	32.0
Average Stack Static Pressure, P_{static}	kPa	0.21
Average Barometric Pressure, P_b	kPa	101.0
Average Pitot Tube Calibration Coefficient, C_p	-	0.84

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 p	Conc kg/m^3 p_i
CO_2 (Estimated)	-	1.50	1.49	0.0150	44.01	1.9635	0.0295
O_2 (Estimated)	-	19.00	18.83	0.1900	32.00	1.4277	0.2713
N_2	-	79.50	78.78	0.7950	28.01	1.2498	0.9936
Moisture (H_2O)	-	-	0.91	0.0091	18.02	0.8037	0.0073

Where: p = M / 22.41

p_i = r x p

Calculation of Stack Gas Densities

Determinand	Units	Result
Dry Density (STP), P_{STD}	kg/m^3	1.2943
Wet Density (STP), P_{STW}	kg/m^3	1.2899
Dry Density (Actual), P_{Actual}	kg/m^3	1.2008
Average Wet Density (Actual), $P_{ActualW}$	kg/m^3	0.5983

Where: P_{STD} = sum of component concentrations, kg/m^3 (not including water vapour)

P_{STW} = sum of all wet concentrations / 100 x density, kg/m^3 (including water vapour)

$P_{Actual} = P_{STD} \times (T_{STP} / (P_{STP})) \times ((P_{static} + P_b) / T_a)$

$P_{ActualW}$ (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	21.0	0.00
Total Pressure	kPa	101.2	101.3
Moisture	%	0.91	0.91

Gas Volumetric Flowrate (from Traverse)	Units	Result
Gas Volumetric Flowrate (Actual)	m^3/hr	4256
Gas Volumetric Flowrate (STP, Wet)	m^3/hr	3949
Gas Volumetric Flowrate (STP, Dry)	m^3/hr	3913
Gas Volumetric Flowrate REF [1]	m^3/hr	3949

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

(1 of 1)

Parameter	Units	Value
Date of Survey	-	13/09/2018
Time of Survey	-	09:55 - 10:01
Atmospheric Pressure	kPa	101.0
Average Stack Static Pressure	Pa	210
Result of Pitot Stagnation Test	-	Pass
Are Water Droplets Present?	-	No
Device Used	S-Type Pitot with Liquid Incline Manometer	

Parameter	Units	Value
Initial Pitot Leak Check	-	Pass
Final Pitot Leak Check	-	Pass
Orientation of Duct	-	Vertical
Pitot Tube, C_p	-	0.84
Number of Lines Available	-	1
Number of Lines Used	-	1

Sampling Line A

Traverse Point	Depth m	ΔP mmH_2O	Temp °C	Wet Density kg/m^3	Velocity m/s	Swirl °
STATIC (Units: Pa)		*210.0*				
Mean		**32.0**	**21.0**	**1.197**	**19.20**	
1	0.14	32.0	21.0	1.197	19.20	0.0

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(Δpi)	5.296	Pa
- Resolution	u(res)	0.52154	
- Calibration	u(cal)	10.254	
- Drift	u(drift)	1.096	
- Lack of Fit	u(fit)	15.176	
- Overall corrections to dynamic measurements	u(Cf)	27.048	
Standard uncertainty associated with the molar mass of the gas	u(M)	0.00002	-
- $\varphi O_2,w$	-	18.828	
- $\varphi CO_2,w$	-	1.486	
- Oxygen, dry	u(ϕO_2,d)	0.582	
- Carbon Dioxide, dry	u(ϕCO_2,d)	0.046	
- Water Vapour	u(ϕH_2O)	0.046	
- Oxygen, wet	u(ϕO_2,w)	0.576	
- Carbon Dioxide, wet	u(ϕCO_2,w)	0.046	
Standard uncertainty associated with the stack temperature	u(Tc)	1.500	K
Standard uncertainty associated with the absolute pressure in the duct	u(pc)	175.772	Pa
- Atmospheric Pressure	u(patm)	175.692	
- Static Pressure	u(pstat)	5.296	
Standard uncertainty associated with the density in the duct	u(ρ)	0.00645	-
Standard uncertainty associated with the local velocities	u(vi)	1.628	Pa
Standard uncertainty associated with the mean velocity	u(v)	1.628	m/s
Standard uncertainty associated with the mean velocity (95% Confidence)	Uc(v)	3.190	m/s
Standard uncertainty associated with the mean velocity (95% Confidence), relative	Uc,rel(v)	16.62	%
Standard uncertainty associated with the volume flow rate (95% Confidence)	Uc(qV,w)	733.0	m^3/hr
- $u^2(a)/a^2$	-	0.00053	
- $u^2(qV,w)/q^2V,w$	-	0.00772	
- $u^2(qV,w)$	-	139861	
- u(qV,w)	-	374.0	
Standard uncertainty associated with the volume flow rate (95% Confidence), relative	Uc,rel(qV,w)	17.22	%

