



Element Materials Technology, Unit 3, Wednesbury One, Black Country New Road, Wednesbury, WS10 7NZ  
Your Element Contact: James Eldridge (07826 916 684)  
E: james.eldridge@element.com

**Stack Emissions Testing Report Commissioned by**  
Henkel AG & Company

**Installation Name & Address**

Henkel AG & Company  
5 Cromwell Road  
St Neots  
Cambridgeshire  
PE19 1QL

**Stack Reference**

Extractor 1 Banbury

**Dates of the Monitoring Campaign**

4th December 2020

**Job Reference Number**

EST-6019

**Report Written by**

Neil Kelly  
Team Leader  
MCERTS Level 2  
MM 16 1390  
TE1 TE2 TE3 TE4

**Report Approved by**

James Eldridge  
Operations Manager  
MCERTS Level 2  
MM 05 641  
TE1 TE2 TE3 TE4

**Report Date**

22nd December 2020

**Version**

Version 1

**Signature of Report Approver**



## CONTENTS

TITLE PAGE

CONTENTS

EXECUTIVE SUMMARY

Monitoring Objectives	3
Monitoring Results	4
Monitoring Dates & Times	5
Process Details	6
Monitoring & Analytical Methods	7
Summary of Sampling Deviations	7
Sampling Location	8
Plant Photos / Sample Points	9

APPENDIX 1 - Monitoring Personnel & List of Equipment

APPENDIX 2 - Raw Data, Sampling Equations & Charts

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

*This test report shall not be reproduced, except in full, without the written approval of Element.*

## Executive Summary

(Page 1 of 7)

### MONITORING OBJECTIVES

Henkel AG & Company, St Neots  
Extractor 1 Banbury  
4th December 2020

#### Overall Aim of the Monitoring Campaign

Element were commissioned by Henkel AG & Company to carry out stack emissions testing on the Extractor 1 Banbury at St Neots.

The aim of the monitoring campaign was to perform testing, as requested by the customer, for a number of prescribed pollutants. There are no emission limits set for any of the pollutants at this time.

#### Special Requirements

There were no special requirements.

#### Target Parameters

Total Particulate Matter

# Executive Summary

(Page 2 of 7)

## MONITORING RESULTS

Henkel AG & Company, St Neots  
 Extractor 1 Banbury  
 4th December 2020

where MU = Measurement Uncertainty associated with the Result

Parameter	Concentration				Mass Emission			
	Units	Result	MU +/-	Limit	Units	Result	MU +/-	Limit
Total Particulate Matter <sup>1</sup>	mg/m <sup>3</sup>	2.39	0.48	50	g/hr	19.60	4.05	-
Water Vapour	% v/v	0.42	0.03					
Stack Gas Temperature	°C	18.00						
Stack Gas Velocity	m/s	6.96	0.15					
Volumetric Flow Rate (ACTUAL)	m <sup>3</sup> /hr	9021	454					
Volumetric Flow Rate (REF) <sup>1</sup>	m <sup>3</sup> /hr	8154	410					

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

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

# Executive Summary

(Page 3 of 7)

## MONITORING DATE(S) & TIMES

Henkel AG & Company, St Neots  
 Extractor 1 Banbury  
 4th December 2020

Parameter		Units	Concentration	Units	Mass Emission	Sampling Date(s)	Sampling Times	Duration mins
Total Particulate Matter	R1	mg/m <sup>3</sup>	2.39	g/hr	19.60	04/12/2020	12:56 - 13:26, 13:28 - 13:58	60
Velocity Traverse	R1					04/12/2020	12:36 - 12:49	

All results are expressed at the respective reference conditions.

