

## STACK EMISSIONS MONITORING REPORT



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### Operator & Address:

Celtic Recycling  
29-31 Clearwater Road  
Queensway Meadows  
Newport  
NP19 4ST

### Permit Reference:

EPR Permit: EPR/YP3135TE

### Release Point:

A1 Shredder

### Sampling Date(s):

26th May 2020

|                         |                                                                                     |
|-------------------------|-------------------------------------------------------------------------------------|
| SOCOTEC Job Number:     | LSO 200529                                                                          |
| Report Date:            | 26th June 2020                                                                      |
| Version:                | 1                                                                                   |
| Report By:              | Jonathan Ward                                                                       |
| MCERTS Number:          | MM 02 080                                                                           |
| MCERTS Level:           | MCERTS Level 2 - Team Leader                                                        |
| Technical Endorsements: | 1, 2, 3 & 4                                                                         |
| Report Approved By:     | David May                                                                           |
| MCERTS Number:          | MM 07 862                                                                           |
| Business Title:         | MCERTS Level 2 - Operations Manager (LSO)                                           |
| Technical Endorsements: | 1, 2, 3 & 4                                                                         |
| Signature:              |  |



1015



## CONTENTS

### EXECUTIVE SUMMARY

#### Stack Emissions Monitoring Objectives

- Plant
- Operator
- Stack Emissions Monitoring Test House

#### Emissions Summary

#### Monitoring Times

#### Process Details

#### Monitoring Methods

#### Analytical Methods

- Sampling Methods with Subsequent Analysis
- On-Site Testing

#### Sampling Location

- Sampling Plane Validation Criteria
- Duct Characteristics
- Sampling Lines & Sample Points
- Sampling Platform
- Sampling Location / Platform Improvement Recommendations

#### Sampling and Analytical Method Deviations

### APPENDICES

#### APPENDIX 1 - Monitoring Schedule, Calibration Checklist & Monitoring Team

#### APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

#### APPENDIX 3 - Measurement Uncertainty Budget Calculations

## EXECUTIVE SUMMARY

### MONITORING OBJECTIVES

Celtic Recycling operates a shredding papered covered copper process at Newport which is subject to EPR Permit EPR/YP3135TE, under the Environmental Permitting Regulations 2010.

SOCOTEC LTD were commissioned by Celtic Recycling to carry out stack emissions monitoring to determine the release of prescribed pollutants from the following Plant under normal operating conditions.

The results of these tests shall be used to demonstrate compliance with a set of emission limit values for prescribed pollutants as specified in the Plant's EPR Permit, EPR/YP3135TE.

#### **Plant**

A1 Shredder

#### **Operator**

Celtic Recycling  
29-31 Clearwater Road  
Queensway Meadows  
Newport  
NP19 4ST

EPR Permit: EPR/YP3135TE

#### **Stack Emissions Monitoring Test House**

SOCOTEC - Cirencester Laboratory  
Units C & D  
Bankside Trade Park  
Cirencester  
GL7 1YT  
UKAS and MCERTS Accreditation Number: 1015

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## EXECUTIVE SUMMARY

| EMISSIONS SUMMARY                                |                    |        |                            |                            |                          |
|--------------------------------------------------|--------------------|--------|----------------------------|----------------------------|--------------------------|
| Parameter                                        | Units              | Result | Calculated Uncertainty +/- | Emission Limit Value (ELV) | MCERTS accredited result |
| Total Particulate Matter                         | mg/m <sup>3</sup>  | 0.86   | 0.72                       | 10                         | ✓                        |
| Particulate Emission Rate                        | g/hr               | 4.43   | 3.69                       | -                          |                          |
| Oil Mist                                         | mg/m <sup>3</sup>  | 0.22   | 0.43                       | -                          | ✗                        |
| Oil Mist Emissions Rate                          | g/hr               | 1.54   | 3.08                       | -                          |                          |
| Moisture                                         | %                  | 1.31   | 0.04                       | -                          | ✓                        |
| Stack Gas Temperature                            | °C                 | 27     | -                          | -                          | ✓                        |
| Stack Gas Velocity                               | m/s                | 22.1   | 0.54                       | -                          |                          |
| Gas Volumetric Flow Rate (Actual)                | m <sup>3</sup> /hr | 12627  | 649                        | -                          |                          |
| Gas Volumetric Flow Rate (STP, Wet)              | m <sup>3</sup> /hr | 11635  | 598                        | -                          |                          |
| Gas Volumetric Flow Rate (STP, Dry)              | m <sup>3</sup> /hr | 11483  | 590                        | -                          |                          |
| Gas Volumetric Flow Rate at Reference Conditions | m <sup>3</sup> /hr | 11635  | 598                        | -                          |                          |

ND = None Detected,

Results at or below the limit of detection are highlighted by bold italic text.

The above volumetric flow rate is calculated using data from the preliminary survey. Mass emissions for non isokinetic tests are calculated using these values. For all isokinetic testing the mass emission is calculated using test specific flow data and not the above values.

Reference conditions are 273K, 101.3kPa without correction for water vapour

## EXECUTIVE SUMMARY

| MONITORING TIMES               |                  |                |                   |
|--------------------------------|------------------|----------------|-------------------|
| Parameter                      | Sampling Date(s) | Sampling Times | Sampling Duration |
| Total Particulate Matter Run 1 | 26 May 2020      | 13:45 - 14:45  | 60 minutes        |
| Preliminary Stack Traverse     | 26 May 2020      | 09:25          | -                 |

## EXECUTIVE SUMMARY

### PROCESS DETAILS

| Parameter                                     | Process Details                  |
|-----------------------------------------------|----------------------------------|
| Description of process                        | Shredding papered covered copper |
| Continuous or batch                           | Batch                            |
| Product Details                               | Shredded Copper                  |
| Part of batch to be monitored (if applicable) | 60 Minute period                 |
| Normal load, throughput or continuous rating  | Normal                           |
| Fuel used during monitoring                   | None                             |
| Abatement                                     | Bag Filter                       |
| Plume Appearance                              | None                             |

## EXECUTIVE SUMMARY

### Monitoring Methods

The selection of standard reference / alternative methods employed by SOCOTEC is determined, wherever possible by the hierarchy of method selection outlined in Environment Agency Technical Guidance Note (Monitoring) M2.