TOTAL PARTICULATE MATTER: RESULTS SUMMARY

Federal Mogul Sintered Products Ltd, Coventry
Main Stack

Sample Runs

Parameter	Units	Run 1		Mean
Concentration	mg/m³	0.22		0.22
Uncertainty	±mg/m³	0.65		0.65
Mass Emission	g/hr	0.89		0.89
Uncertainty	±g/hr	2.56		2.56

NOTE: Where the maximum Blank concentration is higher than the Sample concentration, the maximum Blank concentration has been reported.

Parameter	Units	Run 1		Mean
Water Vapour	% v/v	1.51		1.51
Uncertainty	±% v/v	0.08		0.08

Blank Runs

Parameter	Units	Blank 1		Maximum
Concentration	mg/m³	0.22		0.22

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	FORMAT: Number Used / Number Required
Number of Sampling Points Used	1 / 1	FORMAT: Number Used / Number Required
Sample Point I.D.'s	A1	

Reference Conditions

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

TOTAL PARTICULATE MATTER: ISOKINETIC SAMPLING CALCULATIONS

Test	Units	Run 1	
Absolute pressure of stack gas, P_s			
Barometric pressure, P_b	mmHg	757.5	
Stack static pressure, P_{static}	mmH_2O	21.4	
$P_s = (P_b + (P_{static} / 13.6)$	mmHg	759.1	
Volume of water vapour collected, V_{wstd}			
Total mass collected in impingers (liquid trap)	g	-2.2	
Total mass collected in impingers (silica trap)	g	17.8	
Total mass of liquid collected, V_{lc}	g	15.6	
$V_{wstd} = (0.001246)(V_{lc})$	m^3	0.0194	
Volume of gas metered dry, V_{mstd}			
Volume of gas sample through gas meter, V_m	m^3	1.3761	
Gas meter correction factor, Y_d	-	0.9760	
Average dry gas meter temperature, T_m	°C	15.8	
Average pressure drop across orifice, ΔH	mmH_2O	48.4	
$V_{mstd} = ((0.3592)(V_m)(P_b + (\Delta H/13.6))(Y_d)) / (T_m + 273)$	m^3	1.2712	
Moisture content, B_{wo} & R_{wv}			
$B_{wo} = V_{wstd} / (V_{mstd} + V_{wstd})$	m^3	0.0151	
B_{wo} as a percentage	% v/v	1.51	
Reported Water Vapour, checked with Tables in EN 14790, Rwv	% v/v	1.51	
Volume of gas metered wet, V_{mstw}			
$V_{mstw} = (V_{mstd})(100/(100 - R_{wv}))$	m^3	1.2906	
Volume of gas metered at Oxygen Reference Conditions, $V_{mstd@X\%O_2}$ & $V_{mstw@X\%O_2}$			
IED & Incinerates Hazardous Material? (Yes = no positive O_2 correction)	-	No	
% wet oxygen measured in gas stream, $ACT\%O_{2w}$	% v/v	N/A	
% dry oxygen measured in gas stream, $ACT\%O_{2d}$	% v/v	N/A	
% oxygen reference condition, $REF\%O_2$	% v/v	N/A	
O_2 Reference Factor wet $(O_{2REFw}) = (21 - REF\%O_2) / (21 - ACT\%O_{2w})$	-	N/A	
O_2 Reference Factor dry $(O_{2REFd}) = (21 - REF\%O_2) / (21 - ACT\%O_{2d})$	-	N/A	
$V_{mstw@X\%oxygen} = (V_{mstw}) / (O_{2REFw})$	m^3	N/A	