## Executive Summary

(Page 4 of 7)

### PROCESS DETAILS

Henkel AG & Company, St Neots  
 Extractor 1 Banbury  
 4th December 2020

#### Standard Operating Conditions

Parameter	Value
Process Status	Normal Operation
Capacity (of 100%) and Tonnes / Hour	100% of Capacity
Continuous or Batch Process	Batch
Feedstock (if applicable)	N/A
Abatement System	Bag Filter
Abatement System Running Status	Operational
Fuel	N/A
Plume Appearance	None Visible

## Executive Summary

(Page 5 of 7)

### MONITORING & ANALYTICAL METHODS

Henkel AG & Company, St Neots

Extractor 1 Banbury

4th December 2020

Parameter	Monitoring				Analysis				Overall Status	LOD (Average)
	Standard	Technical Procedure	Sampling Status	Testing Lab	Analytical Procedure	Analytical Technique	Analysis Status	Analysis Lab		
Total Particulate Matter	EN 13284-1	CAT-TP-01	MCERTS	EET	CAT-TP-03	Gravimetric	MCERTS	EET	MCERTS	0.21 mg/m <sup>3</sup>
Water Vapour	EN 14790	CAT-TP-05	MCERTS	EET	CAT-TP-05	Gravimetric	MCERTS	EET	MCERTS	0.10 % v/v
Velocity & Vol. Flow Rate	EN 16911-1 (MID)	CAT-TP-41	MCERTS	EET	Pitot Tube and Thermocouple				MCERTS	1.2 m/s

### ANALYSIS LABORATORIES

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

Element Materials Technology (EET)	ISO 17025 Accreditation Number: 4279
------------------------------------	--------------------------------------

### SUMMARY OF SAMPLING DEVIATIONS

Parameter	Run	Deviation
Total Particulate Matter	1	There are no deviations associated with the sampling employed.

## Executive Summary

(Page 6 of 7)

### SUITABILITY OF SAMPLING LOCATION

#### Duct Characteristics

Parameter	Units	Value
Type	-	Rectangular
Depth	m	0.61
Width	m	0.59
Area	m <sup>2</sup>	0.36
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	Scissor Lift
Inside / Outside	Inside

#### 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)	N/A
Platform has vertical base boards (approx. 0.25m high)	N/A
Platform has chains / self closing gates at top of ladders	N/A
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	30.9	> 5 Pa	Yes
Mean Velocity	m/s	6.96	-	-
Lowest Gas Velocity	m/s	6.00	-	-
Highest Gas Velocity	m/s	7.90	-	-
Ratio of Above	: 1	1.32	< 3 : 1	Yes
Maximum Angle of Swirl	°	3.00	< 15°	Yes
No Local Negative Flow	-	Yes	-	Yes



Executive Summary

(Page 7 of 7)

PLANT PHOTOS

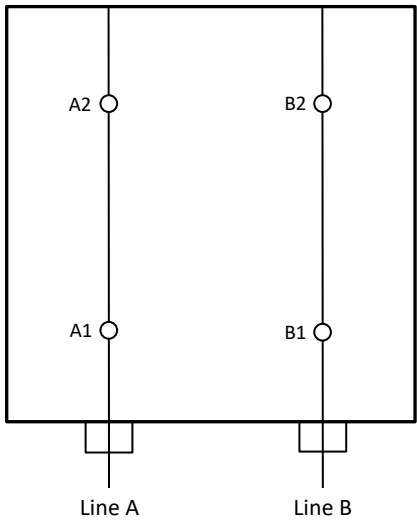
Photo 1



Photo 2



SAMPLE POINTS



where

○ = isokinetic point sampled at

● = isokinetic point not sampled at

● = combustion gases sample point

○ = non-isokinetic sample point

## APPENDICES

### APPENDIX CONTENTS

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

APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

## APPENDIX 1

### STACK EMISSIONS MONITORING PERSONNEL

Position	Name	MCERTS Accreditation	MCERTS Number	Technical Endorsements
Team Leader	Harpreet Badwal	MCERTS Level 2	MM 03 149	TE1 TE2 TE3 TE4
Team Leader	Lee Heaton	MCERTS Level 2	MM 17 1433	TE1 & TE4

