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Stack Emissions Testing Report Commissioned by
Meggitt Aircraft Braking Systems

Installation Name & Address
Meggitt Aircraft Braking Systems
Holkbrook Lane
Coventry
West Midlands
CV6 4AA

PPC Permit: 156

Stack Reference
Plating Shop Main Stack

Dates of the Monitoring Campaign
15th December 2016

Job Reference Number
CAT-3073

Report Written by
David Burns Team Leader MCERTS Level 2 MM05 579 TE1 TE2 TE3 TE4

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

Report Date
17th January 2017

Version
Version 1

Signature of Report Approver
[redacted]

CONTENTS

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

MONITORING OBJECTIVES

Meggitt Aircraft Braking Systems, Coventry
Plating Shop Main Stack
15th December 2016

Overall Aim of the Monitoring Campaign

Exova Catalyst were commissioned by Meggitt Aircraft Braking Systems to carry out stack emissions testing on the Plating Shop Main Stack 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 Oxides of Nitrogen, Hydrogen Fluoride

MONITORING RESULTS

Meggitt Aircraft Braking Systems, Coventry
Plating Shop Main Stack
15th December 2016

where MU = Measurement Uncertainty associated with the Result

	Concentration				Mass Emission			
Parameter	**Units**	**Result**	**MU +/-**	**Limit**	**Units**	**Result**	**MU +/-**	**Limit**
Total Oxides of Nitrogen [1]	mg/m³	51.8	5.5	200	g/hr	2690	310	-
Hydrogen Fluoride [1]	mg/m³	< 0.03	0.002	5	g/hr	< 1.5	0.12	-
Stack Gas Temperature	°C	21.1						
Water Vapour	% v/v	1.4	0.37					
Stack Gas Velocity	m/s	8.9	0.09					
Volumetric Flow Rate (ACTUAL)	m³/hr	56504	2620					
Volumetric Flow Rate (REF) [1]	m³/hr	51905	2407					

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.

MONITORING DATE(S) & TIMES

Meggitt Aircraft Braking Systems, Coventry
Plating Shop Main Stack
15th December 2016

Parameter		Units	Concentration	Units	Mass Emission	Sampling Date(s)	Sampling Times	Duration mins
Total Oxides of Nitrogen	R1	mg/m³	51.8	g/hr	2690	15/12/2016	12:01 - 13:01	60
Hydrogen Fluoride	R1	mg/m³	< 0.03	g/hr	< 1.5	15/12/2016	10:48 - 11:48	60
Velocity & Volumetric Flow Rate	R1					15/12/2016	10:00 - 10:36	

All results are expressed at the respective reference conditions.

PROCESS DETAILS

Meggitt Aircraft Braking Systems, Coventry
Plating Shop Main Stack
15th December 2016

Standard Operating Conditions

Parameter	Value
Process Status	Normal Operation
Capacity (of 100%) and Tonnes / Hour	Standard Operating Capacity
Continuous or Batch Process	Continuous
Feedstock (if applicable)	Metal components/ HF / Acid Dipping
Abatement System	Wet Scrubber
Abatement System Running Status	On
Fuel	N/A
Plume Appearance	None visible

MONITORING & ANALYTICAL METHODS

Meggitt Aircraft Braking Systems, Coventry
Plating Shop Main Stack
15th December 2016

	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 Oxides of Nitrogen	US EPA M7D	CAT-TP-35	Yes	CAT	C27	IC	Yes	RPS	Yes	6.4 mg/m³
Hydrogen Fluoride	ISO 15713	CAT-TP-10	Yes	CAT	Ion Chromatography	IC	Yes	CAT	Yes	0.03 mg/m³
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
RPS Laboratories Ltd (RPS)	ISO 17025 Accreditation Number: 0605

SUMMARY OF SAMPLING DEVIATIONS

Parameter	Run	Deviation
Water Vapour (concurrent with Total Oxides of Nitrogen)	1	The measurement uncertainty for water vapour was greater than 20%. This was due to the low level of water vapour which was found to be present in the stack.

SUITABILITY OF SAMPLING LOCATION

Duct Characteristics

Parameter	Units	Value
Type	-	Circular
Depth	m	1.50
Width	m	-
Area	m²	1.77
Port Depth	cm	9
Orientation of Duct	-	Vertical
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	21.0					> 5 Pa	Yes
Mean Velocity	m/s	8.88					-	-
Lowest Gas Velocity	m/s	4.96					-	-
Highest Gas Velocity	m/s	12.93					-	-
Ratio of Above	: 1	2.61					< 3 : 1	Yes
Maximum Angle of Swirl	°	NM	NM	NM	NM	NM	NM	NM
No Local Negative Flow	-	Yes					-	Yes

Where NM = Not Measured as no Isokinetic sampling was performed.