$V_{mstd@X\%oxygen} = (V_{mstd}) / (O_{2REFd})$	m^3	N/A	
Molecular weight of dry gas stream, M_d			
CO_2 (Estimated)	% v/v	0.06	
O_2 (Estimated)	% v/v	20.80	
Total	% v/v	20.86	
N_2	% v/v	79.14	
$M_d = 0.44(\%CO_2)+0.32(\%O_2)+0.28(\%N_2)$	g/gmol	28.84	
Molecular weight of stack gas (wet), M_s			
$M_s = M_d(1 - (R_{wv}/100)) + 18(R_{wv}/100)$	g/gmol	28.68	
Velocity of stack gas, V_s			
Pitot tube velocity constant, K_p	-	34.97	
Velocity pressure coefficient, C_p	-	0.84	
Average of velocity heads, ΔP_{avg}	mmH_2O	32.50	
Average square root of velocity heads, √ΔP	$\sqrt{mmH_2O}$	5.70	
Average stack gas temperature, T_s	°C	26.5	
$V_s = ((K_p)(C_p)(\sqrt{\Delta P})(\sqrt{T_s} + 273)) / (\sqrt{(M_s)(P_s)})$	m/s	19.64	
Total flow of stack gas: Actual (Q_a), Wet (Q_{stw}), Dry (Q_{std}), Wet@O_{2REF} (Q_{stwO_2}), Dry@O_{2REF} (Q_{stdO_2})			
Area of stack, A_s	m^2	0.06	
$Q_a = (60)(A_s)(V_s)$	m^3/min	72.6	
Conversion factor (K/mm.Hg), C_f	-	0.3592	
$Q_{stw} = ((Q_a)(P_s)(C_f)) / ((T_s) + 273)$	m^3/min	66.1	
$Q_{std} = ((Q_a)(P_s)(C_f)(1 - (R_{wv}/100))) / ((T_s) + 273)$	m^3/min	65.1	
$Q_{stwO_2} = ((Q_a)(P_s)(C_f)) / ((T_s) + 273) / (O_{2REFw})$	m^3/min	N/A	
$Q_{stdO_2} = ((Q_a)(P_s)(C_f)(1 - (R_{wv}/100))) / ((T_s) + 273) / (O_{2REFd})$	m^3/min	N/A	
Percent isokinetic, %I			
Nozzle diameter, D_n	mm	4.98	
Nozzle area, A_n	mm^2	19.48	
Total sampling time, q	min	60	
$\%I = (4.6398E^6)(T_s+273)(V_{mstd}) / (P_s)(V_s)(A_n)(q)(1 - (R_{wv}/100))$	%	102.9	

TOTAL PARTICULATE MATTER: SAMPLING DETAILS

Sample Runs

Parameter	Units	Run 1
Sampling Times	-	10:06 - 11:06
Sampling Dates	-	13/09/2018
Sampling Device	-	ISO
Volume Sampled (REF)	m^3	1.2906
Filter I.D. Number	-	47-53974
Start Filter Mass	g	0.14511
End Filter Mass	g	0.14506
Total Mass on Filter	g	-0.00005
Probe Rinse I.D. Number	-	PR-47-53974
Start Probe Rinse Mass	g	2.83483
End Probe Rinse Mass	g	2.83492
Total Mass in Probe Rinse	g	0.00009
Total Mass Collected	mg	0.04
Calculated Concentration	mg/m^3	0.03
Balance Uncertainty / LOD	mg/m^3	0.15

Where: ISO stands for Manual Isokinetic Sampling Train

Blank Runs

Parameter	Units	Blank 1
Blank Dates	-	13/09/2018
Average Volume Sampled (REF)	m^3	1.2906
Filter I.D. Number	-	47-53927
Start Filter Mass	g	0.14651
End Filter Mass	g	0.14650
Total Mass on Filter	g	-0.00001
Probe Rinse I.D. Number	-	PR-47-53927
Start Probe Rinse Mass	g	2.49675
End Probe Rinse Mass	g	2.49705
Total Mass in Probe Rinse	g	0.00030
Total Mass Collected	mg	0.29
Calculated Concentration	mg/m^3	0.22
Balance Uncertainty / LOD	mg/m^3	0.15