### LIST OF EQUIPMENT

Extractive Sampling		Instrumental Analysers		Miscellaneous Items	
Equipment Type	Equipment I.D.	Equipment Type	Equipment I.D.	Equipment Type	Equipment I.D.
Control Box DGM (1)	CAT 7.57	Horiba PG-350E	-	Digital Manometer (1)	CAT 3.142
Control Box DGM (2)	-	Horiba PG-250	-	Digital Manometer (2)	CAT 3.144
Box Thermocouples (1)	CAT 3.146	Servomex 5200 MP	-	Digital Temperature Meter	-
Box Thermocouples (2)	-	Eco Physics CLD 822Mh	-	Stopwatch	CAT 14.84
Umbilical (1)	CAT 3.146	ABB AO2020-URAS26	-	Barometer	CAT 13.40
Umbilical (2)	-	Testo 350 XL	-	Stack Thermocouple (1)	CAT 4.1277
Oven Box (1)	-	Ankersmid APS 313	-	Stack Thermocouple (2)	CAT 4.1281
Oven Box (2)	-	Gasmet DX4000	-	Stack Thermocouple (3)	CAT 4.0123
Heated Probe (1)	CAT 5.126	Gasmet Sampling System	-	1m Heated Line (1)	-
Heated Probe (2)	CAT 5.127	Bernath 3006 FID	-	1m Heated Line (2)	-
Heated Probe (3)	CAT 5.128	M&C PSS	-	1m Heated Line (3)	-
S-Pitot (1)	CAT 21S.57	Mass Flow Controller (1)	-	5m Heated Line (1)	-
S-Pitot (2)	CAT 21P.38	Mass Flow Controller (2)	-	15m Heated Line (1)	-
L-Pitot	-	Mass View (1)	-	20m Heated Line (1)	-
Site Balance	CAT 17.33	Mass View (2)	-	20m Heated Line (2)	-
500g / 1Kg Check Weights	CAT 17.33 a & b	Hioki 5043 (V)	-	Dual Channel Heater Controller	-
Last Impinger Arm	-	Easylogger EN-EL-12 Bit	-	Single Channel Heater Controller	-
Callipers	CAT 23.40	Bioaerosols Temperature Logger	-	Laboratory Balance	CAT 1.18, 1.18a, 1.18b
Tubes Kit Thermocouple	-	Electronic Refrigerator	-	Tape Measure	CAT 16.45

### 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	0.61
Stack Width, W	m	0.59
Stack Area, A	m <sup>2</sup>	0.36
Average Stack Gas Temperature, T <sub>a</sub>	°C	18.1
Average Stack Gas Pressure	Pa	42.1
Average Stack Static Pressure, P <sub>static</sub>	kPa	0.044
Average Barometric Pressure, P <sub>b</sub>	kPa	97.6
Average Pitot Tube Calibration Coefficient, C <sub>p</sub>	-	0.82

### 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 <sup>3</sup> p	Conc kg/m <sup>3</sup> p <sub>i</sub>
CO <sub>2</sub> (Estimated)	-	0.06	0.06	0.0006	44.01	1.9635	0.00118
O <sub>2</sub> (Estimated)	-	20.80	20.71	0.2080	32.00	1.4277	0.29696
N <sub>2</sub>	-	79.14	78.81	0.7914	28.01	1.2498	0.98913
Moisture (H <sub>2</sub> O)	-	-	0.42	0.0042	18.02	0.8037	0.00335

Where:  $p = M / 22.41$

$p_i = r \times p$

### Calculation of Stack Gas Densities

Determinand	Units	Result
Dry Density (STP), P <sub>STD</sub>	kg/m <sup>3</sup>	1.287
Wet Density (STP), P <sub>STW</sub>	kg/m <sup>3</sup>	1.285
Dry Density (Actual), P <sub>Actual</sub>	kg/m <sup>3</sup>	1.164
Average Wet Density (Actual), P <sub>ActualW</sub>	kg/m <sup>3</sup>	1.162

