Element Materials Technology, Unit 3, Wednesbury One, Black Country New Road, Wednesbury, WS10 7NZ
Your Element Contact: James Eldridge (07826 916 684)
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**Stack Emissions Testing Report Commissioned by**
Air Tech Environmental Consultancy Services

**Installation Name & Address**
Federal-Mogul Coventry Ltd
Holbrook Lane
Holbrook
Coventry
CV6 4BG

PPC Permit: PPC/197

**Stack Reference**
Main Stack

**Dates of the Monitoring Campaign**
15th October 2019

**Job Reference Number**
CAT-5182

| Report Written by |
| --- |
| David Burns<br>Team Leader<br>MCERTS Level 2<br>MM 05 579<br>TE1 TE2 TE3 TE4 |

| Report Approved by |
| --- |
| Michelle Edwards<br>Team Leader<br>MCERTS Level 2<br>MM 05 659<br>TE1 TE2 TE3 TE4 |

| Report Date |
| --- |
| 15th November 2019 |

| Version |
| --- |
| Version 1 |

[redacted]

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

# Executive Summary



## MONITORING OBJECTIVES

Federal-Mogul Coventry Ltd, Coventry
Main Stack
15th October 2019

**Overall Aim of the Monitoring Campaign**

Element, in partnership with Air Tech Environmental Consultancy Services, were commissioned to carry out stack emissions testing on the Main Stack by Federal-Mogul Coventry Ltd 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 Particulate Matter, Sulphur Dioxide, Heavy Metals, Hydrogen Sulphide, Odour

# Executive Summary



## MONITORING RESULTS

Federal-Mogul Coventry Ltd, Coventry
Main Stack
15th October 2019

*where MU = Measurement Uncertainty associated with the Result*

| | Concentration | | | | Mass Emission | | | |
|---|---|---|---|---|---|---|---|---|
| **Parameter** | **Units** | **Result** | **MU +/-** | **Limit** | **Units** | **Result** | **MU +/-** | **Limit** |
| Total Particulate Matter [1] | mg/m³ | 0.38 | 0.34 | 20 | g/hr | 1.6 | 1.4 | - |
| Sulphur Dioxide [1] | mg/m³ | 3.4 | 0.31 | - | g/hr | 13.9 | 1.5 | - |
| Heavy Metals [1] | mg/m³ | 0.022 | 0.005 | 0.1 | g/hr | 0.09 | 0.02 | - |
| Hydrogen Sulphide [1] | mg/m³ | < 0.34 | 0.04 | 5 | g/hr | < 1.4 | 0.19 | - |
| Stack Gas Temperature | °C | 28.6 | | | | | | |
| Stack Gas Velocity | m/s | 20.7 | 0.86 | | | | | |
| Volumetric Flow Rate (ACTUAL) | m³/hr | 4590 | 282 | | | | | |
| Volumetric Flow Rate (REF) [1] | m³/hr | 4060 | 249 | | | | | |
| Volumetric Flow Rate (REF) [2] | m³/hr | 4357 | 267 | | | | | |

*NOTE: VOLUMETRIC FLOW RATE & VELOCITY DATA TAKEN FROM AN AVERAGE OF ALL OF THE ISOKINETIC RUNS.*

[1] Reference Conditions (REF) are: 273K, 101.3kPa, without correction for water vapour content.

## RESULTS FROM ODOUR SAMPLES

| | Concentration | | | | Mass Emission | | | |
|---|---|---|---|---|---|---|---|---|
| **Parameter** | **Units** | **Result** | **LOWER CI** | **UPPER CI** | **Units** | **Result** | **LO CI** | **HI CI** |
| Odour - Main Stack [2] | ouE/m³ | 233 | 147 | 368 | ouE/s | 263 | 166 | 415 |

*Where CI stands for Confidence Interval (or Uncertainty associated with the result)*

[2] Reference Conditions (REF) are: 293K, 101.3kPa, without correction for water vapour content

# Executive Summary



## MONITORING DATE(S) & TIMES

Federal-Mogul Coventry Ltd, Coventry
Main Stack
15th October 2019

| Parameter | | Units | Concentration | Units | Mass Emission | Sampling Date(s) | Sampling Times | Duration mins |
|---|---|---|---|---|---|---|---|---|
| Total Particulate Matter | R1 | mg/m³ | 0.38 | g/hr | 1.6 | 15/10/2019 | 07:56 - 09:26 | 90 |
| Sulphur Dioxide | R1 | mg/m³ | 3.4 | g/hr | 13.9 | 15/10/2019 | 07:56 - 09:26 | 90 |
| Heavy Metals | R1 | mg/m³ | 0.02 | g/hr | 0.09 | 15/10/2019 | 10:54 - 12:29 | 95 |
| Hydrogen Sulphide | R1 | mg/m³ | < 0.34 | g/hr | < 1.4 | 15/10/2019 | 10:54 - 12:29 | 95 |
| Odour - Main Stack | B1 | ouE/m³ | 383 | ouE/s | 432 | 15/10/2019 | 09:00 - 09:06 | 6 |
| Odour - Main Stack | B2 | ouE/m³ | 181 | ouE/s | 204 | 15/10/2019 | 09:07 - 09:13 | 6 |
| Odour - Main Stack | B3 | ouE/m³ | 182 | ouE/s | 205 | 15/10/2019 | 09:15 - 09:21 | 6 |
| Velocity Traverse | R1 | | | | | 15/10/2019 | 07:44 - 07:54 | |

All results are expressed at the respective reference conditions.

## PROCESS DETAILS

Federal-Mogul Coventry Ltd, Coventry
Main Stack
15th October 2019

**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) | Aluminium Scrap |
| Abatement System | Bag Filter |
| Abatement System Running Status | On |
| Fuel | Natural Gas |
| Plume Appearance | None Visible |

## MONITORING & ANALYTICAL METHODS

Federal-Mogul Coventry Ltd, Coventry
Main Stack
15th October 2019

| | Monitoring | | | | Analysis | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Parameter** | **Standard** | **Technical Procedure** | **ISO 17025 Testing** | **Testing Lab** | **Analytical Procedure** | **Analytical Technique** | **ISO 17025 Analysis** | **Analysis Lab** | **MCERTS Testing** | **LOD (Average)** |
| Total Particulate Matter | EN 13284-1 | CAT-TP-01 | Yes | EET | CAT-TP-03 | Gravimetric | Yes | EET | Yes | 0.09 mg/m³ |
| Sulphur Dioxide | EN 14791 | CAT-TP-09 | Yes | EET | CAT-AP-01 | IC | Yes | EET | Yes | 0.008 mg/m³ |
| Heavy Metals | EN 14385 | CAT-TP-06 | Yes | EET | CAT-AP-07 | ICP-MS | Yes | EET | Yes | 0.003 mg/m³ |
| Hydrogen Sulphide | US EPA M11 | CAT-TP-15 | Yes | EET | M120 | Wet Chemistry | Yes | RPS | Yes | 0.332 mg/m³ |
| Odour | BS EN 13725 | CAT-TP-30 | Yes | EET | QD01 | Olfactometry | Yes | ODO | Yes | 30 ouE/m³ |
| Velocity & Vol. Flow Rate | EN 16911-1 (MID) | CAT-TP-41 | Yes | EET | Pitot Tube and Thermocouple | | | | Yes | 1.2 m/s |