TOTAL PARTICULATE MATTER: QUALITY ASSURANCE

Sample Runs

Leak Test Results	Units	Run 1
Mean Sampling Rate	l/min	22.4
Pre-Sampling Leak Rate	l/min	0.08
Post-Sampling Leak Rate	l/min	0.12
Allowable Leak Rate	l/min	0.45
Leak Test Acceptable	-	Yes

Water Droplets	Units	Run 1
Are Water Droplets Present	-	No

MU (Concurrent Water Vapour)	Units	Run 1
Measurement Uncertainty (MU)	%	5.5
Allowable MU	%	20
MU Acceptable	%	Yes

Silica Gel (Concurrent Water Vapour)	Units	Run 1
Less than 50% Faded	%	Yes

Isokinetic Criterion Compliance	Units	Run 1
Isokinetic Variation	%	102.9
Allowable Isokinetic Range	%	95 - 115
Isokineticity Acceptable	-	Yes

Weighing Uncertainty Criteria	Units	Run 1
Overall Weighing Uncertainty	± mg	0.33
Overall Weighing Uncertainty	± mg/m³	0.25
ELV [Daily ELV for IED]	mg/m³	20.0
Allowable Weighing Uncertainty	mg/m³	1.00
Weighing Uncertainty Acceptable	-	Yes

Filter Temperatures	Units	Run 1
Pre-Conditioning Temperature	°C	180
Post-Conditioning Temperature	°C	160
Maximum Filter Temperature	°C	32

Test Conditions	Units	Run 1
Ambient Temperature Recorded?	-	Yes

TOTAL PARTICULATE MATTER: QUALITY ASSURANCE

Blank Runs

Leak Test Results	Units	Blank 1
Expected Sampling Rate	l/min	20.0
Pre-Sampling Leak Rate	l/min	0.10
Post-Sampling Leak Rate	l/min	0.12
Allowable Leak Rate	l/min	0.40
Leak Test Acceptable	-	Yes

Validity of Blank vs ELV	Units	Blank 1
Allowable Blank	mg/m³	2.0
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 (x = deviation applies to the associated run, wx = deviation also applies to the concurrent water vapour run)	Run Number 1	
In order to maintain isokinetic sampling, a nozzle size smaller than that specified in the Standard was used.	x	

TOTAL PARTICULATE MATTER: MEASUREMENT UNCERTAINTY CALCULATIONS

	Value		Standard uncertainty		
Measured Quantities	**Symbol**	**Run 1**	**Symbol**	**Units**	**Run 1**
Sampled Volume (Actual)	V_m	1.38	uV_m	m^3	0.03
Sampled Gas Temperature	T_m	288.8	uT_m	K	2.00
Sampled Gas Pressure	ρ_m	101.2	$u\rho_m$	kPa	0.50
Sampled Gas Humidity	H_m	0.00	uH_m	% v/v	1.00
Leak	L	0.54	uL	%	-
Mass of Particulate	m	0.19	um	mg	0.19
Uncollected Mass	UCM	0.29	uUCM	mg	-

	Uncertainty as a Percentage		
Measured Quantities	**Units**	**Run 1**	**Requirement of Standard**
Sampled Volume (Actual)	%	2.00	≤2%
Sampled Gas Temperature	%	0.69	≤1%
Sampled Gas Pressure	%	0.49	≤1%
Sampled Gas Humidity	%	1.00	≤1%
Leak	%	0.54	≤2%
Mass of Particulate	%	1.12	<5% of ELV
Uncollected Mass	%	-	-

	Uncertainty in Measurement Units			Sensitivity Coefficient
Measured Quantities	**Symbol**	**Units**	**Run 1**	**Run 1**
Sampled Volume (STP)	V_m	m^3	1.27	0.18
Leak	L	mg/m^3	0.00	1.00
Mass of Particulate	L_r	mg	0.19	1.18
Uncollected Mass	UCM	mg	0.17	1.18