PLANT PHOTOS

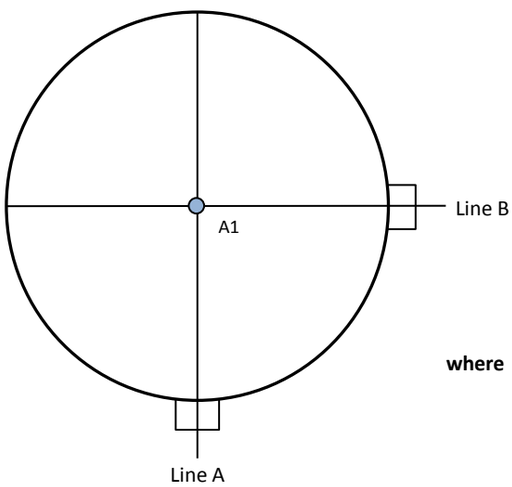
Photo 1

Photo 2

Photo 3

Photo 4

SAMPLE POINTS



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

APPENDIX CONTENTS

STACK EMISSIONS MONITORING PERSONNEL

Position	Name	MCERTS Accreditation	MCERTS Number	Technical Endorsements
Team Leader	David Burns	MCERTS Level 2	MM05 579	TE1 TE2 TE3 TE4
Trainee	Aaron Nagha	MCERTS Trainee	MM16 1392	None

LIST OF EQUIPMENT

Extractive Sampling	
Equipment Type	**Equipment I.D.**
Control Box DGM (1)	-
Control Box DGM (2)	-
Box Thermocouples (1)	-
Box Thermocouples (2)	-
Umbilical (1)	-
Umbilical (2)	-
Oven Box (1)	-
Oven Box (2)	-
Heated Probe (1)	-
Heated Probe (2)	CAT 5.130
Heated Probe (3)	-
S-Pitot (1)	CAT 21P.97
S-Pitot (2)	CAT 21S.56
L-Pitot	-
Site Balance	CAT 17.38
500g / 1Kg Check Weights	CAT 17.38
Last Impinger Arm	-
Callipers	-
Tubes Kit Thermocouple	-

Instrumental Analysers	
Equipment Type	**Equipment I.D.**
Horiba PG-350E	-
Horiba PG-250	-
Servomex 4900	-
Eco Physics CLD 822Mh	-
ABB AO2020-URAS26	-
Servomex 5200MP	-
Ankersmid APS 313	CAT 4.848
Gasmet DX4000	-
Gasmet Sampling System	-
Bernath 3006 FID	-
M&C PSS	-
Mass Flow Controller (1)	-
Mass Flow Controller (2)	-
Mass View (1)	CAT 25.61
Mass View (2)	CAT 25.62
Hioki 5043 (V)	-
Easylogger EN-EL-12 Bit	-
Bioaerosols Temperature Logger	-
Electronic Refrigerator	-

Miscellaneous Items	
Equipment Type	**Equipment I.D.**
Digital Manometer (1)	CAT 3.143
Digital Manometer (2)	CAT 3.145
Digital Temperature Meter	-
Stopwatch	CAT 14.86
Barometer	CAT 13.41
Stack Thermocouple (1)	-
Stack Thermocouple (2)	CAT 4.849
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)	CAT 20.119
20m Heated Line (2)	-
Dual Channel Heater Controller	CAT 3.002
Single Channel Heater Controller	CAT 20.119
Laboratory Balance	
Tape Measure	CAT 16.49

METHODS & TECHNICAL PROCEDURES USED

Parameter	Standard	Technical Procedure
Total Oxides of Nitrogen	US EPA M7D	CAT-TP-35
Hydrogen Fluoride	ISO 15713	CAT-TP-10
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	1.50
Stack Width, W	m	-
Stack Area, A	m^2	1.77
Average Stack Gas Temperature, T_a	°C	21.1
Average Stack Gas Pressure	Pa	72.3
Average Stack Static Pressure, P_{static}	kPa	0.047
Average Barometric Pressure, P_b	kPa	100.2
Average Pitot Tube Calibration Coefficient, C_p	-	0.83

