Exova Catalyst, Unit C6, Emery Court, The Embankment Business Park, Heaton Mersey, Stockport, SK4 3GL
T: 0800 328 1821 (or + 44 161 432 3286 from overseas)
E: toby.campbell@exova.com
Your Exova Catalyst Contact: Toby Campbell (07825 130 074)

Stack Emissions Testing Report Commissioned by
Meggit Aircraft Braking Systems

Installation Name & Address
Meggit Aircraft Braking Systems
Holford Lane
West Midlands
CV6 4AA

PPC Permit: PPC/156

Stack Reference
Plating Shop Main Stack

Dates of the Monitoring Campaign
5th January 2016

Job Reference Number
CAT-2546

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

Report Approved by
James Eldridge Team Leader MCERTS Level 2 MM 05 641 TE1 TE2 TE3 TE4

Report Date
21st January 2016

Version
Version 1

Signature of Report Approver
[redacted]

CONTENTS

MONITORING OBJECTIVES

Meggit Aircraft Braking Systems, Coventry
Plating Shop Main Stack
5th January 2016

Overall Aim of the Monitoring Campaign

Exova Catalyst were commissioned by Meggit 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

Executive Summary

MONITORING RESULTS

Meggit Aircraft Braking Systems, Coventry
Plating Shop Main Stack
5th January 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	< 4.4	0.55	200	g/hr	< 206	27.6	-
Water Vapour	% v/v	2.4	0.80					
Stack Gas Temperature	°C	22.0						
Stack Gas Velocity	m/s	8.3	0.09					
Volumetric Flow Rate (ACTUAL)	m³/hr	52864	2467					
Volumetric Flow Rate (REF) [1]	m³/hr	46815	2185					

NOTE: VOLUMETRIC FLOW RATE 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

Meggit Aircraft Braking Systems, Coventry
Plating Shop Main Stack
5th January 2016

Parameter		Units	Concentration	Units	Mass Emission	Sampling Date(s)	Sampling Times	Duration mins
Total Oxides of Nitrogen	R1	mg/m³	< 4.4	g/hr	< 206	05/01/2016	10:26 - 11:26	60
Velocity & Volumetric Flow Rate	R1					05/01/2016	10:10	

All results are expressed at the respective reference conditions.

PROCESS DETAILS

Meggit Aircraft Braking Systems, Coventry
Plating Shop Main Stack
5th January 2016

Standard Operating Conditions

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

Executive Summary

MONITORING & ANALYTICAL METHODS

Meggit Aircraft Braking Systems, Coventry
Plating Shop Main Stack
5th January 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 Stack	Yes	RPS	Yes	4.4 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
RPS Laboratories Ltd (RPS)	ISO 17025 Accreditation Number: 0605

SUMMARY OF SAMPLING DEVIATIONS

Parameter	Run	Deviation
Water Vapour	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	No
Safe Access Available	Yes
Easy Access Available	Yes

Sampling Location / Platform Improvement Recommendations

The platform is in accordance with the requirements in the Environment Agency's Technical Guidance Note M1 and EN 15259. The recent inspection report outlines reccomendations. These should be actioned prior to the next visit; especially in relation to corrosion at the weld points and anti vibration bolts.

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	47.0		> 5 Pa	Yes
Mean Velocity	m/s	8.31		-	-
Lowest Gas Velocity	m/s	7.65		-	-
Highest Gas Velocity	m/s	9.1		-	-
Ratio of Above	: 1	1.19		< 3 : 1	Yes
Maximum Angle of Swirl	°	NM		< 15°	NM
No Local Negative Flow	-	Yes		-	Yes