Where: P<sub>STD</sub> = sum of component concentrations, kg/m<sup>3</sup> (not including water vapour)

P<sub>STW</sub> = sum of all wet concentrations / 100 x density, kg/m<sup>3</sup> (including water vapour)

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

$P_{ActualW} \text{ (at each sampling point)} = P_{STW} \times (T_s / P_s) \times (P_a / T_a)$

### Calculation of Stack Gas Volumetric Flowrate, Q

Duct gas flow conditions	Units	Actual	REF <sup>1</sup>
Temperature	°C	18.1	0.0
Total Pressure	kPa	97.6	101.3
Moisture	%	0.42	0.42

Gas Volumetric Flowrate (from Traverse)	Units	Result
Gas Volumetric Flowrate (Actual)	m <sup>3</sup> /hr	9021
Gas Volumetric Flowrate (STP, Wet)	m <sup>3</sup> /hr	8154
Gas Volumetric Flowrate (STP, Dry)	m <sup>3</sup> /hr	8120
Gas Volumetric Flowrate REF <sup>1</sup>	m <sup>3</sup> /hr	8154

## APPENDIX 2

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

(1 of 1)

Parameter	Units	Value
Date of Survey	-	04/12/2020
Time of Survey	-	12:36 - 12:49
Atmospheric Pressure	kPa	97.6
Average Stack Static Pressure	Pa	44
Result of Pitot Stagnation Test	-	Pass
Are Water Droplets Present?	-	No
Device Used	S-Type Pitot with KIMO MP 210 (500Pa)	

Parameter	Units	Value
Initial Pitot Leak Check	-	Pass
Final Pitot Leak Check	-	Pass
Orientation of Duct	-	Vertical
Pitot Tube, $C_p$	-	0.82
Number of Lines Available	-	2
Number of Lines Used	-	2

Sampling Line A							Sampling Line B				
Traverse Point	Depth m	$\Delta P$ Pa	Temp °C	Wet Density kg/m <sup>3</sup>	Velocity m/s	Swirl °	$\Delta P$ Pa	Temp °C	Wet Density kg/m <sup>3</sup>	Velocity m/s	Swirl °
STATIC (Units: Pa)		40.8					47.2				
Mean		42.0	18.1	1.162	6.98		42.3	18.2	1.161	6.95	
1	0.15	47.7	17.8	1.163	7.45	3.0	53.6	18.1	1.162	7.90	3.0
2	0.46	36.3	18.3	1.161	6.50	3.0	30.9	18.3	1.161	6.00	3.0

# APPENDIX 2

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

(1 of 1)