## ANALYSIS LABORATORIES

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

| | |
|---|---|
| Element Stockport (EET) | ISO 17025 Accreditation Number: 4279 |
| RPS Laboratories Ltd (RPS) | ISO 17025 Accreditation Number: 0605 |
| OdourNet UK Ltd (ODO) | ISO 17025 Accreditation Number: 2430 |

## SUMMARY OF SAMPLING DEVIATIONS

| Parameter | Run | Deviation |
|---|---|---|
| Sulphur Dioxide | All Runs | The absorption efficiency was less than the required 90%. [75 - 90%] |
| Heavy Metals | All Runs | The absorption efficiency was less than the required 90%. [75 - 90%] |
| Odour | Run 1 | The volume of sample was insuffiecient to complete a valid analysis accordance of EN 13725. The Estimated odour concentration based on 6 ITE values is 383 OU/m^3 |

## SUITABILITY OF SAMPLING LOCATION

### Duct Characteristics

| Parameter | Units | Value |
|---|---|---|
| Type | - | Circular |
| Depth | m | 0.28 |
| Width | m | - |
| Area | m² | 0.06 |
| Port Depth | cm | 9 |
| Orientation of Duct | - | Vertical |
| Number of Ports | - | 2 |
| Sample Port Size | - | 4" BSP |

### Location of Sampling Platform

| General Platform Information | Value |
|---|---|
| Permanent / Temporary Platform | Permanent |
| Inside / Outside | Outside |

### Platform Details

| EA Technical Guidance Note M1 / EN 15259 Platform Requirements | Value |
|---|---|
| Sufficient working area to manipulate probe and operate the measuring instruments | Yes |
| Platform has 2 levels of handrails (approx. 0.5m & 1.0m high) | Yes |
| Platform has vertical base boards (approx. 0.25m high) | Yes |
| Platform has chains / self closing gates at top of ladders | Yes |
| There are no obstructions present which hamper insertion of sampling equipment | Yes |
| Safe Access Available | Yes |
| Easy Access Available | Yes |

### Sampling Location / Platform Improvement Recommendations

All platforms should be designed in accordance with the requirements in the Environment Agency's Technical Guidance Note M1 and EN 15259.

### 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 | 345.2 | > 5 Pa | Yes |
| Mean Velocity | m/s | 20.51 | - | - |
| Lowest Gas Velocity | m/s | 20.51 | - | - |
| Highest Gas Velocity | m/s | 20.51 | - | - |
| Ratio of Above | : 1 | 1.00 | < 3 : 1 | Yes |
| Maximum Angle of Swirl | ° | 0.00 | < 15° | Yes |
| No Local Negative Flow | - | Yes | - | Yes |

# Executive Summary

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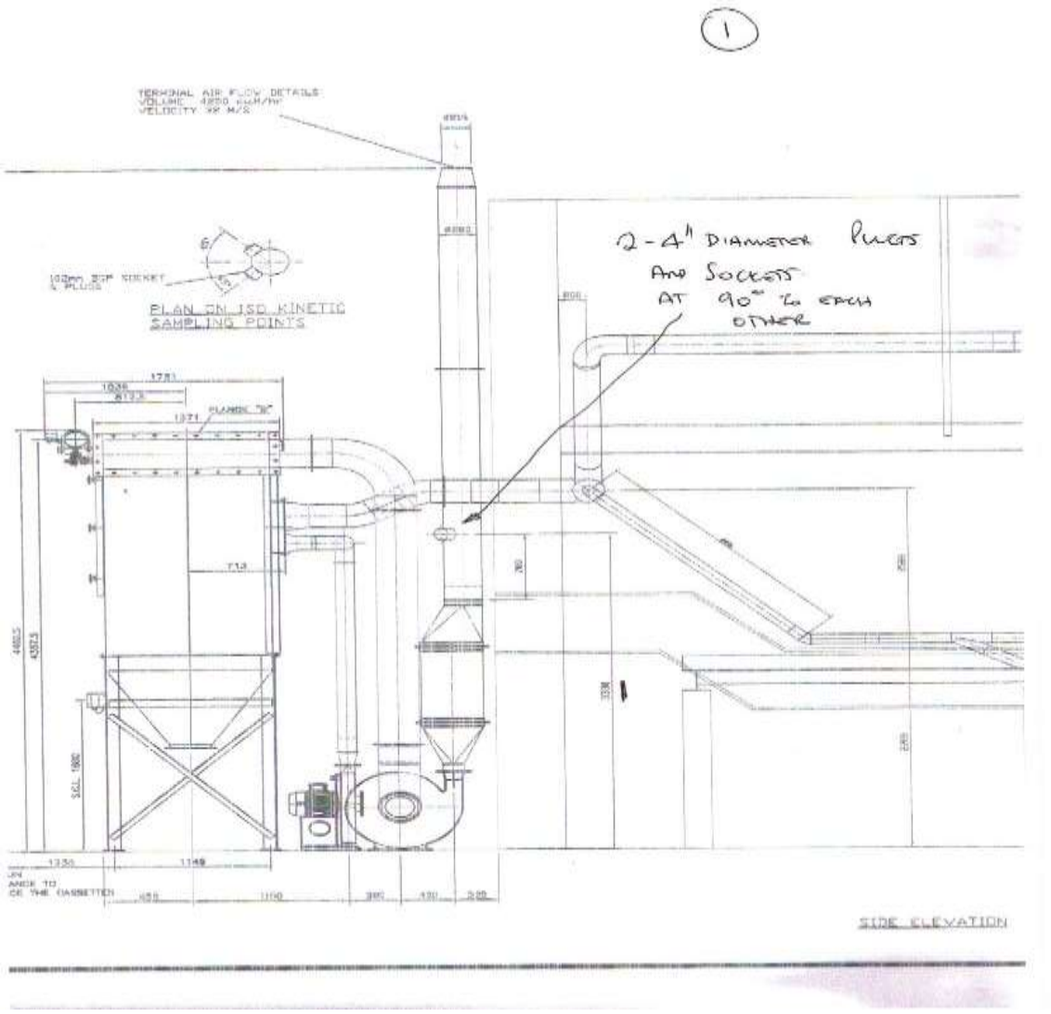
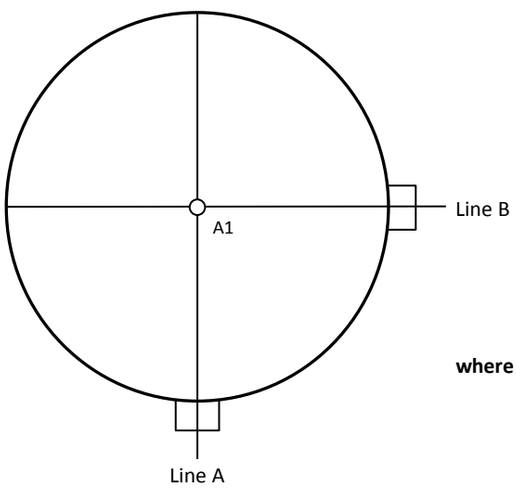
## PLANT DIAGRAM