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

PLANT PHOTOS

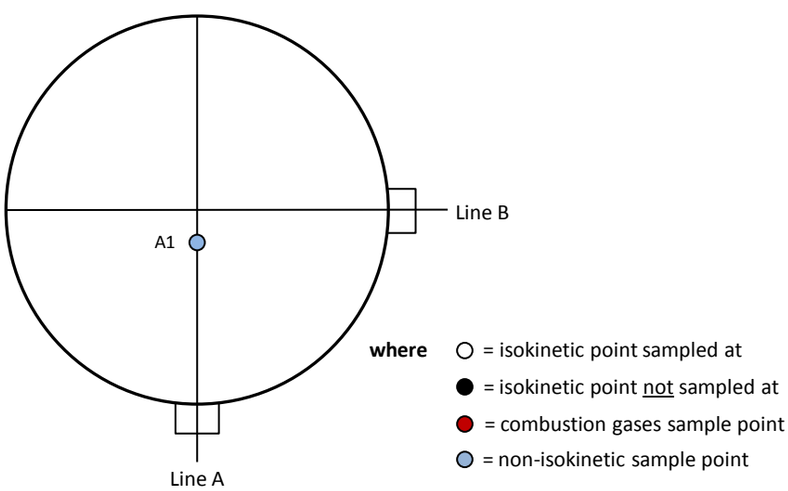
Photo 1

Photo 2

Photo 3

Photo 4

SAMPLE POINTS



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	Joe Cartmell	MCERTS Trainee	MM 15 1355	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)	CAT 5.2
Heated Probe (2)	-
Heated Probe (3)	-
S-Pitot (1)	CAT 21.P.79
S-Pitot (2)	CAT 21.S.45
L-Pitot	-
500g Check Weight	CAT 17.2
1Kg Check Weight	CAT 17.20
Last Impinger Arm	CAT 4.65
Callipers	-
Tubes Kit Thermocouple	-

Instrumental Analysers	
Equipment Type	**Equipment I.D.**
Horiba PG-250 SRM	-
Horiba PG-350E	-
Servomex 4900	-
Eco Physics CLD 822Mh	-
ABB AO2020-URAS26	-
Servomex 5200MP	-
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 25.46
Mass View (2)	-
Easylogger EN-EL-12 Bit	-
Hioki 5043 (V)	-
Bioaerosols Temperature Logger	-
Electronic Refrigerator	-

Miscellaneous Items	
Equipment Type	**Equipment I.D.**
Digital Manometer (500)	CAT 3.47
Digital Manometer (10000)	-
Digital Temperature Meter	CAT 3.47
Stopwatch	CAT 14.25
Barometer	CAT 13.6
Stack Thermocouple (1)	CAT 4.591
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	CAT 3.18
Single Channel Heater Controller	-
Laboratory Balance	CAT 1.18 / 1.18a
Tape Measure	CAT 16.27

METHODS & TECHNICAL PROCEDURES USED

Parameter	Standard	Technical Procedure
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	m^2	1.77
Average Stack Gas Temperature, T_a	°C	22.0
Average Stack Gas Pressure	Pa	55.6
Average Stack Static Pressure, P_{static}	kPa	0.039
Average Barometric Pressure, P_b	kPa	96.9
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	0.00118
O_2 (Estimated)	-	20.80	20.31	0.2080	32.00	1.4277	0.29696
N_2	-	79.14	77.27	0.7914	28.01	1.2498	0.98913
Moisture (H_2O)	-	-	2.37	0.0237	18.02	0.8037	0.01903

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	1.276
Dry Density (Actual), P_{Actual}	kg/m³	1.140
Average Wet Density (Actual), $P_{ActualW}$	kg/m³	1.130

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	22.0	0.0
Total Pressure	kPa	96.9	101.3
Moisture	%	2.37	2.37

Gas Volumetric Flowrate (from Traverse)	Units	Result
Gas Volumetric Flowrate (Actual)	m³/hr	52864
Gas Volumetric Flowrate (STP, Wet)	m³/hr	46815
Gas Volumetric Flowrate (STP, Dry)	m³/hr	45707
Gas Volumetric Flowrate REF [1]	m³/hr	46815

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

(1 of 1)

