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Stack Emissions Testing Report Commissioned by
Meggitt Aircraft Braking Systems

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

PPC Permit: PPC/156

Stack Reference
Plating Shop Main Stack

Dates of the Monitoring Campaign
27th February 2019

Job Reference Number
CAT-4759

Report Written by
Alex Powell Team Leader MCERTS Level 2 MM 10 1082 TE1 TE2 TE3 TE4

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

Report Date
26th March 2019

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.

Executive Summary

MONITORING OBJECTIVES

Meggitt Aircraft Braking Systems, Coventry
Plating Shop Main Stack
27th February 2019

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

Hydrogen Fluoride, Total Oxides of Nitrogen

Executive Summary

MONITORING RESULTS

Meggitt Aircraft Braking Systems, Coventry
Plating Shop Main Stack
27th February 2019

where MU = Measurement Uncertainty associated with the Result

	Concentration				Mass Emission			
Parameter	**Units**	**Result**	**MU +/-**	**Limit**	**Units**	**Result**	**MU +/-**	**Limit**
Hydrogen Fluoride [1]	mg/m³	< 0.05	0.003	5	g/hr	< 2.49	0.20	-
Total Oxides of Nitrogen [1]	mg/m³	< 5.64	1.13	200	g/hr	< 288	59.1	-
Water Vapour	% v/v	3.14	0.16					
Stack Gas Temperature	°C	24.0						
Stack Gas Velocity	m/s	8.75	0.10					
Volumetric Flow Rate (ACTUAL)	m³/hr	55676	2594					
Volumetric Flow Rate (REF) [1]	m³/hr	51051	2379					

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

Meggitt Aircraft Braking Systems, Coventry
Plating Shop Main Stack
27th February 2019

Parameter		Units	Concentration	Units	Mass Emission	Sampling Date(s)	Sampling Times	Duration mins
Hydrogen Fluoride	R1	mg/m³	< 0.05	g/hr	< 2.49	27/02/2019	11:50 - 12:50	60
Total Oxides of Nitrogen	R1	mg/m³	< 5.64	g/hr	< 288	27/02/2019	11:50 - 12:50	60
Velocity Traverse	R1					27/02/2019	13:00 - 13:15	

All results are expressed at the respective reference conditions.

PROCESS DETAILS

Meggitt Aircraft Braking Systems, Coventry
Plating Shop Main Stack
27th February 2019

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)	Metallic Components
Abatement System	Wet Scrubber
Abatement System Running Status	On
Fuel	N/A
Plume Appearance	None Visible

Executive Summary

MONITORING & ANALYTICAL METHODS

Meggitt Aircraft Braking Systems, Coventry
Plating Shop Main Stack
27th February 2019

	Monitoring				Analysis					
Parameter	**Standard**	**Technical Procedure**	**ISO 17025 Testing**	**Testing Lab**	**Analytical Procedure**	**Analytical Technique**	**ISO 17025 Analysis**	**Analysis Lab**	**MCERTS Testing**	**LOD (Average)**
Hydrogen Fluoride	ISO 15713	CAT-TP-10	Yes	CAT	CAT-AP-01	IC	Yes	CAT	Yes	0.05 mg/m³
Total Oxides of Nitrogen	US EPA M7D	CAT-TP-35	Yes	CAT	C27	IC	Yes	RPS	Yes	5.64 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	1.2 m/s

ANALYSIS LABORATORIES

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

Exova Catalyst (CAT)	ISO 17025 Accreditation Number: 4279

SUMMARY OF SAMPLING DEVIATIONS

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

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
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	42.0					> 5 Pa	Yes
Mean Velocity	m/s	8.75					-	-
Lowest Gas Velocity	m/s	7.11					-	-
Highest Gas Velocity	m/s	10.41					-	-
Ratio of Above	: 1	1.46					< 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.

Executive Summary

PLANT PHOTOS

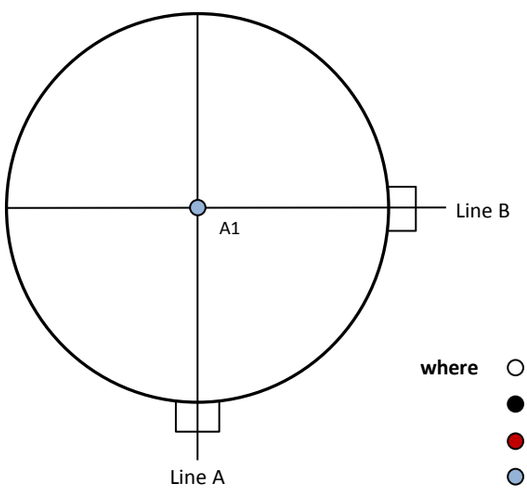
Photo 1

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	Alex Powell	MCERTS Level 2	MM 10 1082	TE1 TE2 TE3 TE4
Team Leader	Matthew Pendlebury	MCERTS Level 2	MM 04 535	TE1 TE2 TE3 TE4