	Uncertainty in Result	
Measured Quantities	**Units**	**Run 1**
Sampled Volume (STP)	mg/m^3	0.01
Leak	mg/m^3	0.00
Mass of Particulate	mg/m^3	0.22
Uncollected Mass	mg/m^3	0.20

	Oxygen Correction Part of MU Budget	
Measured Quantities	**Units**	**Run 1**
O_2 Correction Factor	-	N/A
Stack Gas O_2 Content	% v/v	N/A
MU for O_2 Correction	-	N/A
Overall MU For O_2 Measurement	%	N/A

Parameter	**Units**	**Run 1**
Combined uncertainty	mg/m^3	0.30
Expanded uncertainty (95% confidence), without Oxygen Correction	mg/m^3	0.59
Expanded uncertainty (95% confidence), with Oxygen Correction	mg/m^3	N/A
Expanded uncertainty (95% confidence), estimated with Method Deviations	mg/m^3	0.65
Reported Uncertainty	mg/m^3	0.65
Expanded uncertainty (95% confidence), without Oxygen Correction	%	261.3
Expanded uncertainty (95% confidence), with Oxygen Correction	%	N/A
Expanded uncertainty (95% confidence), estimated with Method Deviations	%	287.4
Reported Uncertainty	%	287.4

HEAVY METALS: RESULTS SUMMARY

Federal Mogul Sintered Products Ltd, Coventry
Main Stack

Sample Runs

Parameter	Units	Run 1		Mean
Concentration	mg/m³	0.04		0.04
Uncertainty	±mg/m³	0.01		0.01
Mass Emission	g/hr	0.1		0.1
Uncertainty	±g/hr	0.1		0.1

Parameter	Units	Run 1		Mean
Water Vapour	% v/v	0.31		0.31
Uncertainty	±% v/v	0.03		0.03

Blank Runs

Parameter	Units	Blank 1		Maximum
Concentration	mg/m³	0.00		0.00

General Sampling Information

Parameter	Value	
Standard	EN 14385	
Technical Procedure	CAT-TP-06	
Name of Analytical Laboratory	CLS	
Analytical Laboratory's Procedure	Section 21	
ISO 17025 Accredited Analysis?	Yes	
Date of Sample Analysis	28/09/2018	
Probe Material	Titanium	
Filter Housing Material	Titanium	
Impinger Material	Borosilicate Glass	
Absorption Solution	Nitric Peroxide	
Positioning of Filter	Out Stack	
Filter Size and Material	47mm Quartz Fibre	
Number of Sampling Lines Used	1 / 1	FORMAT: Number Used / Number Required
Number of Sampling Points Used	1 / 1	FORMAT: Number Used / Number Required
Sample Point I.D.'s	A1	