Performance characteristics (Uncertainty Components)	Uncertainty	Value	Units
Standard Uncertainty on the coefficient of the Pitot Tube	$u(k)$	0.005	-
Standard Uncertainty associated with the mean local dynamic pressures	$u(\Delta p_i)$	1.145	Pa
- Resolution	$u(res)$	0.00087	
- Calibration	$u(cal)$	0.185	
- Drift	$u(drift)$	0.083	
- Lack of Fit	$u(fit)$	0.042	
- Overall corrections to dynamic measurements	$u(C_f)$	0.311	
Standard uncertainty associated with the molar mass of the gas	$u(M)$	0.00003	-
- $\phi_{O_2,w}$	-	20.713	
- $\phi_{CO_2,w}$	-	0.060	
- Oxygen, dry	$u(\phi_{O_2,d})$	0.637	
- Carbon Dioxide, dry	$u(\phi_{CO_2,d})$	0.002	
- Water Vapour	$u(\phi_{H_2O})$	0.021	
- Oxygen, wet	$u(\phi_{O_2,w})$	0.634	
- Carbon Dioxide, wet	$u(\phi_{CO_2,w})$	0.002	
Standard uncertainty associated with the stack temperature	$u(T_c)$	1.485	K
Standard uncertainty associated with the absolute pressure in the duct	$u(p_c)$	175.694	Pa
- Atmospheric Pressure	$u(p_{atm})$	175.692	
- Static Pressure	$u(p_{stat})$	0.810	
Standard uncertainty associated with the density in the duct	$u(\rho)$	0.00629	-
Standard uncertainty associated with the local velocities	$u(v_i)$	0.115	Pa
Standard uncertainty associated with the mean velocity	$u(\bar{v})$	0.078	m/s
Standard uncertainty associated with the mean velocity (95% Confidence)	$U_c(v)$	0.153	m/s
Standard uncertainty associated with the mean velocity (95% Confidence), relative	$U_{c,rel}(v)$	2.20	%
Standard uncertainty associated with the volume flow rate (95% Confidence)	$U_c(qV,w)$	454.1	m <sup>3</sup> /hr
- $u^2(a)/a^2$	-	0.00053	
- $u^2(qV,w)/q^2V,w$	-	0.00066	
- $u^2(qV,w)$	-	53672	
- $u(qV,w)$	-	231.7	
Standard uncertainty associated with the volume flow rate (95% Confidence), relative	$U_{c,rel}(qV,w)$	5.03	%

## APPENDIX 2

### TOTAL PARTICULATE MATTER: RESULTS SUMMARY

Henkel AG & Company, St Neots  
Extractor 1 Banbury

#### Sample Runs

Parameter	Units	Run 1	Mean
Concentration	mg/m <sup>3</sup>	2.39	2.39
Uncertainty	±mg/m <sup>3</sup>	0.48	0.48
Mass Emission	g/hr	19.60	19.60
Uncertainty	±g/hr	4.05	4.05

Parameter	Units	Run 1	Mean
Water Vapour	% v/v	0.42	0.42
Uncertainty	±% v/v	0.03	0.03

#### Blank Runs

Parameter	Units	Blank 1	Maximum
Concentration	mg/m <sup>3</sup>	0.21	0.21

NOTE: Where the Balance Uncertainty / Limit of Detection is higher than the Blank concentration, the Balance Uncertainty / Limit of Detection concentration has been reported.

#### 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	2/2
Number of Sampling Points Used	4/4
Sample Point I.D.'s	A1, A2, B1 & B2