## SAMPLE POINTS



## APPENDIX CONTENTS

## STACK EMISSIONS MONITORING PERSONNEL

| Position | Name | MCERTS Accreditation | MCERTS Number | Technical Endorsements |
|---|---|---|---|---|
| Team Leader | David Burns | MCERTS Level 2 | MM 05 579 | TE1 TE2 TE3 TE4 |
| Technician | Lee Heaton | MCERTS Level 1 | MM 18 1433 | None |

## LIST OF EQUIPMENT

| Extractive Sampling | |
|---|---|
| **Equipment Type** | **Equipment I.D.** |
| Control Box DGM (1) | CAT 7.58 |
| Control Box DGM (2) | - |
| Box Thermocouples (1) | CAT 3.148 |
| Box Thermocouples (2) | - |
| Umbilical (1) | CAT 3.148 |
| Umbilical (2) | - |
| Oven Box (1) | CAT 12.201 |
| Oven Box (2) | - |
| Heated Probe (1) | CAT 5.129 |
| Heated Probe (2) | CAT 5.130 |
| Heated Probe (3) | CAT 5.131 |
| S-Pitot (1) | CAT 21P.97 |
| S-Pitot (2) | CAT 21S.56 |
| L-Pitot | CAT 21L.41 |
| Site Balance | CAT 17.38 |
| 500g / 1Kg Check Weights | CAT 17.38 |
| Last Impinger Arm | CAT 4.902/4.903 |
| Callipers | CAT 23.41 |
| Tubes Kit Thermocouple | - |

| Instrumental Analysers | |
|---|---|
| **Equipment Type** | **Equipment I.D.** |
| Horiba PG-350E | CAT 39.11 |
| Horiba PG-250 | - |
| Servomex 4900 | - |
| Eco Physics CLD 822Mh | - |
| ABB AO2020-URAS26 | - |
| Servomex 5200MP | - |
| Ankersmid APS 313 | CAT 4.848 |
| Gasmet DX4000 | - |
| Gasmet Sampling System | - |
| Bernath 3006 FID | CAT 8.32 |
| M&C PSS | CAT 12.108 |
| Mass Flow Controller (1) | CAT 6.63 |
| Mass Flow Controller (2) | CAT 6.64 |
| Mass View (1) | CAT 25.61 |
| Mass View (2) | CAT 25.62 |
| Hioki 5043 (V) | CAT 11.70 |
| Easylogger EN-EL-12 Bit | - |
| Bioaerosols Temperature Logger | - |
| Electronic Refrigerator | - |

| Miscellaneous Items | |
|---|---|
| **Equipment Type** | **Equipment I.D.** |
| Digital Manometer (1) | CAT 3.143 |
| Digital Manometer (2) | CAT 3.145 |
| Digital Temperature Meter | - |
| Stopwatch | CAT 14.86 |
| Barometer | CAT 13.41 |
| Stack Thermocouple (1) | CAT 4.1113 |
| Stack Thermocouple (2) | CAT 4.1041 |
| Stack Thermocouple (3) | CAT 4.0117 |
| 1m Heated Line (1) | - |
| 1m Heated Line (2) | - |
| 1m Heated Line (3) | - |
| 5m Heated Line (1) | - |
| 15m Heated Line (1) | - |
| 20m Heated Line (1) | CAT 20.119 |
| 20m Heated Line (2) | - |
| Dual Channel Heater Controller | CAT 3.002 |
| Single Channel Heater Controller | CAT 20.119 |
| Laboratory Balance | CAT 1.18, 1.18a, 1.18b |
| Tape Measure | CAT 16.49 |

## METHODS & TECHNICAL PROCEDURES USED

| Parameter | Standard | Technical Procedure |
|---|---|---|
| Total Particulate Matter | EN 13284-1 | CAT-TP-01 |
| Sulphur Dioxide | EN 14791 | CAT-TP-09 |
| Heavy Metals | EN 14385 | CAT-TP-06 |
| Hydrogen Sulphide | US EPA M11 | CAT-TP-15 |
| Odour | BS EN 13725 | CAT-TP-30 |
| 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 | 0.28 |
| Stack Width, W | m | - |
| Stack Area, A | m² | 0.06 |
| Average Stack Gas Temperature, $T_a$ | °C | 25.0 |
| Average Stack Gas Pressure | Pa | 345.2 |
| Average Stack Static Pressure, $P_{static}$ | kPa | 0.110 |
| Average Barometric Pressure, $P_b$ | kPa | 98.9 |
| 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) | - | 2.00 | 1.97 | 0.0200 | 44.01 | 1.9635 | 0.03927 |
| $O_2$ (Estimated) | - | 19.00 | 18.74 | 0.1900 | 32.00 | 1.4277 | 0.27126 |
| $N_2$ | - | 79.00 | 77.91 | 0.7900 | 28.01 | 1.2498 | 0.98738 |
| Moisture ($H_2O$) | - | - | 1.38 | 0.0138 | 18.02 | 0.8037 | 0.01109 |

**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 | 1.298 |
| Wet Density (STP), $P_{STW}$ | kg/m³ | 1.291 |
| Dry Density (Actual), $P_{Actual}$ | kg/m³ | 1.162 |
| Average Wet Density (Actual), $P_{ActualW}$ | kg/m³ | 1.156 |

**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] | REF [2] |
|---|---|---|---|---|
| Temperature | °C | 25.0 | 0.0 | 20.0 |
| Total Pressure | kPa | 99.0 | 101.3 | 101.3 |
| Moisture | % | 1.38 | 1.38 | 1.38 |

| Gas Volumetric Flowrate (from Traverse) | Units | Result |
|---|---|---|
| Gas Volumetric Flowrate (Actual) | m³/hr | 4547 |
| Gas Volumetric Flowrate (STP, Wet) | m³/hr | 4072 |
| Gas Volumetric Flowrate (STP, Dry) | m³/hr | 4015 |
| Gas Volumetric Flowrate REF [1] | m³/hr | 4072 |
| Gas Volumetric Flowrate REF [2] | m³/hr | 4370 |

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

(1 of 1)

| Parameter | Units | Value |
|---|---|---|
| Date of Survey | - | 15/10/2019 |
| Time of Survey | - | 07:44 - 07:54 |
| Atmospheric Pressure | kPa | 98.9 |
| Average Stack Static Pressure | Pa | 110 |
| 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, $C_p$ | - | 0.84 |
| Number of Lines Available | - | 1 |
| Number of Lines Used | - | 1 |