| MONITORING METHODS          |                                                             |                                   |                    |                                |                                |                                  |                               |
|-----------------------------|-------------------------------------------------------------|-----------------------------------|--------------------|--------------------------------|--------------------------------|----------------------------------|-------------------------------|
| Species                     | Method<br>Standard Reference Method /<br>Alternative Method | SOCOTEC<br>Technical<br>Procedure | UKAS Lab<br>Number | MCERTS<br>Accredited<br>Method | Limit of<br>Detection<br>(LOD) | Calculated<br>MU<br>+/- % Result | Calculated<br>MU<br>+/- % ELV |
| Total Particulate<br>Matter | SRM - BS EN 13284-1                                         | AE 104                            | 1015               | Yes                            | 0.36 mg/m <sup>3</sup>         | 83.4%                            | 7.2%                          |
| Moisture                    | SRM - BS EN 14790                                           | AE 105                            | 1015               | Yes                            | 0.01%                          | 3.13%                            | N/A - No ELV                  |
| Velocity                    | SRM - BS EN ISO 16911-1                                     | AE 154                            | 1015               | Yes                            | 5 Pa                           | 2.4%                             | N/A - No ELV                  |
| Volumetric Flow<br>Rate     | SRM - BS EN ISO 16911-1                                     | AE 154                            | 1015               | Yes                            | -                              | 5.1%                             | N/A - No ELV                  |

BS EN 14790 has been validated over a range of 4 - 40%. It is however the preferred method of the Environment Agency for concentrations below 4%

## EXECUTIVE SUMMARY

### Analytical Methods

The following tables list the analytical methods employed together with the custody details. Unless otherwise stated the samples are archived at the analysis lab location.

| SAMPLING METHODS WITH SUBSEQUENT ANALYSIS |                      |                      |                 |                              |                         |                        |                |
|-------------------------------------------|----------------------|----------------------|-----------------|------------------------------|-------------------------|------------------------|----------------|
| Species                                   | Analytical Technique | Analytical Procedure | UKAS Lab Number | UKAS Accredited Lab Analysis | Analysis Lab            | Analysis Report number | Archive Period |
| Total Particulate Matter                  | Gravimetric          | AE 106               | 1015            | Yes                          | SOCOTEC - (Cirencester) | N/A                    | 8 Weeks        |

| ON-SITE TESTING |                      |                      |                 |                            |                         |                       |                |
|-----------------|----------------------|----------------------|-----------------|----------------------------|-------------------------|-----------------------|----------------|
| Species         | Analytical Technique | Analytical Procedure | UKAS Lab Number | MCERTS Accredited Analysis | Laboratory              | Data Archive Location | Archive Period |
| Moisture        | Gravimetric          | AE 105               | 1015            | Yes                        | SOCOTEC - (Cirencester) | -                     | -              |



## EXECUTIVE SUMMARY

| SAMPLING LOCATION                              |        |            |                |           |             |
|------------------------------------------------|--------|------------|----------------|-----------|-------------|
| Sampling Plane Validation Criteria             | Value  | Units      | Requirement    | Compliant | Method      |
| Lowest Differential Pressure                   | 392    | Pa         | $\geq 5$ Pa    | Yes       | BS EN 15259 |
| Lowest Gas Velocity                            | 21.7   | m/s        | -              | -         | -           |
| Highest Gas Velocity                           | 22.3   | m/s        | -              | -         | -           |
| Ratio of Gas Velocities                        | 1.0    | : 1        | $< 3 : 1$      | Yes       | BS EN 15259 |
| Mean Velocity                                  | 22.1   | m/s        | -              | -         | -           |
| Maximum angle of flow with regard to duct axis | $< 15$ | $^{\circ}$ | $< 15^{\circ}$ | Yes       | BS EN 15259 |
| No local negative flow                         | Yes    | -          | -              | Yes       | BS EN 15259 |

| DUCT CHARACTERISTICS |          |                |
|----------------------|----------|----------------|
|                      | Value    | Units          |
| Shape                | Circular | -              |
| Depth                | 0.45     | m              |
| Width                | -        | m              |
| Area                 | 0.16     | m <sup>2</sup> |
| Port Depth           | 90       | mm             |

| SAMPLING LINES & POINTS |               |                 |
|-------------------------|---------------|-----------------|
|                         | Isokinetic    | Non-Iso & Gases |
| Sample port size        | 3 inch flange | -               |
| Number of lines used    | 1             | -               |
| Number of points / line | 1             | -               |
| Duct orientation        | Vertical      | -               |
| Filtration for TPM      | Quartz        | -               |

| SAMPLING PLATFORM                                                  |           |
|--------------------------------------------------------------------|-----------|
| General Platform Information                                       |           |
| Permanent / Temporary Platform / Ground level / Floor Level / Roof | Permanent |
| Inside / Outside                                                   | Outside   |

| M1 Platform requirements                                                           |     |
|------------------------------------------------------------------------------------|-----|
| Is there a sufficient working area so work can be performed in a compliant manner  | Yes |
| Platform has 2 levels of handrails (approximately 0.5 m & 1.0 m high)              | Yes |
| Platform has vertical base boards (approximately 0.25 m high)                      | Yes |
| Platform has removable chains / self closing gates at the top of ladders           | Yes |
| Handrail / obstructions do not hamper insertion of sampling equipment              | Yes |
| Depth of Platform = $\geq$ Stack depth / diameter + wall and port thickness + 1.5m | Yes |

### Sampling Platform Improvement Recommendations (if applicable)

0

## EXECUTIVE SUMMARY

### Sampling & Analytical Method Deviations

#### **Sampling Lines**

Only one line available for sampling, however the number of sampling points were doubled in line with the standard reference method.