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)	CAT 12.48
Oven Box (2)	-
Heated Probe (1)	CAT 5.55
Heated Probe (2)	-
Heated Probe (3)	-
S-Pitot (1)	CAT 21S.41
S-Pitot (2)	-
L-Pitot	-
Site Balance	CAT 17.23
500g / 1Kg Check Weights	CAT 17.23
Last Impinger Arm	CAT 4.400
Callipers	-
Tubes Kit Thermocouple	-

Instrumental Analysers	
Equipment Type	**Equipment I.D.**
Horiba PG-250	-
Horiba PG-250 SRM	-
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)	CAT 25.40
Mass View (2)	CAT 25.41
Easylogger EN-EL-12 Bit	-
Hioki 5043 (V)	-
Bioaerosols Temperature Logger	-
Electronic Refrigerator	-

Miscellaneous Items	
Equipment Type	**Equipment I.D.**
Digital Manometer (1)	CAT 3.169
Digital Manometer (2)	CAT 3.169
Digital Temperature Meter	-
Stopwatch	CAT 14.53
Barometer	CAT 13.26
Stack Thermocouple (1)	CAT 4.1152
Stack Thermocouple (2)	-
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	-
Single Channel Heater Controller	-
Laboratory Balance	
Tape Measure	CAT 16.52

METHODS & TECHNICAL PROCEDURES USED

Parameter	Standard	Technical Procedure
Hydrogen Fluoride	ISO 15713	CAT-TP-10
Total Oxides of Nitrogen	US EPA M7D	CAT-TP-35
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	1.50
Stack Width, W	m	-
Stack Area, A	m²	1.77
Average Stack Gas Temperature, T_a	°C	24.0
Average Stack Gas Pressure	Pa	64.8
Average Stack Static Pressure, P_{static}	kPa	0.05
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/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	20.15	0.2080	32.00	1.4277	0.2970
N_2	-	79.14	76.66	0.7914	28.01	1.2498	0.9891
Moisture (H_2O)	-	-	3.14	0.0314	18.02	0.8037	0.0252

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	1.2873
Wet Density (STP), P_{STW}	kg/m³	1.2721
Dry Density (Actual), P_{Actual}	kg/m³	1.1803
Average Wet Density (Actual), $P_{ActualW}$	kg/m³	1.1664

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	24.0	0.00
Total Pressure	kPa	101.1	101.3
Moisture	%	3.14	3.14

Gas Volumetric Flowrate (from Traverse)	Units	Result
Gas Volumetric Flowrate (Actual)	m³/hr	55676
Gas Volumetric Flowrate (STP, Wet)	m³/hr	51051
Gas Volumetric Flowrate (STP, Dry)	m³/hr	49448
Gas Volumetric Flowrate REF [1]	m³/hr	51051

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

(1 of 1)

Parameter	Units	Value
Date of Survey	-	27/02/2019
Time of Survey	-	13:00 - 13:15
Atmospheric Pressure	kPa	101.0
Average Stack Static Pressure	Pa	50
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	-	0.84
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)		*39.0*					*61.0*				
Mean		**50.0**	**23.8**	**1.167**	**7.74**		**79.5**	**24.3**	**1.165**	**9.77**	
1	0.10	60.0	23.0	1.170	8.49		90.0	24.0	1.166	10.41	
2	0.38	55.0	24.0	1.166	8.14		90.0	24.0	1.166	10.41	
3	1.13	43.0	24.0	1.166	7.20		75.0	24.0	1.166	9.51	
4	1.40	42.0	24.0	1.166	7.11		63.0	25.0	1.162	8.73	