Stack Gas Composition & Molecular Weights

Component	Conc ppm	Conc Dry % v/v	Conc Wet % v/v	Volume Fraction r	Molar Mass M	Density kg/m³ p	Conc kg/m³ p_i
CO_2 (Estimated)	-	0.06	0.06	0.0006	44.01	1.9635	0.0012
O_2 (Estimated)	-	20.80	20.51	0.2080	32.00	1.4277	0.2970
N_2	-	79.14	78.03	0.7914	28.01	1.2498	0.9891
Moisture (H_2O)	-	-	1.40	0.0140	18.02	0.8037	0.0113

Where: p = M / 22.41

p_i = r x p

Calculation of Stack Gas Densities

Determinand	Units	Result
Dry Density (STP), P_{STD}	kg/m³	1.287
Wet Density (STP), P_{STW}	kg/m³	1.280
Dry Density (Actual), P_{Actual}	kg/m³	1.182
Average Wet Density (Actual), $P_{ActualW}$	kg/m³	1.176

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)

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

$P_{ActualW}$ (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	21.1	0.00
Total Pressure	kPa	100.2	101.3
Moisture	%	1.39	1.39

Gas Volumetric Flowrate (from Traverse)	Units	Result
Gas Volumetric Flowrate (Actual)	m³/hr	56504
Gas Volumetric Flowrate (STP, Wet)	m³/hr	51905
Gas Volumetric Flowrate (STP, Dry)	m³/hr	51184
Gas Volumetric Flowrate REF [1]	m³/hr	51905

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

(1 of 1)

Parameter	Units	Value
Date of Survey	-	15/12/2016
Time of Survey	-	10:00 - 10:36
Atmospheric Pressure	kPa	100.2
Average Stack Static Pressure	Pa	47
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	-	0.83
Number of Lines Available	-	2
Number of Lines Used	-	2

		Sampling Line A					Sampling Line B				
Traverse Point	Depth m	ΔP Pa	Temp °C	Wet Density kg/m³	Velocity m/s	Swirl °	ΔP Pa	Temp °C	Wet Density kg/m³	Velocity m/s	Swirl °
STATIC (Units: Pa)		*43.0*					*51.0*				
Mean		**61.8**	**21.1**	**1.176**	**8.05**		**82.9**	**21.1**	**1.176**	**9.71**	
1	0.05	114.0	21.1	1.176	11.55		134.0	21.1	1.176	12.52	
2	0.16	143.0	21.1	1.176	12.93		115.0	21.1	1.176	11.60	
3	0.29	73.0	21.1	1.176	9.24		94.0	21.1	1.176	10.48	
4	0.48	47.0	21.1	1.176	7.41		63.0	21.1	1.176	8.58	
5	1.02	36.0	21.1	1.176	6.49		68.0	21.1	1.176	8.92	
6	1.21	29.0	21.1	1.176	5.82		74.0	21.1	1.176	9.30	
7	1.34	31.0	21.1	1.176	6.02		72.0	21.1	1.176	9.18	
8	1.45	21.0	21.1	1.176	4.96		43.0	21.1	1.176	7.09	

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)	1.302	Pa
- Resolution	u(res)	0.00087	
- Calibration	u(cal)	0.544	
- Drift	u(drift)	0.083	
- Lack of Fit	u(fit)	0.066	
- Overall corrections to dynamic measurements	u(Cf)	0.694	
Standard uncertainty associated with the molar mass of the gas	u(M)	0.00003	-
- $\varphi O_2,w$	-	20.509	
- $\varphi CO_2,w$	-	0.059	
- Oxygen, dry	u(ϕO_2,d)	0.637	
- Carbon Dioxide, dry	u(ϕCO_2,d)	0.002	
- Water Vapour	u(ϕH_2O)	0.071	
- Oxygen, wet	u(ϕO_2,w)	0.628	
- Carbon Dioxide, wet	u(ϕCO_2,w)	0.002	
Standard uncertainty associated with the stack temperature	u(Tc)	1.501	K
Standard uncertainty associated with the absolute pressure in the duct	u(pc)	175.694	Pa
- Atmospheric Pressure	u(patm)	175.692	
- Static Pressure	u(pstat)	0.920	
Standard uncertainty associated with the density in the duct	u(ρ)	0.00635	-
Standard uncertainty associated with the local velocities	u(vi)	0.102	Pa
Standard uncertainty associated with the mean velocity	u(v)	0.045	m/s
Standard uncertainty associated with the mean velocity (95% Confidence)	Uc(v)	0.089	m/s
Standard uncertainty associated with the mean velocity (95% Confidence), relative	Uc,rel(v)	1.00	%
Standard uncertainty associated with the volume flow rate (95% Confidence)	Uc(qV,w)	2619.8	m^3/hr
- $u^2(a)/a^2$	-	0.00053	
- $u^2(qV,w)/q^2V,w$	-	0.00056	
- $u^2(qV,w)$	-	1786521	
- u(qV,w)	-	1336.6	
Standard uncertainty associated with the volume flow rate (95% Confidence), relative	Uc,rel(qV,w)	4.64	%