APPENDICES

**CONTENTS**

APPENDIX 1 - Monitoring Schedule, Calibration Checklist & Monitoring Team

APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

APPENDIX 3 - Measurement Uncertainty Budget Calculations

APPENDIX 1 - Monitoring Schedule, Calibration Checklist & Monitoring Team

| MONITORING SCHEDULE      |                                                             |                                   |                    |                                |                      |
|--------------------------|-------------------------------------------------------------|-----------------------------------|--------------------|--------------------------------|----------------------|
| Species                  | Method<br>Standard Reference Method /<br>Alternative Method | SOCOTEC<br>Technical<br>Procedure | UKAS Lab<br>Number | MCERTS<br>Accredited<br>Method | Number of<br>Samples |
| Total Particulate Matter | SRM - BS EN 13284-1                                         | AE 104                            | 1015               | Yes                            | 1                    |
| Moisture                 | SRM - BS EN 14790                                           | AE 105                            | 1015               | Yes                            | 1                    |
| Velocity                 | SRM - BS EN ISO 16911-1                                     | AE 154                            | 1015               | Yes                            | 1                    |

APPENDIX 1 - Monitoring Schedule, Calibration Checklist & Monitoring Team

| CALIBRATEABLE EQUIPMENT CHECKLIST |                |                           |                |                             |                |
|-----------------------------------|----------------|---------------------------|----------------|-----------------------------|----------------|
| Extractive Sampling               |                | Instrumental Analyser/s   |                | Miscellaneous               |                |
| Equipment                         | Equipment I.D. | Equipment                 | Equipment I.D. | Equipment                   | Equipment I.D. |
| Control Box DGM                   | P1251          | Horiba PG-250 Analyser    | P1892          | Laboratory Balance          | P66            |
| Box Thermocouples                 | P1251          | FT-IR Gasmet              | -              | Tape Measure                | P1259          |
| Meter In Thermocouple             | P1251          | FT-IR Oven Box            | -              | Stopwatch                   | P734           |
| Meter Out Thermocouple            | P1251          | Bernath 3006 FID          | -              | Protractor                  | -              |
| Control Box Timer                 | P734           | Signal 3030 FID           | -              | Barometer                   | P2236          |
| Oven Box                          | -              | Servomex                  | -              | Digital Micromanometer      | P1940          |
| Probe 3ft                         | P2114          | JCT Heated Head Filter    | -              | Digital Temperature Meter   | P1226          |
| Probe Thermocouple                | P1531          | Thermo FID                | -              | Stack Thermocouple          | P2290          |
| Probe 5ft                         | -              | Stackmaster               | -              | Mass Flow Controller        | -              |
| Probe Thermocouple                | -              | Heated Pump               | -              | Wet Gas Meter               | -              |
| S-Pitot                           | P2114          | Chiller (JCT/MAK 10)      | P2052          | 1m Heated Line (1)          | -              |
| L-Pitot                           | -              | Chiller (Horiba PCT100)   | -              | 1m Heated Line (2)          | -              |
| Site Balance                      | P2767          | Winkler HL Controller (1) | P1975          | 1m Heated Line (3)          | -              |
| Last Impinger Arm                 | -              | Kletti Controller (2)     | -              | 10m Winkler Heated Line (1) | P2754          |
| Dioxins Cond. Thermocouple        | -              | O Brian Controller (3)    | -              | 10m Heated Line (1)         | -              |
| Callipers                         | -              | Site temperature Logger   | P2203          | 10m Heated Line (2)         | -              |
| Small DGM                         | -              |                           | -              | 15m Heated Line (1)         | -              |
| Heater Controller                 | -              |                           | -              | 20m Heated Line (1)         | -              |
| Inclinometer (Swirl Device)       | P2095          |                           | -              | 20m Heated Line (2)         | -              |

NOTE: If the equipment I.D is represented by a dash (-), then this piece of equipment has not been used for this test.

| CALIBRATION GASES            |                     |          |     |   |                            |
|------------------------------|---------------------|----------|-----|---|----------------------------|
| Gas (traceable to ISO 17025) | Cylinder I.D Number | Supplier | ppm | % | Analytical Tolerance +/- % |
| -                            | -                   | -        | -   | - | -                          |

**STACK EMISSIONS MONITORING TEAM**

| MONITORING TEAM |               |                |        |                                         |        |        |        |        |
|-----------------|---------------|----------------|--------|-----------------------------------------|--------|--------|--------|--------|
| Personnel       | MCERTS Number | MCERTS         |        | TE / H&S Qualifications and Expiry Date |        |        |        |        |
|                 |               | Level          | Expiry | TE1                                     | TE2    | TE3    | TE4    | H&S    |
| Jonathan Ward   | MM 02 080     | MCERTS Level 2 | Mar-25 | Dec-24                                  | Sep-25 | Mar-25 | Mar-21 | Jun-20 |
| Alistair Holmes | MM 13 1218    | MCERTS Level 1 | Mar-23 | -                                       | -      | -      | -      | Mar-23 |

APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

| TOTAL PARTICULATE MATTER SUMMARY |                              |                                    |                                  |                          |                       |
|----------------------------------|------------------------------|------------------------------------|----------------------------------|--------------------------|-----------------------|
| Parameter                        | Sampling Times               | Concentration<br>mg/m <sup>3</sup> | Uncertainty<br>mg/m <sup>3</sup> | ELV<br>mg/m <sup>3</sup> | Emission<br>Rate g/hr |
| Run 1                            | 13:45 - 14:45<br>26 May 2020 | 0.9                                | 0.72                             | 10                       | 4                     |
| Blank                            | -                            | 0.50                               | -                                | -                        | -                     |

Reference conditions are 273K, 101.3kPa without correction for water vapour

| Acetone Blank Value<br>mg/l | Acceptable Value<br>mg/l |
|-----------------------------|--------------------------|
| 2.0                         | 10                       |

**FILTER INFORMATION**

| SAMPLES |                                |                        |                      |                          |                             |                           |                         |                               |
|---------|--------------------------------|------------------------|----------------------|--------------------------|-----------------------------|---------------------------|-------------------------|-------------------------------|
| Test    | Filter & Probe<br>Rinse Number | Filter Start<br>Weight | Filter End<br>Weight | Mass Gained<br>on Filter | Probe Rinse<br>Start Weight | Probe Rinse<br>End Weight | Mass Gained on<br>Probe | Combined Total<br>Mass Gained |
|         |                                | g                      | g                    | g                        | g                           | g                         | g                       | g                             |
| Run 1   | 310393                         | 0.14890                | 0.14920              | 0.00030                  | 69.10120                    | 69.10210                  | 0.00090                 | 0.00120                       |