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)	1.254	Pa
- Resolution	u(res)	0.00087	
- Calibration	u(cal)	0.437	
- Drift	u(drift)	0.083	
- Lack of Fit	u(fit)	0.053	
- Overall corrections to dynamic measurements	u(Cf)	0.573	
Standard uncertainty associated with the molar mass of the gas	u(M)	0.00003	-
- $\varphi O_2,w$	-	20.147	
- $\varphi CO_2,w$	-	0.058	
- Oxygen, dry	u(ϕO_2,d)	0.637	
- Carbon Dioxide, dry	u(ϕCO_2,d)	0.002	
- Water Vapour	u(ϕH_2O)	0.160	
- Oxygen, wet	u(ϕO_2,w)	0.618	
- Carbon Dioxide, wet	u(ϕCO_2,w)	0.002	
Standard uncertainty associated with the stack temperature	u(Tc)	1.515	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)	0.887	
Standard uncertainty associated with the density in the duct	u(ρ)	0.00629	-
Standard uncertainty associated with the local velocities	u(vi)	0.096	Pa
Standard uncertainty associated with the mean velocity	u(v)	0.049	m/s
Standard uncertainty associated with the mean velocity (95% Confidence)	Uc(v)	0.097	m/s
Standard uncertainty associated with the mean velocity (95% Confidence), relative	Uc,rel(v)	1.10	%
Standard uncertainty associated with the volume flow rate (95% Confidence)	Uc(qV,w)	2594.0	m^3/hr
- $u^2(a)/a^2$	-	0.00053	
- $u^2(qV,w)/q^2V,w$	-	0.00057	
- $u^2(qV,w)$	-	1751621	
- u(qV,w)	-	1323.5	
Standard uncertainty associated with the volume flow rate (95% Confidence), relative	Uc,rel(qV,w)	4.66	%

HYDROGEN FLUORIDE: RESULTS SUMMARY

Meggitt Aircraft Braking Systems, Coventry

Plating Shop Main Stack

Sample Runs

Parameter	Units	Run 1		Mean
Concentration	mg/m³	< 0.049		< 0.049
Uncertainty	±mg/m³	0.003		0.003
Mass Emission	g/hr	< 2.49		< 2.49
Uncertainty	±g/hr	0.20		0.20

Parameter	Units	Run 1		Mean
Water Vapour	% v/v	3.14		3.14
Uncertainty	±% v/v	0.16		0.16

NOTE: Where water droplets are present (See the Quality Assurance page), the Water Vapour concentration as found in Annex A of EN 14790 has been reported instead of the calculated value.

Blank Runs

Parameter	Units	Blank 1		Maximum
Concentration	mg/m³	< 0.031		< 0.031

General Sampling Information

Parameter	Value	
Standard	ISO 15713	
Technical Procedure	CAT-TP-10	
Name of Analytical Laboratory	CAT	
Analytical Laboratory's Procedure	CAT-AP-01	
ISO 17025 Accredited Analysis?	Yes	
Date of Sample Analysis	04/03/2019	
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	A3	

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	-	11:50 - 12:50
Sampling Dates	-	27/02/2019
Sampling Device	-	MFC / MV
Duration	mins	60
Volume Sampled (STP, Dry)	m^3	0.3347
Volume Sampled (STP, Wet)	m^3	0.3455
Volume Sampled (REF)	m^3	0.3455
Sample Flow Rate	l/min	5.58
Laboratory Result for Front Impingers	µg/ml	< 0.05
Laboratory Result for Back Impinger	µg/ml	< 0.05
Volume in Front Impingers	ml	235.9
Volume in Back Impinger	ml	100.5
Mass in Front Impingers	µg	< 11.8
Mass in Back Impinger	µg	< 5.0
Total Mass Collected	µg	< 16.8
Calculated Concentration	mg/m^3	< 0.05
Liquid Trap Start Mass	g	1260.3
Liquid Trap End Mass	g	1274.6
Silica Trap Start Mass	g	460.7
Silica Trap End Mass	g	464.4
Total Mass Of Water Vapour	g	18.0
Calculated Water Vapour	% v/v	6.28

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

Blank Runs

Parameter	Units	Blank 1
Blank Dates	-	27/02/2019
Average Volume Sampled (REF)	m^3	0.3455
Laboratory Result for Impingers	µg/ml	< 0.05
Volume in Impingers	ml	217.4
Total Mass Collected	µg	< 10.9
Calculated Concentration	mg/m^3	< 0.03

HYDROGEN FLUORIDE: QUALITY ASSURANCE

Sample Runs

Leak Test Results	Units	Run 1
Mean Sampling Rate	l/min	5.58
Pre-Sampling Leak Rate	l/min	0.04
Post-Sampling Leak Rate	l/min	0.05
Allowable Leak Rate	l/min	0.11
Leak Test Acceptable	-	Yes

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

MU (Concurrent Water Vapour)	Units	Run 1
Measurement Uncertainty (MU)	%	5.0
Allowable MU	%	20.0
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	5.00
Pre-Sampling Leak Rate	l/min	0.08
Post-Sampling Leak Rate	l/min	0.08
Allowable Leak Rate	l/min	0.10
Leak Test Acceptable	-	Yes

Validity of Blank vs ELV	Units	Blank 1
Allowable Blank	mg/m^3	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	0.33	uV_m	m^3	0.01
Leak	L	0.90	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	%	0.90	≤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	0.33	0.15
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	0.001
Leak	mg/m^3	0.000
Laboratory Result	mg/m^3	0.001