Parameter	Units	Value
Date of Survey	-	05/01/2016
Time of Survey	-	10:10
Atmospheric Pressure	kPa	96.9
Average Stack Static Pressure	Pa	39
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)		*38.0*					*39.0*				
Mean		**55.0**	**22.0**	**1.130**	**8.27**		**56.3**	**22.0**	**1.130**	**8.35**	
1	0.10	55.0	22.0	1.130	8.27	4.0	67.0	22.0	1.130	9.13	5.0
2	0.38	52.0	22.0	1.130	8.04	3.0	59.0	22.0	1.130	8.57	4.0
3	1.13	56.0	22.0	1.130	8.35	3.0	52.0	22.0	1.130	8.04	4.0
4	1.40	57.0	22.0	1.130	8.42	4.0	47.0	22.0	1.130	7.65	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(Δpi)	1.202	Pa
- Resolution	u(res)	0.00087	
- Calibration	u(cal)	0.322	
- Drift	u(drift)	0.083	
- Lack of Fit	u(fit)	0.039	
- Overall corrections to dynamic measurements	u(Cf)	0.445	
Standard uncertainty associated with the molar mass of the gas	u(M)	0.00003	-
- $\varphi O_2,w$	-	20.307	
- $\varphi CO_2,w$	-	0.059	
- Oxygen, dry	u(ϕO_2,d)	0.637	
- Carbon Dioxide, dry	u(ϕCO_2,d)	0.002	
- Water Vapour	u(ϕH_2O)	0.121	
- Oxygen, wet	u(ϕO_2,w)	0.622	
- Carbon Dioxide, wet	u(ϕCO_2,w)	0.002	
Standard uncertainty associated with the stack temperature	u(Tc)	1.505	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)	0.850	
Standard uncertainty associated with the density in the duct	u(ρ)	0.00612	-
Standard uncertainty associated with the local velocities	u(vi)	0.097	Pa
Standard uncertainty associated with the mean velocity	u(v)	0.048	m/s
Standard uncertainty associated with the mean velocity (95% Confidence)	Uc(v)	0.094	m/s
Standard uncertainty associated with the mean velocity (95% Confidence), relative	Uc,rel(v)	1.14	%
Standard uncertainty associated with the volume flow rate (95% Confidence)	Uc(qV,w)	2467.2	m^3/hr
- $u^2(a)/a^2$	-	0.00053	
- $u^2(qV,w)/q^2V,w$	-	0.00057	
- $u^2(qV,w)$	-	1584547	
- u(qV,w)	-	1258.8	
Standard uncertainty associated with the volume flow rate (95% Confidence), relative	Uc,rel(qV,w)	4.67	%

TOTAL OXIDES OF NITROGEN: RESULTS SUMMARY

Meggit Aircraft Braking Systems, Coventry
Plating Shop Main Stack

Sample Runs

Parameter	Units	Run 1		Mean
Concentration	mg/m³	< 4.4		< 4.4
Uncertainty	±mg/m³	0.55		0.55
Mass Emission	g/hr	< 206		< 206
Uncertainty	±g/hr	27.6		27.6

Parameter	Units	Run 1		Mean
Water Vapour	% v/v	2.4		2.4
Uncertainty	±% v/v	0.80		0.80

Blank Runs

Parameter	Units	Blank 1		Maximum
Concentration	mg/m³	< 1.4		< 1.4

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	13/01/2016	
Probe Material	Stainless Steel	
Filter Housing Material	Borosilicate Glass	
Impinger Material	Borosilicate Glass	
Absorption Solution	Potassium Permanganate Solution	
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.