If total mass gained is less than the LOD then the LOD is reported

| BLANKS |                          |                        |                      |                       |                       |                     |                      |                               |
|--------|--------------------------|------------------------|----------------------|-----------------------|-----------------------|---------------------|----------------------|-------------------------------|
| Test   | Filter & Probe<br>Number | Filter Start<br>Weight | Filter End<br>Weight | Mass Gained<br>Filter | Probe Start<br>Weight | Probe End<br>Weight | Mass Gained<br>Probe | Combined Total<br>Mass Gained |
|        |                          | g                      | g                    | g                     | g                     | g                   | g                    | g                             |
| Run 1  | 313092                   | 0.14590                | 0.14620              | 0.00030               | 76.50960              | 76.51000            | 0.00040              | 0.00070                       |

If total mass gained is less than the LOD then the LOD is reported

APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

| ISOKINETIC SAMPLING EQUATIONS - RUN 1                                             |                   |           |                                                                                        | TPM                           |
|-----------------------------------------------------------------------------------|-------------------|-----------|----------------------------------------------------------------------------------------|-------------------------------|
| <b>Absolute pressure of stack gas, P<sub>s</sub></b>                              |                   |           | <b>Molecular weight of dry gas, M<sub>d</sub></b>                                      |                               |
| Barometric pressure, P <sub>b</sub>                                               | Kpa               | 102.4     | CO <sub>2</sub>                                                                        | % 0.03                        |
| Stack static pressure, P <sub>static</sub>                                        | pa                | 170       | O <sub>2</sub>                                                                         | % 20.89                       |
| P <sub>s</sub> = P <sub>b</sub> + P <sub>static</sub>                             | Kpa               | 102.6     | Total                                                                                  | % 20.92                       |
|                                                                                   |                   |           | N <sub>2</sub> (100 -Total)                                                            | % 79.08                       |
| <b>Vol. of water vapour collected, V<sub>wstd</sub></b>                           |                   |           | M <sub>d</sub> = 0.44(%CO <sub>2</sub> )+0.32(%O <sub>2</sub> )+0.28(%N <sub>2</sub> ) | 28.84                         |
| Moisture trap weight increase, V <sub>lc</sub>                                    | g                 | 14.6      | <b>Molecular weight of wet gas, M<sub>s</sub></b>                                      |                               |
| V <sub>wstd</sub> = (0.001246)(V <sub>lc</sub> )                                  | m <sup>3</sup>    | 0.0181916 | M <sub>s</sub> = M <sub>d</sub> (1 - B <sub>wo</sub> ) + 18(B <sub>wo</sub> )          | g/gmol 28.70                  |
| <b>Volume of gas metered dry, V<sub>mstd</sub></b>                                |                   |           | <b>Actual flow of stack gas, Q<sub>a</sub></b>                                         |                               |
| Volume of gas sample through gas meter, V <sub>m</sub>                            |                   | 1.471     | Area of stack, A <sub>s</sub>                                                          | m <sup>2</sup> 0.16           |
| Gas meter correction factor, Y <sub>d</sub>                                       |                   | 0.994     | Q <sub>a</sub> = (60)(A <sub>s</sub> )(V <sub>s</sub> )                                | m <sup>3</sup> /min 94.2      |
| Mean dry gas meter temperature, T <sub>m</sub>                                    |                   | 295       | <b>Total flow of stack gas, Q</b>                                                      |                               |
| Mean pressure drop across orifice, DH mmH <sub>2</sub> O                          |                   | 47.779    | Conversion factor (K/mm.Hg)                                                            | 0.3592                        |
| V <sub>mstd</sub> = $\frac{(0.3592)(V_m)(P_b + (DH/13.6))(Y_d)}{T_m}$             | m <sup>3</sup>    | 1.373     | Q <sub>std</sub> = $\frac{(Q_a)P_s(0.3592)(1-B_{wo})}{(T_s)}$                          | Dry 84.5                      |
| <b>Volume of gas metered wet, V<sub>mstw</sub></b>                                |                   |           | Q <sub>stdO2</sub> = $\frac{(Q_a)P_s(0.3592)(1-B_{wo})(O_2REF)}{(T_s)}$                | @O <sub>2</sub> ref No O2 Ref |
| V <sub>mstw</sub> = V <sub>mstd</sub> + V <sub>wstd</sub>                         | m <sup>3</sup>    | 1.3910    | Q <sub>stw</sub> = $\frac{(Q_a)P_s(0.3592)}{(T_s)}$                                    | Wet 85.58                     |
| <b>Vol. of gas metered at O<sub>2</sub> Ref. Cond., V<sub>mstd@X%O2</sub></b>     |                   |           | <b>Percent isokinetic, %I</b>                                                          |                               |
| Is the process burning hazardous waste? (If yes, no favourable oxygen correction) | No                |           | Nozzle diameter, D <sub>n</sub>                                                        | mm 7.50                       |
| % oxygen measured in gas stream, act%O <sub>2</sub>                               | 20.9              |           | Nozzle area, A <sub>n</sub>                                                            | mm <sup>2</sup> 44.18         |
| % oxygen reference condition                                                      | 21                |           | Total sampling time, q                                                                 | min 60                        |
| O <sub>2</sub> Reference O <sub>2</sub> Ref = 21.0 - act%O <sub>2</sub>           | No O2 Ref         |           | %I = $\frac{(4.6398E6)(T_s)(V_{mstd})}{(P_s)(V_s)(A_n)(q)(1-B_{wo})}$                  | % 97.5                        |
| Factor 21.0 - ref%O <sub>2</sub>                                                  | No O2 Ref         |           | Acceptable isokinetic range 95% to 115%                                                | Yes                           |
| V <sub>mstd@X%oxygen</sub> = (V <sub>mstd</sub> ) (O <sub>2</sub> Ref)            | m <sup>3</sup>    | No O2 Ref | <b>Particulate Concentration, C</b>                                                    |                               |
| <b>Moisture content, B<sub>wo</sub></b>                                           |                   |           | Mass collected on filter, M <sub>f</sub>                                               | g 0.00030                     |
| B <sub>wo</sub> = $\frac{V_{wstd}}{V_{mstd} + V_{wstd}}$                          | %                 | 0.0131    | Mass collected in probe, M <sub>p</sub>                                                | g 0.00090                     |
|                                                                                   |                   | 1.31      | Total mass collected, M <sub>n</sub>                                                   | g 0.00120                     |
| <b>Moisture by FTIR</b>                                                           | %                 | -         | C <sub>wet</sub> = $\frac{M_n}{V_{mstw}}$                                              | mg/m <sup>3</sup> 0.863       |
| <b>Velocity of stack gas, V<sub>s</sub></b>                                       |                   |           | C <sub>dry</sub> = $\frac{M_n}{V_{mstd}}$                                              | mg/m <sup>3</sup> 0.874       |
| Velocity pressure coefficient, C <sub>p</sub>                                     |                   | 0.84      | C <sub>dry@X%O2</sub> = $\frac{M_n}{V_{mstd@X\%oxygen}}$                               | mg/m <sup>3</sup> No O2 Ref   |
| Mean of velocity heads, DP <sub>avg</sub>                                         | Pa                | 80.36     | <b>Particulate Emission Rates, E</b>                                                   |                               |
| Mean stack gas temperature, T <sub>s</sub>                                        | K                 | 304       | E = $\frac{[(C_{wet})(Q_{stw})(60)]}{1000}$                                            | 4.43                          |
| Gas density (wet, ambient), p                                                     | kg/m <sup>3</sup> | 1.164     |                                                                                        |                               |
| p = (M <sub>s</sub> *P <sub>s</sub> )/(8.314*T <sub>s</sub> )                     |                   |           |                                                                                        |                               |
| Stack Velocity, V <sub>s</sub> $V_s = C_p \sqrt{\frac{\Delta DP_{avg}}{p}}$       | m/s               | 9.87      |                                                                                        |                               |