	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	0.002
Expanded uncertainty (95% confidence), without Oxygen Correction	mg/m^3	0.003
Expanded uncertainty (95% confidence), with Oxygen Correction	mg/m^3	N/A
Expanded uncertainty (95% confidence), estimated with Method Deviations	mg/m^3	0.003
Reported Uncertainty	mg/m^3	0.003
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

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	< 5.64		< 5.64
Uncertainty	±mg/m³	1.13		1.13
Mass Emission	g/hr	< 288		< 288
Uncertainty	±g/hr	59.1		59.1

Parameter	Units	Run 1		Mean
Water Vapour	% v/v	3.14		3.14
Uncertainty	±% v/v	0.16		0.16

NOTE: Where water droplets are present (See the Quality Assurance page), the Water Vapour concentration as found in Annex A of EN 14790 has been reported instead of the calculated value.

Blank Runs

Parameter	Units	Blank 1		Maximum
Concentration	mg/m³	< 3.50		< 3.50

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	08/03/2019	
Probe Material	Stainless Steel	
Filter Housing Material	Borosilicate Glass	
Impinger Material	Borosilicate Glass	
Absorption Solution	Potassium Permanganate Solution	
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	B3	

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	-	11:50 - 12:50
Sampling Dates	-	27/02/2019
Sampling Device	-	MFC / MV
Duration	mins	60
Volume Sampled (STP, Dry)	m^3	0.0277
Volume Sampled (STP, Wet)	m^3	0.0286
Volume Sampled (REF)	m^3	0.0286
Sample Flow Rate	l/min	0.46
Laboratory Result for Front Impingers	µg/ml	< 0.25
Laboratory Result for Back Impinger	µg/ml	< 0.25
Volume in Front Impingers	ml	434.0
Volume in Back Impinger	ml	212.6
Mass in Front Impingers	µg	< 108.5
Mass in Back Impinger	µg	< 53.2
Total Mass Collected	µg	< 161.7
Calculated Concentration	mg/m^3	< 5.64
Liquid Trap Start Mass	g	2755.1
Liquid Trap End Mass	g	2657.8
Silica Trap Start Mass	g	761.2
Silica Trap End Mass	g	859.9
Total Mass Of Water Vapour	g	1.4
Calculated Water Vapour	% v/v	5.92

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

Blank Runs

Parameter	Units	Blank 1
Blank Dates	-	27/02/2019
Average Volume Sampled (REF)	m^3	0.0286
Laboratory Result for Impingers	µg/ml	< 0.25
Volume in Impingers	ml	400.9
Total Mass Collected	µg	< 100.2
Calculated Concentration	mg/m^3	< 3.50

TOTAL OXIDES OF NITROGEN: QUALITY ASSURANCE

Sample Runs

Leak Test Results	Units	Run 1
Mean Sampling Rate	l/min	0.46
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	%	100.0
Allowable Absorption Efficiency	%	N/A
Absorption Efficiency Acceptable	-	N/A

Water Droplets	Units	Run 1
Are Water Droplets Present	-	Yes

MU (Concurrent Water Vapour)	Units	Run 1
Measurement Uncertainty (MU)	%	5.0
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	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	
There are no deviations associated with the sampling employed.	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	m³	0.001
Leak	L	0.00	uL	%	-
Laboratory Result	L_r	10.0	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	%	10.0	No Requirement

	Uncertainty in Measurement Units			Sensitivity Coefficient
Measured Quantities	**Symbol**	**Units**	**Run 1**	**Run 1**
Sampled Volume (STP)	V_m	m³	0.03	203
Leak	L	mg/m³	0.00	1.00
Laboratory Result	L_r	mg/m³	0.56	1.00

	Uncertainty in Result	
Measured Quantities	**Units**	**Run 1**
Sampled Volume (STP)	mg/m³	0.11
Leak	mg/m³	0.00
Laboratory Result	mg/m³	0.56

	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/m³	0.58
Expanded uncertainty (95% confidence), without Oxygen Correction	mg/m³	1.13
Expanded uncertainty (95% confidence), with Oxygen Correction	mg/m³	N/A
Expanded uncertainty (95% confidence), estimated with Method Deviations	mg/m³	1.13
Reported Uncertainty	mg/m³	1.13
Expanded uncertainty (95% confidence), without Oxygen Correction	%	20.0
Expanded uncertainty (95% confidence), with Oxygen Correction	%	N/A
Expanded uncertainty (95% confidence), estimated with Method Deviations	%	20.0
Reported Uncertainty	%	20.0