Reference Conditions

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

HEAVY METALS: ISOKINETIC SAMPLING CALCULATIONS

Test	Units	Run 1
Absolute pressure of stack gas, P_s		
Barometric pressure, P_b	mmHg	757.5
Stack static pressure, P_{static}	mmH_2O	21.4
$P_s = (P_b + (P_{static} / 13.6)$	mmHg	759.1
Volume of water vapour collected, V_{wstd}		
Total mass collected in impingers (liquid trap)	g	0.0
Total mass collected in impingers (silica trap)	g	3.2
Total mass of liquid collected, V_{lc}	g	3.2
$V_{wstd} = (0.001246)(V_{lc})$	m^3	0.0040
Volume of gas metered dry, V_{mstd}		
Volume of gas sample through gas meter, V_m	m^3	1.4397
Gas meter correction factor, Y_d	-	0.9760
Average dry gas meter temperature, T_m	°C	21.8
Average pressure drop across orifice, ΔH	mmH_2O	47.9
$V_{mstd} = ((0.3592)(V_m)(P_b + (\Delta H/13.6))(Y_d)) / (T_m + 273)$	m^3	1.3030
Moisture content, B_{wo} & R_{wv}		
$B_{wo} = V_{wstd} / (V_{mstd} + V_{wstd})$	m^3	0.0031
B_{wo} as a percentage	% v/v	0.31
Reported Water Vapour, checked with Tables in EN 14790, Rwv	% v/v	0.31
Volume of gas metered wet, V_{mstw}		
$V_{mstw} = (V_{mstd})(100/(100 - R_{wv}))$	m^3	1.3069
Volume of gas metered at Oxygen Reference Conditions, $V_{mstd@X\%O_2}$ & $V_{mstw@X\%O_2}$		
IED & Incinerates Hazardous Material? (Yes = no positive O_2 correction)	-	No
% wet oxygen measured in gas stream, $ACT\%O_{2w}$	% v/v	N/A
% dry oxygen measured in gas stream, $ACT\%O_{2d}$	% v/v	N/A
% oxygen reference condition, $REF\%O_2$	% v/v	N/A
O_2 Reference Factor wet $(O_{2REFw}) = (21 - REF\%O_2) / (21 - ACT\%O_{2w})$	-	N/A
O_2 Reference Factor dry $(O_{2REFd}) = (21 - REF\%O_2) / (21 - ACT\%O_{2d})$	-	N/A
$V_{mstw@X\%oxygen} = (V_{mstw}) / (O_{2REFw})$	m^3	N/A
$V_{mstd@X\%oxygen} = (V_{mstd}) / (O_{2REFd})$	m^3	N/A
Molecular weight of dry gas stream, M_d		
CO_2 (Estimated)	% v/v	0.06
O_2 (Estimated)	% v/v	20.80
Total	% v/v	20.86
N_2	% v/v	79.14
$M_d = 0.44(\%CO_2)+0.32(\%O_2)+0.28(\%N_2)$	g/gmol	28.84
Molecular weight of stack gas (wet), M_s		
$M_s = M_d(1 - (R_{wv}/100)) + 18(R_{wv}/100)$	g/gmol	28.81
Velocity of stack gas, V_s		
Pitot tube velocity constant, K_p	-	34.97
Velocity pressure coefficient, C_p	-	0.84
Average of velocity heads, ΔP_{avg}	mmH_2O	32.53
Average square root of velocity heads, √ΔP	$\sqrt{mmH_2O}$	5.70
Average stack gas temperature, T_s	°C	36.4
$V_s = ((K_p)(C_p)(\sqrt{\Delta P})(\sqrt{T_s} + 273)) / (\sqrt{(M_s)(P_s)})$	m/s	19.93
Total flow of stack gas: Actual (Q_a), Wet (Q_{stw}), Dry (Q_{std}), Wet@O_{2REF} (Q_{stwO_2}), Dry@O_{2REF} (Q_{stdO_2})		
Area of stack, A_s	m^2	0.06
$Q_a = (60)(A_s)(V_s)$	m^3/min	73.6
Conversion factor (K/mm.Hg), C_f	-	0.3592
$Q_{stw} = ((Q_a)(P_s)(C_f)) / ((T_s) + 273)$	m^3/min	64.9
$Q_{std} = ((Q_a)(P_s)(C_f)(1 - (R_{wv}/100))) / ((T_s) + 273)$	m^3/min	64.7
$Q_{stwO_2} = ((Q_a)(P_s)(C_f)) / ((T_s) + 273) / (O_{2REFw})$	m^3/min	N/A
$Q_{stdO_2} = ((Q_a)(P_s)(C_f)(1 - (R_{wv}/100))) / ((T_s) + 273) / (O_{2REFd})$	m^3/min	N/A
Percent isokinetic, %I		
Nozzle diameter, D_n	mm	4.98
Nozzle area, A_n	mm^2	19.48
Total sampling time, q	min	60
$\%I = (4.6398E^6)(T_s+273)(V_{mstd}) / (P_s)(V_s)(A_n)(q)(1 - (R_{wv}/100))$	%	106.1