**Sampling Line A**

| Traverse Point | Depth m | ΔP Pa | Temp °C | Wet Density kg/m³ | Velocity m/s | Swirl ° |
|---|---|---|---|---|---|---|
| *STATIC (Units: Pa)* | | *110.0* | | | | |
| **Mean** | | **345.2** | **25.0** | **1.156** | **20.51** | |
| 1 | 0.14 | 345.2 | 25.0 | 1.156 | 20.51 | 0.0 |

## 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) | 7.170 | Pa |
| *- Resolution* | u(res) | 0.00087 | |
| *- Calibration* | u(cal) | 12.408 | |
| *- Drift* | u(drift) | 0.083 | |
| *- Lack of Fit* | u(fit) | 37.922 | |
| *- Overall corrections to dynamic measurements* | u(Cf) | 50.414 | |
| Standard uncertainty associated with the molar mass of the gas | u(M) | 0.00003 | - |
| *- $\varphi O_2,w$* | - | 18.738 | |
| *- $\varphi CO_2,w$* | - | 1.972 | |
| *- Oxygen, dry* | u($\phi O_2$,d) | 0.582 | |
| *- Carbon Dioxide, dry* | u($\phi CO_2$,d) | 0.061 | |
| *- Water Vapour* | u($\phi H_2O$) | 0.070 | |
| *- Oxygen, wet* | u($\phi O_2$,w) | 0.574 | |
| *- Carbon Dioxide, wet* | u($\phi CO_2$,w) | 0.060 | |
| Standard uncertainty associated with the stack temperature | u(Tc) | 1.520 | K |
| Standard uncertainty associated with the absolute pressure in the duct | u(pc) | 175.838 | Pa |
| *- Atmospheric Pressure* | u(patm) | 175.692 | |
| *- Static Pressure* | u(pstat) | 7.170 | |
| Standard uncertainty associated with the density in the duct | u(ρ) | 0.00625 | - |
| Standard uncertainty associated with the local velocities | u(vi) | 0.434 | Pa |
| Standard uncertainty associated with the mean velocity | u(v) | 0.434 | m/s |
| Standard uncertainty associated with the mean velocity (95% Confidence) | Uc(v) | 0.850 | m/s |
| Standard uncertainty associated with the mean velocity (95% Confidence), relative | Uc,rel(v) | 4.14 | % |
| Standard uncertainty associated with the volume flow rate (95% Confidence) | Uc(qV,w) | 279.1 | $m^3/hr$ |
| *- $u^2(a)/a^2$* | - | 0.00053 | |
| *- $u^2(qV,w)/q^2V,w$* | - | 0.00098 | |
| *- $u^2(qV,w)$* | - | 20275 | |
| *- $u(qV,w)$* | - | 142.4 | |
| Standard uncertainty associated with the volume flow rate (95% Confidence), relative | Uc,rel(qV,w) | 6.14 | % |

# TOTAL PARTICULATE MATTER: RESULTS SUMMARY

Federal-Mogul Coventry Ltd, Coventry
Main Stack

## Sample Runs

| Parameter | Units | Run 1 | | Mean |
|---|---|---|---|---|
| Concentration | mg/m³ | 0.38 | | 0.38 |
| Uncertainty | ±mg/m³ | 0.34 | | 0.34 |
| Mass Emission | g/hr | 1.6 | | 1.6 |
| Uncertainty | ±g/hr | 1.4 | | 1.4 |

| Parameter | Units | Run 1 | | Mean |
|---|---|---|---|---|
| Water Vapour | % v/v | 0.86 | | 0.86 |
| Uncertainty | ±% v/v | 0.05 | | 0.05 |

## Blank Runs

| Parameter | Units | Blank 1 | | Maximum |
|---|---|---|---|---|
| Concentration | mg/m³ | 0.26 | | 0.26 |

## 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 | 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 PARTICULATE MATTER: ISOKINETIC SAMPLING CALCULATIONS

| Test | Units | Run 1 | |
|---|---|---|---|
| **Absolute pressure of stack gas, $P_s$** | | | |
| Barometric pressure, $P_b$ | mmHg | 741.8 | |
| Stack static pressure, $P_{static}$ | $mmH_2O$ | 11.2 | |
| $P_s = (P_b + (P_{static} / 13.6)$ | mmHg | 742.6 | |
| **Volume of water vapour collected, $V_{wstd}$** | | | |
| Total mass collected in impingers (liquid trap) | g | 7.0 | |
| Total mass collected in impingers (silica trap) | g | 6.5 | |
| Total mass of liquid collected, $V_{lc}$ | g | 13.5 | |
| $V_{wstd} = (0.001246)(V_{lc})$ | $m^3$ | 0.0168 | |
| **Volume of gas metered dry, $V_{mstd}$** | | | |
| Volume of gas sample through gas meter, $V_m$ | $m^3$ | 2.1490 | |
| Gas meter correction factor, $Y_d$ | - | 0.9790 | |
| Average dry gas meter temperature, $T_m$ | °C | 18.0 | |
| Average pressure drop across orifice, ΔH | $mmH_2O$ | 56.4 | |
| $V_{mstd} = ((0.3592)(V_m)(P_b + (\Delta H/13.6))(Y_d)) / (T_m + 273)$ | $m^3$ | 1.9371 | |
| **Moisture content, $B_{wo}$ & $R_{wv}$** | | | |
| $B_{wo} = V_{wstd} / (V_{mstd} + V_{wstd})$ | $m^3$ | 0.0086 | |
| $B_{wo}$ as a percentage | % v/v | 0.86 | |
| Reported Water Vapour, checked with Tables in EN 14790, Rwv | % v/v | 0.86 | |
| **Volume of gas metered wet, $V_{mstw}$** | | | |
| $V_{mstw} = (V_{mstd})(100/(100 - R_{wv}))$ | $m^3$ | 1.9539 | |
| **Volume of gas metered at Oxygen Reference Conditions, $V_{mstd@X\%O_2}$ & $V_{mstw@X\%O_2}$** | | | |
| IED & Incinerates Hazardous Material? (Yes = no positive $O_2$ correction) | - | No | |
| % wet oxygen measured in gas stream, $ACT\%O_{2w}$ | % v/v | N/A | |
| % dry oxygen measured in gas stream, $ACT\%O_{2d}$ | % v/v | N/A | |
| % oxygen reference condition, $REF\%O_2$ | % v/v | N/A | |
| $O_2$ Reference Factor wet $(O_{2REFw}) = (21 - REF\%O_2) / (21 - ACT\%O_{2w})$ | - | N/A | |
| $O_2$ Reference Factor dry $(O_{2REFd}) = (21 - REF\%O_2) / (21 - ACT\%O_{2d})$ | - | N/A | |
| $V_{mstw@X\%oxygen} = (V_{mstw}) / (O_{2REFw})$ | $m^3$ | N/A | |
| $V_{mstd@X\%oxygen} = (V_{mstd}) / (O_{2REFd})$ | $m^3$ | N/A | |
| **Molecular weight of dry gas stream, $M_d$** | | | |
| $CO_2$ (Estimated) | % v/v | 2.00 | |
| $O_2$ (Estimated) | % v/v | 19.00 | |
| Total | % v/v | 21.00 | |
| $N_2$ | % v/v | 79.00 | |
| $M_d = 0.44(\%CO_2)+0.32(\%O_2)+0.28(\%N_2)$ | g/gmol | 29.08 | |
| **Molecular weight of stack gas (wet), $M_s$** | | | |
| $M_s = M_d(1 - (R_{wv}/100)) + 18(R_{wv}/100)$ | g/gmol | 28.98 | |
| **Velocity of stack gas, $V_s$** | | | |
| Pitot tube velocity constant, $K_p$ | - | 34.97 | |
| Velocity pressure coefficient, $C_p$ | - | 0.86 | |
| Average of velocity heads, $\Delta P_{avg}$ | $mmH_2O$ | 34.00 | |
| Average square root of velocity heads, √ΔP | $\sqrt{mmH_2O}$ | 5.83 | |
| Average stack gas temperature, $T_s$ | °C | 29.5 | |
| $V_s = ((K_p)(C_p)(\sqrt{\Delta P})(\sqrt{T_s} + 273)) / (\sqrt{(M_s)(P_s)})$ | m/s | 20.72 | |
| **Total flow of stack gas: Actual ($Q_a$), Wet ($Q_{stw}$), Dry ($Q_{std}$), Wet@$O_{2REF}$ ($Q_{stwO_2}$), Dry@$O_{2REF}$ ($Q_{stdO_2}$)** | | | |
| Area of stack, $A_s$ | $m^2$ | 0.06 | |
| $Q_a = (60)(A_s)(V_s)$ | $m^3$/min | 76.5 | |
| Conversion factor (K/mm.Hg), $C_f$ | - | 0.3592 | |
| $Q_{stw} = ((Q_a)(P_s)(C_f)) / ((T_s) + 273)$ | $m^3$/min | 67.5 | |
| $Q_{std} = ((Q_a)(P_s)(C_f)(1 - (R_{wv}/100))) / ((T_s) + 273)$ | $m^3$/min | 66.9 | |
| $Q_{stwO_2} = ((Q_a)(P_s)(C_f)) / ((T_s) + 273) / (O_{2REFw})$ | $m^3$/min | N/A | |
| $Q_{stdO_2} = ((Q_a)(P_s)(C_f)(1 - (R_{wv}/100))) / ((T_s) + 273) / (O_{2REFd})$ | $m^3$/min | N/A | |
| **Percent isokinetic, %I** | | | |
| Nozzle diameter, $D_n$ | mm | 4.95 | |
| Nozzle area, $A_n$ | $mm^2$ | 19.25 | |
| Total sampling time, q | min | 90 | |
| $\%I = (4.6398E^6)(T_s+273)(V_{mstd}) / (P_s)(V_s)(A_n)(q)(1 - (R_{wv}/100))$ | % | 102.9 | |