TOTAL OXIDES OF NITROGEN: SAMPLING DETAILS

Sample Runs

Parameter	Units	Run 1	
Sampling Times	-	10:26 - 11:26	
Sampling Dates	-	05/01/2016	
Sampling Device	-	MFC / MV	
Duration	mins	60	
Volume Sampled (STP, Dry)	m^3	0.0360	
Volume Sampled (STP, Wet)	m^3	0.0368	
Volume Sampled (REF)	m^3	0.0368	
Sample Flow Rate	l/min	0.5991	
Laboratory Result for Front Impingers	µg/ml	< 0.25	
Laboratory Result for Back Impinger	µg/ml	< 0.25	
Volume in Front Impingers	ml	383.0	
Volume in Back Impinger	ml	266.6	
Mass in Front Impingers	µg	< 95.8	
Mass in Back Impinger	µg	< 66.7	
Total Mass Collected	µg	< 162.4	
Calculated Concentration	mg/m^3	< 4.41	
Liquid Trap Start Mass	g	2351.9	
Liquid Trap End Mass	g	2352.0	
Silica Trap Start Mass	g	801.1	
Silica Trap End Mass	g	801.7	
Total Mass Of Water Vapour	g	0.7	
Calculated Water Vapour	% v/v	2.37	

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

Blank Runs

Parameter	Units	Blank 1	
Blank Dates	-	05/01/2016	
Average Volume Sampled (REF)	m^3	0.0368	
Laboratory Result for Impingers	µg/ml	< 0.25	
Volume in Impingers	ml	207.3	
Total Mass Collected	µg	< 51.8	
Calculated Concentration	mg/m^3	< 1.41	

TOTAL OXIDES OF NITROGEN: QUALITY ASSURANCE

Sample Runs

Leak Test Results	Units	Run 1	
Mean Sampling Rate	l/min	0.60	
Pre-Sampling Leak Rate	l/min	0.01	
Post-Sampling Leak Rate	l/min	0.01	
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	-	No	

MU (Concurrent Water Vapour)	Units	Run 1	
Measurement Uncertainty (MU)	%	33.9	
Allowable MU	%	20	
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	1.00	
Pre-Sampling Leak Rate	l/min	0.01	
Post-Sampling Leak Rate	l/min	0.01	
Allowable Leak Rate	l/min	0.02	
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, w = deviation only 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.	w	

TOTAL OXIDES OF NITROGEN: MEASUREMENT UNCERTAINTY CALCULATIONS

	Value			Standard uncertainty			
Measured Quantities	**Symbol**	**Run 1**		**Symbol**	**Units**	**Run 1**	
Sampled Volume (STP)	V_m	0.0360		uV_m	m^3	0.0007	
Leak	L	1.67		uL	%	-	
Laboratory Result	L_r	6.00		uL_r	%	-	

	Uncertainty as a Percentage			
Measured Quantities	**Units**	**Run 1**		**Requirement of Standard**
Sampled Volume (STP)	%	2.00		≤2%
Leak	%	1.67		≤2%
Laboratory Result	%	6.00		No Requirement

	Uncertainty in Measurement Units				Sensitivity Coefficient	
Measured Quantities	**Symbol**	**Units**	**Run 1**		**Run 1**	
Sampled Volume (STP)	V_m	m^3	0.0360		123	
Leak	L	mg/m^3	0.042		1.00	
Laboratory Result	L_r	mg/m^3	0.265		1.00	

	Uncertainty in Result		
Measured Quantities	**Units**	**Run 1**	
Sampled Volume (STP)	mg/m^3	0.09	
Leak	mg/m^3	0.04	
Laboratory Result	mg/m^3	0.26	

	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	0.3	
Expanded uncertainty (95% confidence), without Oxygen Correction	mg/m^3	0.6	
Expanded uncertainty (95% confidence), with Oxygen Correction	mg/m^3	N/A	
Expanded uncertainty (95% confidence), estimated with Method Deviations	mg/m^3	0.6	
Reported Uncertainty	mg/m^3	0.6	
Expanded uncertainty (95% confidence), without Oxygen Correction	%	12.5	
Expanded uncertainty (95% confidence), with Oxygen Correction	%	N/A	
Expanded uncertainty (95% confidence), estimated with Method Deviations	%	12.5	
Reported Uncertainty	%	12.5	