HEAVY METALS: SAMPLING DETAILS

Sample Runs

Parameter	Units	Run 1
Sampling Times	-	11:17 - 12:17
Sampling Dates	-	13/09/2018
Sampling Device	-	ISO
Volume Sampled (REF)	m^3	1.3069
Cobalt		
Mass on Filter / in Rinse	µg	< 0.50
Mass in Front Impingers	µg	0.51
Mass in Back Impinger	µg	0.14
Total Mass Collected	µg	1.15
Calculated Concentration	mg/m^3	0.0009
Reported Concentration	mg/m^3	0.0009
Mass Emission	g/hr	0.00
Chromium		
Mass on Filter / in Rinse	µg	2.00
Mass in Front Impingers	µg	26.47
Mass in Back Impinger	µg	12.39
Total Mass Collected	µg	40.87
Calculated Concentration	mg/m^3	0.0313
Reported Concentration	mg/m^3	0.0313
Mass Emission	g/hr	0.12

HEAVY METALS: SAMPLING DETAILS

Sample Runs (continued)

Parameter	Units	Run 1	
Nickel			
Mass on Filter / in Rinse	µg	< 2.00	
Mass in Front Impingers	µg	2.04	
Mass in Back Impinger	µg	0.86	
Total Mass Collected	µg	4.90	
Calculated Concentration	mg/m³	0.0037	
Reported Concentration	mg/m³	0.0037	
Mass Emission	g/hr	0.01	

HEAVY METALS: SAMPLING DETAILS

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Sample Runs (continued)

Parameter	Units	Run 1
Heavy Metals Combined		
Total Mass Collected	µg	46.92
Calculated Concentration	mg/m³	0.0359
Reported Concentration	mg/m³	0.0359

Where: ISO stands for Manual Isokinetic Sampling Train

Blank Runs

Parameter	Units	Blank 1
Blank Dates	-	13/09/2018
Average Volume Sampled (REF)	m³	1.3069
Cobalt		
Mass on Filter / in Rinse	µg	< 0.50
Mass in Front Impingers	µg	< 0.04
Mass in Back Impinger	µg	< 0.03
Total Mass Collected	µg	< 0.57
Calculated Concentration	mg/m³	< 0.0004
Reported Concentration	mg/m³	< 0.0004

HEAVY METALS: SAMPLING DETAILS

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Blank Runs (continued)

Parameter	Units	Blank 1	
Chromium			
Mass on Filter / in Rinse	µg	< 2.00	
Mass in Front Impingers	µg	< 0.10	
Mass in Back Impinger	µg	< 0.06	
Total Mass Collected	µg	< 2.17	
Calculated Concentration	mg/m³	< 0.0017	
Reported Concentration	mg/m³	< 0.0017	
Nickel			
Mass on Filter / in Rinse	µg	< 2.00	
Mass in Front Impingers	µg	< 0.42	
Mass in Back Impinger	µg	< 0.26	
Total Mass Collected	µg	< 2.68	
Calculated Concentration	mg/m³	< 0.0020	
Reported Concentration	mg/m³	< 0.0020	

HEAVY METALS: SAMPLING DETAILS

Blank Runs (continued)

Parameter	Units	Blank 1	
Heavy Metals Combined			
Total Mass Collected	µg	5.41	
Calculated Concentration	mg/m³	0.0041	
Reported Concentration	mg/m³	0.0041	

HEAVY METALS: QUALITY ASSURANCE

Sample Runs

Leak Test Results	Units	Run 1
Mean Sampling Rate	l/min	23.4
Pre-Sampling Leak Rate	l/min	0.16
Post-Sampling Leak Rate	l/min	0.26
Allowable Leak Rate	l/min	0.47
Leak Test Acceptable	-	Yes

Absorption Efficiency	Units	Run 1
Cobalt	%	87.5
Chromium	%	69.7
Nickel	%	82.4
Allowable Absorption Efficiency	%	N/A
Absorption Efficiency Acceptable	-	Yes

Where the emissions are < 30% of the ELV, MID 14385 does not require the absorption efficiency requirement to be applied

Detection Limit	Units	Run 1
Cobalt	µg/m³	0.46
Chromium	µg/m³	1.72
Nickel	µg/m³	2.27
Allowable Detection Limit	µg/m³	5.0
Detection Limit Acceptable	-	Yes

Water Droplets	Units	Run 1
Are Water Droplets Present	-	No

MU (Concurrent Water Vapour)	Units	Run 1
Measurement Uncertainty (MU)	%	11.1
Allowable MU	%	20
MU Acceptable	%	Yes