# TOTAL PARTICULATE MATTER: SAMPLING DETAILS

## Sample Runs

| Parameter | Units | Run 1 |
|---|---|---|
| Sampling Times | - | 07:56 - 09:26 |
| Sampling Dates | - | 15/10/2019 |
| Sampling Device | - | ISO |
| Volume Sampled (REF) | $m^3$ | 1.9539 |
| Filter I.D. Number | - | 47-60905 |
| Start Filter Mass | g | 0.14405 |
| End Filter Mass | g | 0.14438 |
| Total Mass on Filter | g | 0.00033 |
| Probe Rinse I.D. Number | - | PR-47-60905 |
| Start Probe Rinse Mass | g | 2.73022 |
| End Probe Rinse Mass | g | 2.73064 |
| Total Mass in Probe Rinse | g | 0.00042 |
| Total Mass Collected | mg | 0.75 |
| Calculated Concentration | $mg/m^3$ | 0.38 |
| Balance Uncertainty / LOD | $mg/m^3$ | 0.09 |

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

## Blank Runs

| Parameter | Units | Blank 1 |
|---|---|---|
| Blank Dates | - | 15/10/2019 |
| Average Volume Sampled (REF) | $m^3$ | 1.9539 |
| Filter I.D. Number | - | 47-60682 |
| Start Filter Mass | g | 0.14286 |
| End Filter Mass | g | 0.14314 |
| Total Mass on Filter | g | 0.00028 |
| Probe Rinse I.D. Number | - | PR-47-60682 |
| Start Probe Rinse Mass | g | 2.73855 |
| End Probe Rinse Mass | g | 2.73878 |
| Total Mass in Probe Rinse | g | 0.00023 |
| Total Mass Collected | mg | 0.51 |
| Calculated Concentration | $mg/m^3$ | 0.26 |
| Balance Uncertainty / LOD | $mg/m^3$ | 0.09 |

# TOTAL PARTICULATE MATTER: QUALITY ASSURANCE



## Sample Runs

| Leak Test Results | Units | Run 1 |
|---|---|---|
| Mean Sampling Rate | l/min | 23.4 |
| Pre-Sampling Leak Rate | l/min | 0.10 |
| Post-Sampling Leak Rate | l/min | 0.10 |
| Allowable Leak Rate | l/min | 0.47 |
| Leak Test Acceptable | - | Yes |

| Water Droplets | Units | Run 1 |
|---|---|---|
| Are Water Droplets Present | - | No |

| MU (Concurrent Water Vapour) | Units | Run 1 |
|---|---|---|
| Measurement Uncertainty (MU) | % | 5.5 |
| 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 | % | 102.9 |
| Allowable Isokinetic Range | % | 95 - 115 |
| Isokineticity Acceptable | - | Yes |

| Weighing Uncertainty Criteria | Units | Run 1 |
|---|---|---|
| Overall Weighing Uncertainty | ± mg | 0.32 |
| Overall Weighing Uncertainty | ± mg/m³ | 0.16 |
| ELV [Daily ELV for IED] | mg/m³ | 20.00 |
| Allowable Weighing Uncertainty | mg/m³ | 1.00 |
| Weighing Uncertainty Acceptable | - | Yes |

| Filter Temperatures | Units | Run 1 |
|---|---|---|
| Pre-Conditioning Temperature | °C | 180 |
| Post-Conditioning Temperature | °C | 160 |
| Maximum Filter Temperature | °C | 31 |

| Test Conditions | Units | Run 1 |
|---|---|---|
| Ambient Temperature Recorded? | - | Yes |

# TOTAL PARTICULATE MATTER: QUALITY ASSURANCE



## Blank Runs

| Leak Test Results | Units | Blank 1 |
|---|---|---|
| Expected Sampling Rate | l/min | 18.0 |
| Pre-Sampling Leak Rate | l/min | 0.10 |
| Post-Sampling Leak Rate | l/min | 0.10 |
| Allowable Leak Rate | l/min | 0.36 |
| Leak Test Acceptable | - | Yes |

| Validity of Blank vs ELV | Units | Blank 1 |
|---|---|---|
| Allowable Blank | mg/m³ | 2.0 |
| 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 (x = deviation applies to the associated run, wx = deviation also applies to the concurrent water vapour run) | Run Number 1 | |
|---|---|---|
| There are no deviations associated with the sampling employed. | x | |