| TAR FUME DATA - RUN 1 |                   |         |
|-----------------------|-------------------|---------|
| Parameters            | Units             | Results |
| Mass Collected        | mg                | 0.300   |
| Concentration wet     | mg/m <sup>3</sup> | 0.216   |
| Concentration Dry     | mg/m <sup>3</sup> | 0.219   |
| Mass Emission         | g/hr              | 1.540   |

APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

**TOTAL PARTICULATE MATTER QUALITY ASSURANCE CHECKLIST**

| LEAK RATE |                                 |                                     |                                      |                         |                                   |                        |
|-----------|---------------------------------|-------------------------------------|--------------------------------------|-------------------------|-----------------------------------|------------------------|
| Run       | Mean Sampling Rate<br>litre/min | Pre-sampling Leak Rate<br>litre/min | Post-sampling Leak Rate<br>litre/min | Maximum Vacuum<br>mm Hg | Acceptable Leak Rate<br>litre/min | Leak Tests Acceptable? |
| Run 1     | 24.37                           | 0.15                                | 0.16                                 | -381                    | 0.49                              | Yes                    |

| ISOKINETICITY |                           |                          |
|---------------|---------------------------|--------------------------|
| Run           | Isokinetic Variation<br>% | Acceptable Isokineticity |
| Run 1         | 97.52                     | Yes                      |

Acceptable isokinetic range 95% to 115%

| WEIGHING BALANCE UNCERTAINTY |                             |                             |              |
|------------------------------|-----------------------------|-----------------------------|--------------|
| Run                          | Result<br>mg/m <sup>3</sup> | 5% ELV<br>mg/m <sup>3</sup> | LOD < 5% ELV |
| Run 1                        | 0.36                        | 0.5                         | Yes          |

The above is based on both the Filter and rinse uncertainty

| BLANK VALUE |                                          |                                                 |                                             |                                               |
|-------------|------------------------------------------|-------------------------------------------------|---------------------------------------------|-----------------------------------------------|
| Run         | Overall Blank Value<br>mg/m <sup>3</sup> | Daily Emission Limit Value<br>mg/m <sup>3</sup> | Acceptable Blank Value<br>mg/m <sup>3</sup> | Overall Blank Acceptable<br>mg/m <sup>3</sup> |
| Blank 1     | 0.50                                     | 10                                              | 1.0                                         | Yes                                           |

| FILTERS |                 |                   |                                  |                                               |                                                |
|---------|-----------------|-------------------|----------------------------------|-----------------------------------------------|------------------------------------------------|
| Run     | Filter Material | Filter Size<br>mm | Max Filtration Temperature<br>°C | Pre-use Filter Conditioning Temperature<br>°C | Post-use Filter Conditioning Temperature<br>°C |
| Run 1   | Quartz Fibre    | 47                | 34                               | 180                                           | 160                                            |



APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

**MOISTURE CALCULATIONS**

| Moisture Determination - Isokinetic |                              |              |            |            |               |      |             |
|-------------------------------------|------------------------------|--------------|------------|------------|---------------|------|-------------|
| Test Number                         | Sampling Time and Date       | Start Weight | End Weight | Total gain | Concentration | LOD  | Uncertainty |
|                                     |                              | kg           | kg         | kg         | %             | %    | %           |
| Run 1                               | 13:45 - 14:45<br>26 May 2020 | 3.1122       | 3.1268     | 0.0146     | 1.3           | 0.01 | 3.1         |

| Moisture Quality Assurance |                   |                      |               |                 |               |                      |                        |
|----------------------------|-------------------|----------------------|---------------|-----------------|---------------|----------------------|------------------------|
| Test Number                | Sampling Duration | Total Volume Sampled | Sampling Rate | Start Leak Rate | End Leak Rate | Acceptable Leak Rate | Leak Tests Acceptable? |
|                            | mins              | l                    | l/min         | l/min           | l/min         | l/min                |                        |
| Run 1                      | 60                | 1391                 | 24.4          | 0.15            | 0.16          | 0.49                 | Yes                    |