HEAVY METALS: QUALITY ASSURANCE

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Silica Gel (Concurrent Water Vapour)	Units	Run 1
Less than 50% Faded	%	Yes

Isokinetic Criterion Compliance	Units	Run 1
Isokinetic Variation	%	106.1
Allowable Isokinetic Range	%	95 - 115
Isokineticity Acceptable	-	Yes

Filter Temperatures	Units	Run 1
Maximum Filter Temperature	°C	160

Impingers Exit Temperature	Units	Run 1
Maximum Temperature Recorded	°C	20
Maximum Allowable Temperature	°C	30
Exit Temperature Acceptable	-	Yes

Test Conditions	Units	Run 1
Ambient Temperature Recorded?	-	Yes

Blank Runs

Leak Test Results	Units	Blank 1
Expected Sampling Rate	l/min	20.0
Pre-Sampling Leak Rate	l/min	0.12
Post-Sampling Leak Rate	l/min	0.16
Allowable Leak Rate	l/min	0.40
Leak Test Acceptable	-	Yes

Validity of Blank vs ELV	Units	Blank 1
Allowable Blank	mg/m³	0.50
Blank Acceptable	-	Yes

Method Deviations

Nature of Deviation (x = deviation applies to the associated run, wx = deviation also applies to the concurrent water vapour run)	Run Number 1	
In order to maintain isokinetic sampling, a nozzle size smaller than that specified in the Standard was used.	x	

HEAVY METALS: MEASUREMENT UNCERTAINTY CALCULATIONS

	Value			Standard uncertainty		
Measured Quantities	**Symbol**	**Run 1**		**Symbol**	**Units**	**Run 1**
Sampled Volume (Actual)	V_m	1.44		uV_m	m^3	0.03
Sampled Gas Temperature	T_m	294.8		uT_m	K	2.00
Sampled Gas Pressure	ρ_m	101.2		$u\rho_m$	kPa	0.50
Sampled Gas Humidity	H_m	0.00		uH_m	% v/v	1.00
Leak	L	1.11		uL	%	-
Laboratory Result	L_r	15.0		uL_r	%	-

	Uncertainty as a Percentage			
Measured Quantities	**Units**	**Run 1**		**Requirement of Standard**
Sampled Volume (Actual)	%	2.00		≤2%
Sampled Gas Temperature	%	0.68		≤1%
Sampled Gas Pressure	%	0.49		≤1%
Sampled Gas Humidity	%	1.00		≤1%
Leak	%	1.11		≤2%
Laboratory Result	%	15.0		No Requirement

	Uncertainty in Measurement Units				Sensitivity Coefficient	
Measured Quantities	**Symbol**	**Units**	**Run 1**		**Run 1**	
Sampled Volume (STP)	V_m	m^3	1.30		0.03	
Leak	L	mg/m^3	0.000		1.00	
Laboratory Result	L_r	mg/m^3	0.005		1.00	

	Uncertainty in Result		
Measured Quantities	**Units**	**Run 1**	
Sampled Volume (STP)	mg/m^3	0.0009	
Leak	mg/m^3	0.0002	
Laboratory Result	mg/m^3	0.0054	

	Oxygen Correction Part of MU Budget		
Measured Quantities	**Units**	**Run 1**	
O_2 Correction Factor	-	N/A	
Stack Gas O_2 Content	% v/v	N/A	
MU for O_2 Correction	-	N/A	
Overall MU For O_2 Measurement	%	N/A	

Parameter	**Units**	**Run 1**
Combined uncertainty	mg/m^3	0.005
Expanded uncertainty (95% confidence), without Oxygen Correction	mg/m^3	0.011
Expanded uncertainty (95% confidence), with Oxygen Correction	mg/m^3	N/A
Expanded uncertainty (95% confidence), estimated with Method Deviations	mg/m^3	0.012
Reported Uncertainty	mg/m^3	0.012
Expanded uncertainty (95% confidence), without Oxygen Correction	%	29.9
Expanded uncertainty (95% confidence), with Oxygen Correction	%	N/A
Expanded uncertainty (95% confidence), estimated with Method Deviations	%	32.8
Reported Uncertainty	%	32.8