# TOTAL PARTICULATE MATTER: MEASUREMENT UNCERTAINTY CALCULATIONS

| | Value | | Standard uncertainty | | |
|---|---|---|---|---|---|
| **Measured Quantities** | **Symbol** | **Run 1** | **Symbol** | **Units** | **Run 1** |
| Sampled Volume (Actual) | $V_m$ | 2.1490 | $uV_m$ | $m^3$ | 0.0430 |
| Sampled Gas Temperature | $T_m$ | 291.0 | $uT_m$ | K | 2.0 |
| Sampled Gas Pressure | $\rho_m$ | 99.0 | $u\rho_m$ | kPa | 0.5 |
| Sampled Gas Humidity | $H_m$ | 0.0 | $uH_m$ | % v/v | 1.0 |
| Leak | L | 0.43 | uL | % | - |
| Mass of Particulate | m | 0.75 | um | mg | 0.17 |
| Uncollected Mass | UCM | 0.51 | uUCM | mg | - |

| | Uncertainty as a Percentage | | |
|---|---|---|---|
| **Measured Quantities** | **Units** | **Run 1** | **Requirement of Standard** |
| Sampled Volume (Actual) | % | 2.00 | ≤2% |
| Sampled Gas Temperature | % | 0.69 | ≤1% |
| Sampled Gas Pressure | % | 0.50 | ≤1% |
| Sampled Gas Humidity | % | 1.00 | ≤1% |
| Leak | % | 0.43 | ≤2% |
| Mass of Particulate | % | 0.44 | <5% of ELV |
| Uncollected Mass | % | - | - |

| | Uncertainty in Measurement Units | | | Sensitivity Coefficient |
|---|---|---|---|---|
| **Measured Quantities** | **Symbol** | **Units** | **Run 1** | **Run 1** |
| Sampled Volume (STP) | $V_m$ | $m^3$ | 1.9371 | 0.20 |
| Leak | L | $mg/m^3$ | 0.001 | 1.00 |
| Mass of Particulate | $L_r$ | mg | 0.750 | 0.51 |
| Uncollected Mass | UCM | mg | 0.30 | 0.51 |

| | Uncertainty in Result | |
|---|---|---|
| **Measured Quantities** | **Units** | **Run 1** |
| Sampled Volume (STP) | $mg/m^3$ | 0.010 |
| Leak | $mg/m^3$ | 0.0009 |
| Mass of Particulate | $mg/m^3$ | 0.0870 |
| Uncollected Mass | $mg/m^3$ | 0.1517 |

| | 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 | $mg/m^3$ | 0.18 |
| Expanded uncertainty (95% confidence), without Oxygen Correction | $mg/m^3$ | 0.34 |
| Expanded uncertainty (95% confidence), with Oxygen Correction | $mg/m^3$ | N/A |
| Expanded uncertainty (95% confidence), estimated with Method Deviations | $mg/m^3$ | 0.34 |
| Reported Uncertainty | $mg/m^3$ | 0.34 |
| Expanded uncertainty (95% confidence), without Oxygen Correction | % | 89.4 |
| Expanded uncertainty (95% confidence), with Oxygen Correction | % | N/A |
| Expanded uncertainty (95% confidence), estimated with Method Deviations | % | 89.4 |
| Reported Uncertainty | % | 89.4 |

# SULPHUR DIOXIDE: RESULTS SUMMARY

Federal-Mogul Coventry Ltd, Coventry
Main Stack

## Sample Runs

| Parameter | Units | Run 1 | | Mean |
|---|---|---|---|---|
| Concentration | mg/m³ | 3.4 | | 3.4 |
| Uncertainty | ±mg/m³ | 0.31 | | 0.31 |
| Mass Emission | g/hr | 13.9 | | 13.9 |
| Uncertainty | ±g/hr | 1.5 | | 1.5 |

| Parameter | Units | Run 1 | | Mean |
|---|---|---|---|---|
| Water Vapour | % v/v | 0.86 | | 0.86 |
| Uncertainty | ±% v/v | 0.05 | | 0.05 |

## Blank Runs

| Parameter | Units | Blank 1 | | Maximum |
|---|---|---|---|---|
| Concentration | mg/m³ | < 0.01 | | < 0.01 |

## General Sampling Information

| Parameter | Value | |
|---|---|---|
| Standard | EN 14791 | |
| Technical Procedure | CAT-TP-09 | |
| Name of Analytical Laboratory | EET | |
| Analytical Laboratory's Procedure | CAT-AP-01 | |
| ISO 17025 Accredited Analysis? | Yes | |
| Date of Sample Analysis | 23/10/2019 | |
| Probe Material | Titanium | |
| Filter Housing Material | Titanium | |
| Impinger Material | Polyethylene | |
| Absorption Solution | 0.3% Hydrogen Peroxide | |
| Positioning of Filter | In Stack | |
| Filter Size and Material | 47mm Glass Fibre | |
| Number of Sampling Lines Used | 1 / 1 | FORMAT: Number Used / Number Required |
| Number of Sampling Points Used | 1 / 1 | FORMAT: Number Used / Number Required |
| Sample Point I.D.'s | A1 | |