**PRELIMINARY STACK SURVEY**

| Stack Characteristics         |       |                |
|-------------------------------|-------|----------------|
| Stack Diameter / Depth, D     | 0.45  | m              |
| Stack Width, W                | -     | m              |
| Stack Area, A                 | 0.16  | m <sup>2</sup> |
| Average stack gas temperature | 27    | °C             |
| Stack static pressure         | 0.17  | kPa            |
| Barometric Pressure           | 102.4 | kPa            |

| Stack Gas Composition & Molecular Weights |                 |                                   |                   |                          |                                     |                   |                          |                                     |
|-------------------------------------------|-----------------|-----------------------------------|-------------------|--------------------------|-------------------------------------|-------------------|--------------------------|-------------------------------------|
| Component                                 | Molar Mass<br>M | Density<br>kg/m <sup>3</sup><br>p | Conc Dry<br>% Vol | Dry Volume Fraction<br>r | Dry Conc<br>kg/m <sup>3</sup><br>pi | Conc Wet<br>% Vol | Wet Volume Fraction<br>r | Wet Conc<br>kg/m <sup>3</sup><br>pi |
| CO <sub>2</sub>                           | 44              | 1.963059                          | 0.031429          | 0.000314                 | 0.000617                            | 0.031018          | 0.000310                 | 0.000609                            |
| O <sub>2</sub>                            | 32              | 1.427679                          | 20.890000         | 0.208900                 | 0.298242                            | 20.616803         | 0.206168                 | 0.294342                            |
| N <sub>2</sub>                            | 28              | 1.249219                          | 79.078571         | 0.790786                 | 0.987865                            | 78.044390         | 0.780444                 | 0.974946                            |
| H <sub>2</sub> O                          | 18              | 0.803070                          | -                 | -                        | -                                   | 1.307790          | 0.013078                 | 0.010502                            |

Where:  $p = M / 22.41$   $pi = r \times p$

| Calculation of Stack Gas Densities          |        |                   |
|---------------------------------------------|--------|-------------------|
| Determinand                                 | Result | Units             |
| Dry Density (STP), $P_{STD}$                | 1.2867 | kg/m <sup>3</sup> |
| Wet Density (STP), $P_{STW}$                | 1.2804 | kg/m <sup>3</sup> |
| Dry Density (Actual), $P_{Actual}$          | 1.1856 | kg/m <sup>3</sup> |
| Average Wet Density (Actual), $P_{ActualW}$ | 1.180  | kg/m <sup>3</sup> |

Where:

$P_{STD}$  = sum of component concentrations, kg/m<sup>3</sup> (not including water vapour)

$P_{STW} = (P_{STD} + pi \text{ of H}_2\text{O}) / (1 + (pi \text{ of H}_2\text{O} / 0.8036))$

$P_{Actual} = P_{STD} \times (Ts / Ps) \times (Pa / Ta)$

$P_{ActualW} = P_{STW} \times (Ts / Ps) \times (Pa / Ta)$

APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

**PRELIMINARY STACK SURVEY**

**TRAVERSE 1**

|                              |              |
|------------------------------|--------------|
| Date of Survey               | 26 May 2020  |
| Time of Survey               | 09:25        |
| Velocity Measurement Device: | S-Type Pitot |

| Sampling Line A |                        |                                     |                                                     |         |              |                                                 |                         |                  |
|-----------------|------------------------|-------------------------------------|-----------------------------------------------------|---------|--------------|-------------------------------------------------|-------------------------|------------------|
| Traverse Point  | Distance into duct (m) | DP pt Pa<br>(average of 3 readings) | DP pt mmH <sub>2</sub> O<br>(average of 3 readings) | Temp °C | Velocity m/s | Volumetric Flow Rate (actual) m <sup>3</sup> /s | O <sub>2</sub> %<br>Vol | Angle of Swirl ° |
| 1               | 0.05                   | 395.3                               | 40.3                                                | 27      | 21.7         | 3.5                                             | -                       | <15              |
| 2               | 0.11                   | 405.1                               | 41.3                                                | 27      | 22.0         | 3.5                                             | -                       | <15              |
| 3               | 0.34                   | 411.6                               | 42.0                                                | 27      | 22.2         | 3.5                                             | -                       | <15              |
| 4               | 0.40                   | 414.9                               | 42.3                                                | 27      | 22.3         | 3.5                                             | -                       | <15              |
| Mean            | -                      | 406.7                               | 41.5                                                | 27      | 22.1         | 3.5                                             | -                       | -                |

**PRELIMINARY STACK SURVEY QUALITY ASSURANCE CHECKLIST**

| PITOT LEAK CHECK |                                |                              |              |         |                                |                              |              |         |
|------------------|--------------------------------|------------------------------|--------------|---------|--------------------------------|------------------------------|--------------|---------|
| Run              | Pre Traverse Leak Rate         |                              |              |         | Post Traverse Leak Rate        |                              |              |         |
|                  | Start Value mmH <sub>2</sub> O | End Value mmH <sub>2</sub> O | Difference % | Outcome | Start Value mmH <sub>2</sub> O | End Value mmH <sub>2</sub> O | Difference % | Outcome |
| Run 1            | 88                             | 87                           | 1.1          | Pass    | 89                             | 88                           | 1.1          | Pass    |

To complete a compliant pitot leak check a pressure of over 80 mmH<sub>2</sub>O (or 800 Pa) is applied and the pressure drop monitored over 5 mins. A drop of less than 5% must be observed.

| S-Type Pitot Stagnation Check |                 |                |                 |                               |
|-------------------------------|-----------------|----------------|-----------------|-------------------------------|
| Run                           | Stagnation (Pa) | Reference (Pa) | Difference (Pa) | Outcome (Permitted +/- 10 Pa) |
| Run 1                         | 100             | 102            | -2.0            | Pass                          |

APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

**PRELIMINARY STACK SURVEY (CONTINUED)**

| Sampling Plane Validation Criteria             |        |            |                |           |
|------------------------------------------------|--------|------------|----------------|-----------|
| EA Technical Guidance Note (Monitoring) M1     | Result | Units      | Requirement    | Compliant |
| Lowest Differential Pressure                   | 395    | Pa         | $\geq 5$ Pa    | Yes       |
| Lowest Gas Velocity                            | 21.7   | m/s        | -              | -         |
| Highest Gas Velocity                           | 22.3   | m/s        | -              | -         |
| Ratio of Gas Velocities                        | 1.0    | -          | $< 3 : 1$      | Yes       |
| Maximum angle of flow with regard to duct axis | $< 15$ | $^{\circ}$ | $< 15^{\circ}$ | Yes       |
| No local negative flow                         | Yes    | -          | -              | Yes       |