FORMAT: Number Used / Number Required

FORMAT: Number Used / Number Required

#### Reference Conditions

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

# APPENDIX 2

## TOTAL PARTICULATE MATTER: ISOKINETIC SAMPLING CALCULATIONS

Test	Units	Run 1	
<b>Absolute pressure of stack gas, <math>P_s</math></b>			
Barometric pressure, $P_b$	mmHg	732.1	
Stack static pressure, $P_{static}$	mmH <sub>2</sub> O	4.2	
$P_s = (P_b + (P_{static} / 13.6))$	mmHg	732.4	
<b>Volume of water vapour collected, <math>V_{wstd}</math></b>			
Total mass collected in impingers (liquid trap)	g	-3.8	
Total mass collected in impingers (silica trap)	g	7.9	
Total mass of liquid collected, $V_{lc}$	g	4.1	
$V_{wstd} = (0.001246)(V_{lc})$	m <sup>3</sup>	0.0051	
<b>Volume of gas metered dry, <math>V_{mstd}</math></b>			
Volume of gas sample through gas meter, $V_m$	m <sup>3</sup>	1.3832	
Gas meter correction factor, $Y_d$	-	0.9720	
Average dry gas meter temperature, $T_m$	°C	17.8	
Average pressure drop across orifice, $\Delta H$	mmH <sub>2</sub> O	52.5	
$V_{mstd} = ((0.3592)(V_m)(P_b + (\Delta H/13.6))(Y_d)) / (T_m + 273)$	m <sup>3</sup>	1.2224	
<b>Moisture content, <math>B_{wo}</math> &amp; <math>R_{wv}</math></b>			
$B_{wo} = V_{wstd} / (V_{mstd} + V_{wstd})$	m <sup>3</sup>	0.0042	
$B_{wo}$ as a percentage	% v/v	0.42	
Reported Water Vapour, checked with Tables in EN 14790, $R_{wv}$	% v/v	0.42	
<b>Volume of gas metered wet, <math>V_{mstw}</math></b>			
$V_{mstw} = (V_{mstd})(100/(100 - R_{wv}))$	m <sup>3</sup>	1.2275	
<b>Volume of gas metered at Oxygen Reference Conditions, <math>V_{mstd@X\%O_2}</math> &amp; <math>V_{mstw@X\%O_2}</math></b>			
IED & Incinerates Hazardous Material? (Yes = no positive O <sub>2</sub> correction)	-	No	
% wet oxygen measured in gas stream, ACT%O <sub>2w</sub>	% v/v	N/A	
% dry oxygen measured in gas stream, ACT%O <sub>2d</sub>	% v/v	N/A	
% oxygen reference condition, REF%O <sub>2</sub>	% v/v	N/A	
O <sub>2</sub> Reference Factor wet ( $O_{2REFw} = (21 - REF\%O_2) / (21 - ACT\%O_{2w})$ )	-	N/A	
O <sub>2</sub> Reference Factor dry ( $O_{2REFd} = (21 - REF\%O_2) / (21 - ACT\%O_{2d})$ )	-	N/A	
$V_{mstw@X\%oxygen} = (V_{mstw}) / (O_{2REFw})$	m <sup>3</sup>	N/A	
$V_{mstd@X\%oxygen} = (V_{mstd}) / (O_{2REFd})$	m <sup>3</sup>	N/A	
<b>Molecular weight of dry gas stream, <math>M_d</math></b>			
CO <sub>2</sub> (Estimated)	% v/v	0.06	
O <sub>2</sub> (Estimated)	% v/v	20.80	
Total	% v/v	20.86	
N <sub>2</sub>	% v/v	79.14	
$M_d = 0.44(\%CO_2) + 0.32(\%O_2) + 0.28(\%N_2)$	g/gmol	28.84	
<b>Molecular weight of stack gas (wet), <math>M_s</math></b>			
$M_s = M_d(1 - (R_{wv}/100)) + 18(R_{wv}/100)$	g/gmol	28.80	
<b>Velocity of stack gas, <math>V_s</math></b>			
Pitot tube velocity constant, $K_p$	-	34.97	
Velocity pressure coefficient, $C_p$	-	0.85	
Average of velocity heads, $\Delta P_{avg}$	mmH <sub>2</sub> O	4.05	
Average square root of velocity heads, $\sqrt{\Delta P}$	√mmH <sub>2</sub> O	2.01	
Average stack gas temperature, $T_s$	°C	18.0	
$V_s = ((K_p)(C_p)(\sqrt{\Delta P})(\sqrt{T_s + 273})) / (\sqrt{M_s}(P_s))$	m/s	7.01	
<b>Total flow of stack gas: Actual (<math>Q_a</math>), Wet (<math>Q_{stw}</math>), Dry (<math>Q_{std}</math>), Wet@O<sub>2REF</sub> (<math>Q_{stwO_2}</math>), Dry@O<sub>2REF</sub> (<math>Q_{stdO_2}</math>)</b>			
Area of stack, $A_s$	m <sup>2</sup>	0.36	
$Q_a = (60)(A_s)(V_s)$	m <sup>3</sup> /min	151.4	
Conversion factor (K/mm.Hg), $C_f$	-	0.3592	
$Q_{stw} = ((Q_a)(P_s)(C_f)) / ((T_s) + 273)$	m <sup>3</sup> /min	136.8	
$Q_{std} = ((Q_a)(P_s)(C_f)(1 - (R_{wv}/100))) / ((T_s) + 273)$	m <sup>3</sup> /min	136.3	
$Q_{stwO_2} = ((Q_a)(P_s)(C_f)) / ((T_s) + 273) / (O_{2REFw})$	m <sup>3</sup> /min	N/A	
$Q_{stdO_2} = ((Q_a)(P_s)(C_f)(1 - (R_{wv}/100))) / ((T_s) + 273) / (O_{2REFd})$	m <sup>3</sup> /min	N/A	
<b>Percent isokinetic, %I</b>			
Nozzle diameter, $D_n$	mm	8.01	
Nozzle area, $A_n$	mm <sup>2</sup>	50.36	
Total sampling time, q	min	60	
$\%I = (4.6398E^6)(T_s+273)(V_{mstd}) / (P_s)(V_s)(A_n)(q)(1 - (R_{wv}/100))$	%	106.8	