TOTAL OXIDES OF NITROGEN: RESULTS SUMMARY

Meggitt Aircraft Braking Systems, Coventry
Plating Shop Main Stack

Sample Runs

Parameter	Units	Run 1		Mean
Concentration	mg/m³	51.8		51.8
Uncertainty	±mg/m³	5.5		5.5
Mass Emission	g/hr	2690		2690
Uncertainty	±g/hr	310		310

Parameter	Units	Run 1		Mean
Water Vapour	% v/v	1.26		1.26
Uncertainty	±% v/v	0.91		0.91

Blank Runs

Parameter	Units	Blank 1		Maximum
Concentration	mg/m³	< 3.96		< 3.96

General Sampling Information

Parameter	Value	
Standard	US EPA M7D	
Technical Procedure	CAT-TP-35	
Name of Analytical Laboratory	RPS	
Analytical Laboratory's Procedure	C27	
ISO 17025 Accredited Analysis?	Yes	
Date of Sample Analysis	15/12/2016	
Probe Material	Titanium	
Filter Housing Material	Titanium	
Impinger Material	Polyethylene	
Absorption Solution	Potassium Permanganate Solution	
Positioning of Filter	Out Stack Heated Head	
Filter Size and Material	0.1µm 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 OXIDES OF NITROGEN: SAMPLING DETAILS

Sample Runs

Parameter	Units	Run 1	
Sampling Times	-	12:01 - 13:01	
Sampling Dates	-	15/12/2016	
Sampling Device	-	MFC / MV	
Duration	mins	60	
Volume Sampled (STP, Dry)	m^3	0.0294	
Volume Sampled (STP, Wet)	m^3	0.0297	
Volume Sampled (REF)	m^3	0.0297	
Sample Flow Rate	l/min	0.49	
Laboratory Result for Front Impingers	µg/ml	2.04	
Laboratory Result for Back Impinger	µg/ml	2.00	
Volume in Front Impingers	ml	374.0	
Volume in Back Impinger	ml	389.0	
Mass in Front Impingers	µg	763.0	
Mass in Back Impinger	µg	778.0	
Total Mass Collected	µg	1541.0	
Calculated Concentration	mg/m^3	51.83	
Liquid Trap Start Mass	g	2637.9	
Liquid Trap End Mass	g	2638.0	
Silica Trap Start Mass	g	734.1	
Silica Trap End Mass	g	734.3	
Total Mass Of Water Vapour	g	0.3	
Calculated Water Vapour	% v/v	1.26	

Where: MFC stands for Mass Flow Controller, MV stands for Mass View Flowmeter

Blank Runs

Parameter	Units	Blank 1	
Blank Dates	-	15/12/2016	
Average Volume Sampled (REF)	m^3	0.0297	
Laboratory Result for Impingers	µg/ml	< 0.25	
Volume in Impingers	ml	470.8	
Total Mass Collected	µg	< 117.7	
Calculated Concentration	mg/m^3	< 3.96	

TOTAL OXIDES OF NITROGEN: QUALITY ASSURANCE

Sample Runs

Leak Test Results	Units	Run 1	
Mean Sampling Rate	l/min	0.49	
Pre-Sampling Leak Rate	l/min	0.00	
Post-Sampling Leak Rate	l/min	0.00	
Allowable Leak Rate	l/min	0.01	
Leak Test Acceptable	-	Yes	

Absorption Efficiency	Units	Run 1	
Absorption Efficiency	%	49.5	
Allowable Absorption Efficiency	%	N/A	
Absorption Efficiency Acceptable	-	N/A	

Water Droplets	Units	Run 1	
Are Water Droplets Present	-	No	

MU (Concurrent Water Vapour)	Units	Run 1	
Measurement Uncertainty (MU)	%	72.0	
Allowable MU	%	20.0	
MU Acceptable	%	No	