| Calculation of Stack Gas Velocity, V                                                                                                       |      |     |
|--------------------------------------------------------------------------------------------------------------------------------------------|------|-----|
| Velocity at Traverse Point, $V = K_{pt} \times (1-e) \times \sqrt{2 \times DP_{pt} / \rho_{ActualW}}$                                      |      |     |
| <b>Where:</b><br>$K_{pt}$ = Pitot tube calibration coefficient<br>$(1-e)$ = Compressibility correction factor, assumed at a constant 0.998 |      |     |
| Average Stack Gas Velocity, $V_a$                                                                                                          | 22.1 | m/s |

| Calculation of Stack Gas Volumetric Flowrate, Q |        |           |                    |
|-------------------------------------------------|--------|-----------|--------------------|
| Duct gas flow conditions                        | Actual | Reference | Units              |
| Temperature                                     | 27     | 0         | $^{\circ}\text{C}$ |
| Total Pressure                                  | 102.57 | 101.3     | kPa                |
| Oxygen                                          | 20.9   | 21        | %                  |
| Moisture                                        | 1.31   | 1.31      | %                  |
| Pitot tube calibration coefficient, $K_{pt}$    | 0.84   |           |                    |

| Gas Volumetric Flowrate                           | Result | Units                  |
|---------------------------------------------------|--------|------------------------|
| Average Stack Gas Velocity ( $V_a$ )              | 22.05  | m/s                    |
| Stack Area (A)                                    | 0.16   | $\text{m}^2$           |
| Gas Volumetric Flowrate (Actual), $Q_{Actual}$    | 12627  | $\text{m}^3/\text{hr}$ |
| Gas Volumetric Flowrate (STP, Wet), $Q_{STP}$     | 11635  | $\text{m}^3/\text{hr}$ |
| Gas Volumetric Flowrate (STP, Dry), $Q_{STP,Dry}$ | 11483  | $\text{m}^3/\text{hr}$ |
| Gas Volumetric Flowrate (REF), $Q_{Ref}$          | 11635  | $\text{m}^3/\text{hr}$ |

**Where:**

$$Q_{Actual} = V_a \times A \times 3600$$

$$Q_{STP} = Q_{Actual} \times (T_s / T_a) \times (P_a / P_s) \times 3600$$

$$Q_{STP,Dry} = Q_{STP} / (100 - (100 / Ma)) \times 3600$$

$$Q_{Ref} = Q_{STP} \times ((100 - Ma) / (100 - Ms)) \times ((21 - O_{2a}) / (21 - O_{2s}))$$

**Nomenclature:**

$T_s$  = Absolute Temperature, Standard Conditions, 273 K

$P_s$  = Absolute Pressure, Standard Conditions, 101.3 kPa

$T_a$  = Absolute Temperature, Actual Conditions, K

$P_a$  = Absolute Pressure, Actual Conditions, kPa

$Ma$  = Water vapour, Actual Conditions, % Vol

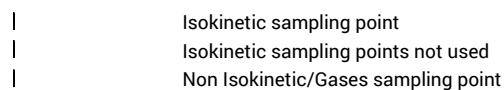
$Ms$  = Water vapour, Reference Conditions, % Vol

$O_{2a}$  = Oxygen, Actual Conditions, % Vol

$O_{2s}$  = Oxygen, Reference Conditions, % Vol

### STACK DIAGRAM

| Non-Isokinetic/Gases Sampling |                       |                     |       |
|-------------------------------|-----------------------|---------------------|-------|
| Sampling Point                | Distance (% of Depth) | Distance into Stack | Units |
| -                             | -                     | -                   | -     |

[illegible]

### SAMPLING LOCATION



APPENDIX 3 - Measurement Uncertainty Budget Calculations

**MEASUREMENT UNCERTAINTY BUDGET - TOTAL PARTICULATE MATTER**

| Run                | Sampled Volume<br>m <sup>3</sup> | Sampled Gas Temp<br>K | Sampled Gas Pressure<br>kPa | Sampled Gas Humidity<br>% by volume | Oxygen Content<br>% by volume | Limit of Detection<br>% by mass | Leak<br>%   | Uncollected Mass<br>mg |
|--------------------|----------------------------------|-----------------------|-----------------------------|-------------------------------------|-------------------------------|---------------------------------|-------------|------------------------|
| <b>MU required</b> | <b>≤ 2%</b>                      | <b>≤ 2%</b>           | <b>≤ 1%</b>                 | <b>≤ 1%</b>                         | <b>≤ 10%</b>                  | <b>≤ 5% of ELV</b>              | <b>≤ 2%</b> | <b>≤ 10% of ELV</b>    |
| Run 1              | 0.001                            | 2.0                   | 0.50                        | 1.0                                 | N/A                           | 0.5000                          | -           | -                      |
| as a %             | 0.07                             | 0.66                  | 0.49                        | 1.0                                 | N/A                           | 3.59449                         | 0.66        | 0.007                  |
| <b>compliant?</b>  | <b>Yes</b>                       | <b>Yes</b>            | <b>Yes</b>                  | <b>Yes</b>                          | <b>N/A</b>                    | <b>Yes</b>                      | <b>Yes</b>  | <b>Yes</b>             |

| Run                     | Volume (STP)<br>m <sup>3</sup> | Mass of particulate<br>mg | O <sub>2</sub> Correction<br>- | Leak<br>mg/m <sup>3</sup> | Uncollected Mass<br>mg | Combined uncertainty |
|-------------------------|--------------------------------|---------------------------|--------------------------------|---------------------------|------------------------|----------------------|
| Run 1                   | 1.25                           | 1.2000                    | 1.0                            | 0.003                     | 0.0004                 | -                    |
| MU as mg/m <sup>3</sup> | 0.01                           | 0.3594                    | -                              | 0.003                     | 0.0003                 | <b>0.36</b>          |
| MU as %                 | 1.30                           | 41.6667                   | -                              | 0.379                     | 0.0337                 | -                    |

|                                                                           |             |                         |              |                 |             |              |
|---------------------------------------------------------------------------|-------------|-------------------------|--------------|-----------------|-------------|--------------|
| <b>R1 - Uncertainty expressed at a 95% confidence level (where k = 2)</b> | <b>0.72</b> | <b>mg/m<sup>3</sup></b> | <b>83.38</b> | <b>% Result</b> | <b>7.19</b> | <b>% ELV</b> |
|---------------------------------------------------------------------------|-------------|-------------------------|--------------|-----------------|-------------|--------------|

(k is a coverage factor which gives a 95% confidence in the quoted figures)