## TOTAL PARTICULATE MATTER: SAMPLING DETAILS

### Sample Runs

Parameter	Units	Run 1
Sampling Times	-	12:56 - 13:26, 13:28 - 13:58
Sampling Dates	-	04/12/2020
Sampling Device	-	ISO
Volume Sampled (REF)	m <sup>3</sup>	1.2275
Filter I.D. Number	-	47-73615
Start Filter Mass	g	0.16458
End Filter Mass	g	0.16710
Total Mass on Filter	g	0.00252
Probe Rinse I.D. Number	-	PR-47-73615
Start Probe Rinse Mass	g	2.97801
End Probe Rinse Mass	g	2.97842
Total Mass in Probe Rinse	g	0.00041
Total Mass Collected	mg	2.93
Calculated Concentration	mg/m <sup>3</sup>	2.39
Balance Uncertainty / LOD	mg/m <sup>3</sup>	0.21

**Where:** ISO stands for Manual Isokinetic Sampling Train

### Blank Runs

Parameter	Units	Blank 1
Blank Dates	-	04/12/2020
Average Volume Sampled (REF)	m <sup>3</sup>	1.2275
Filter I.D. Number	-	47-73614
Start Filter Mass	g	0.16354
End Filter Mass	g	0.16365
Total Mass on Filter	g	0.00011
Probe Rinse I.D. Number	-	PR-47-73614
Start Probe Rinse Mass	g	2.86839
End Probe Rinse Mass	g	2.86850
Total Mass in Probe Rinse	g	0.00011
Total Mass Collected	mg	0.22
Calculated Concentration	mg/m <sup>3</sup>	0.18
Balance Uncertainty / LOD	mg/m <sup>3</sup>	0.21

## APPENDIX 2

### TOTAL PARTICULATE MATTER: QUALITY ASSURANCE

(PAGE 1 OF 2)

#### Sample Runs

Leak Test Results	Units	Run 1	
Mean Sampling Rate	l/min	22.4	
Pre-Sampling Leak Rate	l/min	0.05	
Post-Sampling Leak Rate	l/min		
Allowable Leak Rate	l/min	0.40	
Leak Test Acceptable	-	Yes	
Water Droplets	Units	Run 1	
Are Water Droplets Present	-	No	
MU (Concurrent Water Vapour)	Units	Run 1	
Measurement Uncertainty (MU)	%	7.8	
Allowable MU	%	20.0	
MU Acceptable	%	Yes	
Silica Gel (Concurrent Water Vapour)	Units	Run 1	
Less than 50% Faded	%	Yes	
Isokinetic Criterion Compliance	Units	Run 1	
Isokinetic Variation	%	106.8	
Allowable Isokinetic Range	%	95 - 115	
Isokineticity Acceptable	-	Yes	
Weighing Uncertainty Criteria	Units	Run 1	
Overall Weighing Uncertainty	± mg	0.49	
Overall Weighing Uncertainty	± mg/m <sup>3</sup>	0.40	
ELV [Daily ELV for IED]	mg/m <sup>3</sup>	50.00	
Allowable Weighing Uncertainty	mg/m <sup>3</sup>	2.50	
Weighing Uncertainty Acceptable	-	Yes	
Filter Temperatures	Units	Run 1	
Pre-Conditioning Temperature	°C	180	
Post-Conditioning Temperature	°C	160	
Maximum Filter Temperature	°C	18	
Test Conditions	Units	Run 1	
Ambient Temperature Recorded?	-	Yes	