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

Test Conditions	Units	Run 1	
Ambient Temperature Recorded?	-	Yes	

Blank Runs

Leak Test Results	Units	Blank 1	
Expected Sampling Rate	l/min	0.50	
Pre-Sampling Leak Rate	l/min	0.00	
Post-Sampling Leak Rate	l/min	0.00	
Allowable Leak Rate	l/min	0.01	
Leak Test Acceptable	-	Yes	

Validity of Blank vs ELV	Units	Blank 1	
Allowable Blank	mg/m³	20.0	
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	
The measurement uncertainty for water vapour was greater than 20%. This was due to the low level of water vapour which was found to be present in the stack.	wx	

TOTAL OXIDES OF NITROGEN: MEASUREMENT UNCERTAINTY CALCULATIONS

	Value			Standard uncertainty			
Measured Quantities	**Symbol**	**Run 1**		**Symbol**	**Units**	**Run 1**	
Sampled Volume (STP)	V_m	0.03		uV_m	m^3	0.0006	
Leak	L	0.00		uL	%	-	
Laboratory Result	L_r	5.00		uL_r	%	-	

	Uncertainty as a Percentage			
Measured Quantities	**Units**	**Run 1**		**Requirement of Standard**
Sampled Volume (STP)	%	2.00		≤2%
Leak	%	0.00		≤2%
Laboratory Result	%	5.00		No Requirement

	Uncertainty in Measurement Units				Sensitivity Coefficient	
Measured Quantities	**Symbol**	**Units**	**Run 1**		**Run 1**	
Sampled Volume (STP)	V_m	m^3	0.03		1766	
Leak	L	mg/m^3	0.00		1.00	
Laboratory Result	L_r	mg/m^3	2.59		1.00	

	Uncertainty in Result		
Measured Quantities	**Units**	**Run 1**	
Sampled Volume (STP)	mg/m^3	1.04	
Leak	mg/m^3	0.00	
Laboratory Result	mg/m^3	2.59	

	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	2.8	
Expanded uncertainty (95% confidence), without Oxygen Correction	mg/m^3	5.5	
Expanded uncertainty (95% confidence), with Oxygen Correction	mg/m^3	N/A	
Expanded uncertainty (95% confidence), estimated with Method Deviations	mg/m^3	5.5	
Reported Uncertainty	mg/m^3	5.5	
Expanded uncertainty (95% confidence), without Oxygen Correction	%	10.6	
Expanded uncertainty (95% confidence), with Oxygen Correction	%	N/A	
Expanded uncertainty (95% confidence), estimated with Method Deviations	%	10.6	
Reported Uncertainty	%	10.6	

HYDROGEN FLUORIDE: RESULTS SUMMARY

Meggitt Aircraft Braking Systems, Coventry
Plating Shop Main Stack

Sample Runs

Parameter	Units	Run 1		Mean
Concentration	mg/m³	< 0.03		< 0.03
Uncertainty	±mg/m³	0.002		0.002
Mass Emission	g/hr	< 1.5		< 1.5
Uncertainty	±g/hr	0.12		0.12

Parameter	Units	Run 1		Mean
Water Vapour	% v/v	1.52		1.52
Uncertainty	±% v/v	0.08		0.08

Blank Runs

Parameter	Units	Blank 1		Maximum
Concentration	mg/m³	< 0.03		< 0.03

General Sampling Information

Parameter	Value	
Standard	ISO 15713	
Technical Procedure	CAT-TP-10	
Name of Analytical Laboratory	CAT	
Analytical Laboratory's Procedure	Ion Chromatography	
ISO 17025 Accredited Analysis?	Yes	
Date of Sample Analysis	15/12/2016	
Probe Material	Monel	
Filter Housing Material	Monel	
Impinger Material	Polyethylene	
Absorption Solution	0.1 mol/l Sodium Hydroxide	
Positioning of Filter	In 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.