Reference – SOCOTEC Technical Procedure AE150 Estimation of Uncertainty of Measurement

APPENDIX 3 - Measurement Uncertainty Budget Calculations

**MEASUREMENT UNCERTAINTY BUDGET - MOISTURE**

| Run                | Sampled Volume<br>m <sup>3</sup> | Sampled Gas Temp<br>K | Sampled Gas Pressure<br>kPa | Sampled Gas Humidity<br>% by volume | Oxygen Content<br>% by volume | Leak<br>%   |
|--------------------|----------------------------------|-----------------------|-----------------------------|-------------------------------------|-------------------------------|-------------|
| <b>MU required</b> | <b>≤ 2%</b>                      | <b>≤ 2%</b>           | <b>≤ 1%</b>                 | <b>≤ 1%</b>                         | <b>≤ 10%</b>                  | <b>≤ 2%</b> |
| Run 1              | 0.001                            | 2.0                   | 0.50                        | 1.0                                 | N/A                           | -           |
| as a %             | 0.07                             | 0.66                  | 0.49                        | 1.0                                 | N/A                           | 0.66        |
| <b>compliant?</b>  | <b>Yes</b>                       | <b>Yes</b>            | <b>Yes</b>                  | <b>Yes</b>                          | <b>N/A</b>                    | <b>Yes</b>  |

| Run         | Volume (STP)<br>m <sup>3</sup> | Mass Gained<br>mg | O <sub>2</sub> Correction<br>- | Leak<br>mg/m <sup>3</sup> | Uncollected Mass<br>mg | Combined uncertainty |
|-------------|--------------------------------|-------------------|--------------------------------|---------------------------|------------------------|----------------------|
| Run 1       | 1.25                           | 14600             | 1.0                            | 40.31                     | 58                     | -                    |
| MU as % v/v | 0.02                           | 0.01              | -                              | 0.01                      | 0.005                  | <b>0.02</b>          |
| MU as %     | 1.30                           | 0.68              | -                              | 0.38                      | 0.40                   | -                    |

|                                                                           |             |              |             |          |
|---------------------------------------------------------------------------|-------------|--------------|-------------|----------|
| <b>R1 - Uncertainty expressed at a 95% confidence level (where k = 2)</b> | <b>0.04</b> | <b>% v/v</b> | <b>3.13</b> | <b>%</b> |
|---------------------------------------------------------------------------|-------------|--------------|-------------|----------|

**MEASUREMENT UNCERTAINTY BUDGET - VELOCITY & VOLUMETRIC FLOW RATE**

|                                                    |       |                    |
|----------------------------------------------------|-------|--------------------|
| Measured Velocity at Actual Conditions             | 22.1  | m/s                |
| Measured Volumetric Flow rate at Actual Conditions | 12627 | m <sup>3</sup> /hr |

| Performance Characteristics & Source of Value                 | Units      | Values  | Requirement                                | Compliant |
|---------------------------------------------------------------|------------|---------|--------------------------------------------|-----------|
| Uncertainty of Local Gas Velocity Determination               | -          | 0.010   |                                            |           |
| Uncertainty of pitot tube coefficient                         | -          | 3.11    |                                            |           |
| Uncertainty of mean local dynamic pressures                   | -          | 3.11    |                                            |           |
| Factor loading, function of the number of measurements.       | 3 readings | 0.591   | minimum 3                                  | Yes       |
| Range of measurement device                                   | pa         | 1000    |                                            |           |
| Resolution                                                    | pa         | 1.00    |                                            |           |
| Calibration uncertainty                                       | pa         | 60.55   | <1% of Value or 20 Pa whichever is greater | Yes       |
| Drift                                                         | % range    | 0.10    |                                            |           |
| Linearity                                                     | % range    | 0.06    | <2% of value                               | Yes       |
| Uncertainty of gas density determination                      |            |         |                                            |           |
| Uncertainty of molar mass determination                       | kg/mol     | 0.00003 |                                            |           |
| Uncertainty of temperature measurement                        | K          | 1.53    | <1% of value                               | Yes       |
| Uncertainty of absolute pressure in the duct                  | pa         | 523     |                                            |           |
| Uncertainty associated with the estimate of density           | -          | 0.007   |                                            |           |
| Uncertainty associated with the measurement of local velocity | -          | 0.0001  |                                            |           |
| Uncertainty associated with the measurement of mean velocity  | -          | 0.0002  |                                            |           |

| Measurement Uncertainty - Velocity                | m/s  |
|---------------------------------------------------|------|
| Combined uncertainty                              | 0.27 |
| Expanded uncertainty at a 95% Confidence Interval | 0.54 |

Note - The expanded uncertainty uses a coverage factor of  $k = 2$ .

| Expanded Measurement Uncertainty of Velocity at a 95% Confidence Interval | %   |
|---------------------------------------------------------------------------|-----|
| Expressed as a % of the Measured Velocity                                 | 1.2 |
| Expanded uncertainty at a 95% Confidence Interval                         | 2.4 |

| Measurement Uncertainty Volumetric Flow Rate      | m <sup>3</sup> /hr |
|---------------------------------------------------|--------------------|
| Combined uncertainty                              | 331                |
| Expanded uncertainty at a 95% Confidence Interval | 649                |

Note - The expanded uncertainty uses a coverage factor of  $k = 2$ .

| Expanded Measurement Uncertainty of Volumetric Flow Rate at a 95% Confidence Interval | %   |
|---------------------------------------------------------------------------------------|-----|
| Expressed as a % of the Measured Volumetric Flow Rate                                 | 2.6 |
| Expanded uncertainty at a 95% Confidence Interval                                     | 5.1 |

Reference – SOCOTEC Technical Procedure AE150 Estimation of Uncertainty of Measurement

## END OF REPORT

*Thank you for choosing SOCOTEC for your environmental monitoring needs. We hope our services have met your requirements and that you are fully satisfied with your experience of working with us, we really do value your custom and would welcome your feedback. We would appreciate it if you could take a moment to complete a short online questionnaire so that we can improve our operations and address any areas that have not met with your expectations, by clicking on the following*

[https://www.surveymonkey.co.uk/r/CAE\\_customer\\_feedback\\_weblink](https://www.surveymonkey.co.uk/r/CAE_customer_feedback_weblink)