# TOTAL PARTICULATE MATTER: QUALITY ASSURANCE

(PAGE 2 OF 2)

## Blank Runs

Leak Test Results	Units	Blank 1	
Expected Sampling Rate	l/min	20.0	
Pre-Sampling Leak Rate	l/min	0.05	
Post-Sampling Leak Rate	l/min		
Allowable Leak Rate	l/min	0.40	
Leak Test Acceptable	-	Yes	

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

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

## Method Deviations

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

APPENDIX 2

**TOTAL PARTICULATE MATTER: MEASUREMENT UNCERTAINTY CALCULATIONS**

Measured Quantities	Value		Standard uncertainty		
	Symbol	Run 1	Symbol	Units	Run 1
Sampled Volume (Actual)	V <sub>m</sub>	1.3832	uV <sub>m</sub>	m <sup>3</sup>	0.0277
Sampled Gas Temperature	T <sub>m</sub>	290.8	uT <sub>m</sub>	K	2.00
Sampled Gas Pressure	p <sub>m</sub>	97.7	up <sub>m</sub>	kPa	0.50
Sampled Gas Humidity	H <sub>m</sub>	0.00	uH <sub>m</sub>	% v/v	1.00
Leak	L	0.22	uL	%	-
Mass of Particulate	m	2.93	um	mg	0.26
Uncollected Mass	UCM	0.22	uUCM	mg	-

Measured Quantities	Uncertainty as a Percentage		Requirement of Standard
	Units	Run 1	
Sampled Volume (Actual)	%	2.00	≤2%
Sampled Gas Temperature	%	0.69	≤1%
Sampled Gas Pressure	%	0.51	≤1%
Sampled Gas Humidity	%	1.00	≤1%
Leak	%	0.22	≤2%
Mass of Particulate	%	0.42	<5% of ELV
Uncollected Mass	%	-	-

Measured Quantities	Uncertainty in Measurement Units			Sensitivity Coefficient	
	Symbol	Units	Run 1	Run 1	
Sampled Volume (STP)	V <sub>m</sub>	m <sup>3</sup>	1.2224	1.95	
Leak	L	mg/m <sup>3</sup>	0.003	1.00	
Mass of Particulate	L <sub>r</sub>	mg	2.930	0.81	
Uncollected Mass	UCM	mg	0.13	0.81	

Measured Quantities	Uncertainty in Result	
	Units	Run 1
Sampled Volume (STP)	mg/m <sup>3</sup>	0.063
Leak	mg/m <sup>3</sup>	0.0031
Mass of Particulate	mg/m <sup>3</sup>	0.2118
Uncollected Mass	mg/m <sup>3</sup>	0.1035

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

Parameter	Units	Run 1
Combined uncertainty	mg/m <sup>3</sup>	0.24
Expanded uncertainty (95% confidence), without Oxygen Correction	mg/m <sup>3</sup>	0.48
Expanded uncertainty (95% confidence), with Oxygen Correction	mg/m <sup>3</sup>	N/A
Expanded uncertainty (95% confidence), estimated with Method Deviations	mg/m <sup>3</sup>	0.48
Reported Uncertainty	mg/m <sup>3</sup>	0.48
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

Version Number	Record of changes made within this version of the document
V1	The original document issued to the client