HYDROGEN FLUORIDE: SAMPLING DETAILS

Sample Runs

Parameter	Units	Run 1	
Sampling Times	-	10:48 - 11:48	
Sampling Dates	-	15/12/2016	
Sampling Device	-	MFC / MV	
Duration	mins	60	
Volume Sampled (STP, Dry)	m^3	0.5907	
Volume Sampled (STP, Wet)	m^3	0.5998	
Volume Sampled (REF)	m^3	0.5998	
Sample Flow Rate	l/min	9.84	
Laboratory Result for Front Impingers	µg/ml	< 0.05	
Laboratory Result for Back Impinger	µg/ml	< 0.05	
Volume in Front Impingers	ml	239.5	
Volume in Back Impinger	ml	118.6	
Mass in Front Impingers	µg	< 12.0	
Mass in Back Impinger	µg	< 5.9	
Total Mass Collected	µg	< 17.9	
Calculated Concentration	mg/m^3	< 0.03	
Liquid Trap Start Mass	g	1230.0	
Liquid Trap End Mass	g	1233.4	
Silica Trap Start Mass	g	1594.5	
Silica Trap End Mass	g	1598.4	
Total Mass Of Water Vapour	g	7.3	
Calculated Water Vapour	% v/v	1.52	

Where: MFC stands for Mass Flow Controller, MV stands for Mass View Flowmeter

Blank Runs

Parameter	Units	Blank 1	
Blank Dates	-	15/12/2016	
Average Volume Sampled (REF)	m^3	0.5998	
Laboratory Result for Impingers	µg/ml	< 0.05	
Volume in Impingers	ml	307.9	
Total Mass Collected	µg	< 15.4	
Calculated Concentration	mg/m^3	< 0.03	

HYDROGEN FLUORIDE: QUALITY ASSURANCE

Sample Runs

Leak Test Results	Units	Run 1	
Mean Sampling Rate	l/min	9.84	
Pre-Sampling Leak Rate	l/min	0.11	
Post-Sampling Leak Rate	l/min	0.09	
Allowable Leak Rate	l/min	0.20	
Leak Test Acceptable	-	Yes	

Absorption Efficiency	Units	Run 1	
Absorption Efficiency	%	100.0	
Allowable Absorption Efficiency	%	N/A [2]	
Absorption Efficiency Acceptable	-	N/A [2]	

[2] The concentration is less than 30% of the ELV, therefore no assessment against an allowable efficiency is required.

Water Droplets	Units	Run 1	
Are Water Droplets Present	-	No	

MU (Concurrent Water Vapour)	Units	Run 1	
Measurement Uncertainty (MU)	%	5.1	
Allowable MU	%	20	
MU Acceptable	%	Yes	

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

Test Conditions	Units	Run 1	
Ambient Temperature Recorded?	-	Yes	

Blank Runs

Leak Test Results	Units	Blank 1	
Expected Sampling Rate	l/min	9.00	
Pre-Sampling Leak Rate	l/min	0.11	
Post-Sampling Leak Rate	l/min	0.10	
Allowable Leak Rate	l/min	0.18	
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	
There are no deviations associated with the sampling employed.	wx	

HYDROGEN FLUORIDE: MEASUREMENT UNCERTAINTY CALCULATIONS

	Value			Standard uncertainty			
Measured Quantities	**Symbol**	**Run 1**		**Symbol**	**Units**	**Run 1**	
Sampled Volume (STP)	V_m	0.59		uV_m	m^3	0.01	
Leak	L	0.91		uL	%	-	
Laboratory Result	L_r	2.65		uL_r	%	-	

	Uncertainty as a Percentage			
Measured Quantities	**Units**	**Run 1**		**Requirement of Standard**
Sampled Volume (STP)	%	2.00		≤2%
Leak	%	0.91		≤2%
Laboratory Result	%	2.65		No Requirement

	Uncertainty in Measurement Units				Sensitivity Coefficient	
Measured Quantities	**Symbol**	**Units**	**Run 1**		**Run 1**	
Sampled Volume (STP)	V_m	m^3	0.59		0.05	
Leak	L	mg/m^3	0.000		1.00	
Laboratory Result	L_r	mg/m^3	0.001		1.00	

	Uncertainty in Result		
Measured Quantities	**Units**	**Run 1**	
Sampled Volume (STP)	mg/m^3	0.0006	
Leak	mg/m^3	0.0002	
Laboratory Result	mg/m^3	0.0008	

	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	0.001	
Expanded uncertainty (95% confidence), without Oxygen Correction	mg/m^3	0.002	
Expanded uncertainty (95% confidence), with Oxygen Correction	mg/m^3	N/A	
Expanded uncertainty (95% confidence), estimated with Method Deviations	mg/m^3	0.002	
Reported Uncertainty	mg/m^3	0.002	
Expanded uncertainty (95% confidence), without Oxygen Correction	%	6.6	
Expanded uncertainty (95% confidence), with Oxygen Correction	%	N/A	
Expanded uncertainty (95% confidence), estimated with Method Deviations	%	6.6	
Reported Uncertainty	%	6.6	