## Reference Conditions

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

## SULPHUR DIOXIDE: ISOKINETIC SAMPLING CALCULATIONS

| Test | Units | Run 1 |
|---|---|---|
| **Absolute pressure of stack gas, $P_s$** | | |
| Barometric pressure, $P_b$ | mmHg | 741.8 |
| Stack static pressure, $P_{static}$ | $mmH_2O$ | 11.2 |
| $P_s = (P_b + (P_{static} / 13.6)$ | mmHg | 742.6 |
| **Volume of water vapour collected, $V_{wstd}$** | | |
| Total mass collected in impingers (liquid trap) | g | 7.0 |
| Total mass collected in impingers (silica trap) | g | 6.5 |
| Total mass of liquid collected, $V_{lc}$ | g | 13.5 |
| $V_{wstd} = (0.001246)(V_{lc})$ | $m^3$ | 0.0168 |
| **Volume of gas metered dry, $V_{mstd}$** | | |
| Volume of gas sample through gas meter, $V_m$ | $m^3$ | 2.1490 |
| Gas meter correction factor, $Y_d$ | - | 0.9790 |
| Average dry gas meter temperature, $T_m$ | °C | 18.0 |
| Average pressure drop across orifice, ΔH | $mmH_2O$ | 56.4 |
| $V_{mstd} = ((0.3592)(V_m)(P_b + (\Delta H/13.6))(Y_d)) / (T_m + 273)$ | $m^3$ | 1.9371 |
| **Moisture content, $B_{wo}$ & $R_{wv}$** | | |
| $B_{wo} = V_{wstd} / (V_{mstd} + V_{wstd})$ | $m^3$ | 0.0086 |
| $B_{wo}$ as a percentage | % v/v | 0.86 |
| Reported Water Vapour, checked with Tables in EN 14790, Rwv | % v/v | 0.86 |
| **Volume of gas metered wet, $V_{mstw}$** | | |
| $V_{mstw} = (V_{mstd})(100/(100 - R_{wv}))$ | $m^3$ | 1.9539 |
| **Volume of gas metered at Oxygen Reference Conditions, $V_{mstd@X\%O_2}$ & $V_{mstw@X\%O_2}$** | | |
| IED & Incinerates Hazardous Material? (Yes = no positive $O_2$ correction) | - | No |
| % wet oxygen measured in gas stream, $ACT\%O_{2w}$ | % v/v | N/A |
| % dry oxygen measured in gas stream, $ACT\%O_{2d}$ | % v/v | N/A |
| % oxygen reference condition, $REF\%O_2$ | % v/v | N/A |
| $O_2$ Reference Factor wet $(O_{2REFw}) = (21 - REF\%O_2) / (21 - ACT\%O_{2w})$ | - | N/A |
| $O_2$ Reference Factor dry $(O_{2REFd}) = (21 - REF\%O_2) / (21 - ACT\%O_{2d})$ | - | N/A |
| $V_{mstw@X\%oxygen} = (V_{mstw}) / (O_{2REFw})$ | $m^3$ | N/A |
| $V_{mstd@X\%oxygen} = (V_{mstd}) / (O_{2REFd})$ | $m^3$ | N/A |
| **Molecular weight of dry gas stream, $M_d$** | | |
| $CO_2$ (Estimated) | % v/v | 2.00 |
| $O_2$ (Estimated) | % v/v | 19.00 |
| Total | % v/v | 21.00 |
| $N_2$ | % v/v | 79.00 |
| $M_d = 0.44(\%CO_2)+0.32(\%O_2)+0.28(\%N_2)$ | g/gmol | 29.08 |
| **Molecular weight of stack gas (wet), $M_s$** | | |
| $M_s = M_d(1 - (R_{wv}/100)) + 18(R_{wv}/100)$ | g/gmol | 28.98 |
| **Velocity of stack gas, $V_s$** | | |
| Pitot tube velocity constant, $K_p$ | - | 34.97 |
| Velocity pressure coefficient, $C_p$ | - | 0.86 |
| Average of velocity heads, $\Delta P_{avg}$ | $mmH_2O$ | 34.00 |
| Average square root of velocity heads, √ΔP | $\sqrt{mmH_2O}$ | 5.83 |
| Average stack gas temperature, $T_s$ | °C | 29.5 |
| $V_s = ((K_p)(C_p)(\sqrt{\Delta P})(\sqrt{T_s} + 273)) / (\sqrt{(M_s)(P_s)})$ | m/s | 20.72 |
| **Total flow of stack gas: Actual ($Q_a$), Wet ($Q_{stw}$), Dry ($Q_{std}$), Wet@$O_{2REF}$ ($Q_{stwO_2}$), Dry@$O_{2REF}$ ($Q_{stdO_2}$)** | | |
| Area of stack, $A_s$ | $m^2$ | 0.06 |
| $Q_a = (60)(A_s)(V_s)$ | $m^3$/min | 76.5 |
| Conversion factor (K/mm.Hg), $C_f$ | - | 0.3592 |
| $Q_{stw} = ((Q_a)(P_s)(C_f)) / ((T_s) + 273)$ | $m^3$/min | 67.5 |
| $Q_{std} = ((Q_a)(P_s)(C_f)(1 - (R_{wv}/100))) / ((T_s) + 273)$ | $m^3$/min | 66.9 |
| $Q_{stwO_2} = ((Q_a)(P_s)(C_f)) / ((T_s) + 273) / (O_{2REFw})$ | $m^3$/min | N/A |
| $Q_{stdO_2} = ((Q_a)(P_s)(C_f)(1 - (R_{wv}/100))) / ((T_s) + 273) / (O_{2REFd})$ | $m^3$/min | N/A |
| **Percent isokinetic, %I** | | |
| Nozzle diameter, $D_n$ | mm | 4.95 |
| Nozzle area, $A_n$ | $mm^2$ | 19.25 |
| Total sampling time, q | min | 90 |
| $\%I = (4.6398E^6)(T_s+273)(V_{mstd}) / (P_s)(V_s)(A_n)(q)(1 - (R_{wv}/100))$ | % | 102.9 |

# SULPHUR DIOXIDE: SAMPLING DETAILS

## Sample Runs

| Parameter | Units | Run 1 |
|---|---|---|
| Sampling Times | - | 07:56 - 09:26 |
| Sampling Dates | - | 15/10/2019 |
| Sampling Device | - | ISO |
| Volume Sampled (REF) | $m^3$ | 1.9539 |
| Laboratory Result for Front Impingers | µg/ml | 26.53 |
| Laboratory Result for Back Impinger | µg/ml | 10.47 |
| Volume in Front Impingers | ml | 211.8 |
| Volume in Back Impinger | ml | 101.2 |
| Mass in Front Impingers | µg | 5619.1 |
| Mass in Back Impinger | µg | 1059.6 |
| Total Mass Collected | µg | 6678.6 |
| Calculated Concentration | $mg/m^3$ | 3.42 |

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

## Blank Runs

| Parameter | Units | Blank 1 |
|---|---|---|
| Blank Dates | - | 15/10/2019 |
| Average Volume Sampled (REF) | $m^3$ | 1.9539 |
| Laboratory Result for Impingers | µg/ml | < 0.05 |
| Volume in Impingers | ml | 308.2 |
| Total Mass Collected | µg | < 15.4 |
| Calculated Concentration | $mg/m^3$ | < 0.01 |

# SULPHUR DIOXIDE: QUALITY ASSURANCE



## Sample Runs

| Leak Test Results | Units | Run 1 |
|---|---|---|
| Mean Sampling Rate | l/min | 23.4 |
| Pre-Sampling Leak Rate | l/min | 0.10 |
| Post-Sampling Leak Rate | l/min | 0.10 |
| Allowable Leak Rate | l/min | 0.47 |
| Leak Test Acceptable | - | Yes |

| Absorption Efficiency | Units | Run 1 |
|---|---|---|
| Absorption Efficiency | % | 84.1 |
| Allowable Absorption Efficiency | % | 95 |
| Absorption Efficiency Acceptable | - | No |

| Water Droplets | Units | Run 1 |
|---|---|---|
| Are Water Droplets Present | - | No |

| MU (Concurrent Water Vapour) | Units | Run 1 |
|---|---|---|
| Measurement Uncertainty (MU) | % | 5.5 |
| 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 | % | 102.9 |
| Allowable Isokinetic Range | % | 95 - 115 |
| Isokineticity Acceptable | - | Yes |

| Filter Temperatures | Units | Run 1 |
|---|---|---|
| Maximum Filter Temperature | °C | 30 |

| Test Conditions | Units | Run 1 |
|---|---|---|
| Ambient Temperature Recorded? | - | Yes |

# SULPHUR DIOXIDE: QUALITY ASSURANCE



## Blank Runs

| Leak Test Results | Units | Blank 1 |
|---|---|---|
| Expected Sampling Rate | l/min | 18.0 |
| Pre-Sampling Leak Rate | l/min | 0.10 |
| Post-Sampling Leak Rate | l/min | 0.10 |
| Allowable Leak Rate | l/min | 0.36 |
| Leak Test Acceptable | - | Yes |

| Validity of Blank vs ELV | Units | Blank 1 |
|---|---|---|
| Allowable Blank | mg/m³ | N/A |
| Blank Acceptable | - | N/A |

## Method Deviations

| Nature of Deviation (x = deviation applies to the associated run, wx = deviation also applies to the concurrent water vapour run) | Run Number | |
|---|---|---|
| | 1 | |
| The absorption efficiency was less than the required 90%. [75 - 90%] | wx | |

## SULPHUR DIOXIDE: MEASUREMENT UNCERTAINTY CALCULATIONS

| | Value | | Standard uncertainty | | |
|---|---|---|---|---|---|
| **Measured Quantities** | **Symbol** | **Run 1** | **Symbol** | **Units** | **Run 1** |
| Sampled Volume (Actual) | $V_m$ | 2.1490 | $uV_m$ | $m^3$ | 0.0430 |
| Sampled Gas Temperature | $T_m$ | 291.0 | $uT_m$ | K | 2.0 |
| Sampled Gas Pressure | $\rho_m$ | 99.0 | $u\rho_m$ | kPa | 0.5 |
| Sampled Gas Humidity | $H_m$ | 0.0 | $uH_m$ | % v/v | 1.0 |
| Leak | L | 0.43 | uL | % | - |
| Laboratory Result | $L_r$ | 2.90 | $uL_r$ | % | - |

| | Uncertainty as a Percentage | | |
|---|---|---|---|
| **Measured Quantities** | **Units** | **Run 1** | **Requirement of Standard** |
| Sampled Volume (Actual) | % | 2.00 | ≤2% |
| Sampled Gas Temperature | % | 0.69 | ≤1% |
| Sampled Gas Pressure | % | 0.50 | ≤1% |
| Sampled Gas Humidity | % | 1.00 | ≤1% |
| Leak | % | 0.43 | ≤2% |
| Laboratory Result | % | 2.90 | No Requirement |

| | Uncertainty in Measurement Units | | | Sensitivity Coefficient |
|---|---|---|---|---|
| **Measured Quantities** | **Symbol** | **Units** | **Run 1** | **Run 1** |
| Sampled Volume (STP) | $V_m$ | $m^3$ | 1.9371 | 1.76 |
| Leak | L | $mg/m^3$ | 0.008 | 1.00 |
| Laboratory Result | $L_r$ | $mg/m^3$ | 0.099 | 1.00 |

| | Uncertainty in Result | |
|---|---|---|
| **Measured Quantities** | **Units** | **Run 1** |
| Sampled Volume (STP) | $mg/m^3$ | 0.088 |
| Leak | $mg/m^3$ | 0.0084 |
| Laboratory Result | $mg/m^3$ | 0.0991 |

| | 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 | $mg/m^3$ | 0.13 |
| Expanded uncertainty (95% confidence), without Oxygen Correction | $mg/m^3$ | 0.26 |
| Expanded uncertainty (95% confidence), with Oxygen Correction | $mg/m^3$ | N/A |
| Expanded uncertainty (95% confidence), estimated with Method Deviations | $mg/m^3$ | 0.31 |
| Reported Uncertainty | $mg/m^3$ | 0.31 |
| Expanded uncertainty (95% confidence), without Oxygen Correction | % | 7.6 |
| Expanded uncertainty (95% confidence), with Oxygen Correction | % | N/A |
| Expanded uncertainty (95% confidence), estimated with Method Deviations | % | 9.1 |
| Reported Uncertainty | % | 9.1 |

# HEAVY METALS: RESULTS SUMMARY

Federal-Mogul Coventry Ltd, Coventry
Main Stack

## Sample Runs

| Parameter | Units | Run 1 | | Mean |
|---|---|---|---|---|
| Concentration | mg/m³ | 0.02 | | 0.02 |
| Uncertainty | ±mg/m³ | 0.005 | | 0.005 |
| Mass Emission | g/hr | 0.09 | | 0.09 |
| Uncertainty | ±g/hr | 0.02 | | 0.02 |

| Parameter | Units | Run 1 | | Mean |
|---|---|---|---|---|
| Water Vapour | % v/v | 2.3 | | 2.3 |
| Uncertainty | ±% v/v | 0.14 | | 0.14 |

## Blank Runs

| Parameter | Units | Blank 1 | | Maximum |
|---|---|---|---|---|
| Concentration | mg/m³ | 0.003 | | 0.003 |

## General Sampling Information

| Parameter | Value | |
|---|---|---|
| Standard | EN 14385 | |
| Technical Procedure | CAT-TP-06 | |
| Name of Analytical Laboratory | EET | |
| Analytical Laboratory's Procedure | CAT-AP-07 | |
| ISO 17025 Accredited Analysis? | Yes | |
| Date of Sample Analysis | 25/10/2019 | |
| Probe Material | Titanium | |
| Filter Housing Material | Titanium | |
| Impinger Material | Borosilicate Glass | |
| Absorption Solution | Nitric Peroxide | |
| Positioning of Filter | Out Stack | |
| Filter Size and Material | 47mm Quartz Fibre | |
| Number of Sampling Lines Used | 1 / 1 | FORMAT: Number Used / Number Required |
| Number of Sampling Points Used | 1 / 1 | FORMAT: Number Used / Number Required |
| Sample Point I.D.'s | A1 | |

## Reference Conditions

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

## HEAVY METALS: ISOKINETIC SAMPLING CALCULATIONS

| Test | Units | Run 1 | |
|---|---|---|---|
| **Absolute pressure of stack gas, $P_s$** | | | |
| Barometric pressure, $P_b$ | mmHg | 741.8 | |
| Stack static pressure, $P_{static}$ | $mmH_2O$ | 11.2 | |
| $P_s = (P_b + (P_{static} / 13.6)$ | mmHg | 742.6 | |
| **Volume of water vapour collected, $V_{wstd}$** | | | |
| Total mass collected in impingers (liquid trap) | g | 31.5 | |
| Total mass collected in impingers (silica trap) | g | 6.5 | |
| Total mass of liquid collected, $V_{lc}$ | g | 38.0 | |
| $V_{wstd} = (0.001246)(V_{lc})$ | $m^3$ | 0.0473 | |
| **Volume of gas metered dry, $V_{mstd}$** | | | |
| Volume of gas sample through gas meter, $V_m$ | $m^3$ | 2.2990 | |
| Gas meter correction factor, $Y_d$ | - | 0.9790 | |
| Average dry gas meter temperature, $T_m$ | °C | 21.3 | |
| Average pressure drop across orifice, ΔH | $mmH_2O$ | 57.5 | |
| $V_{mstd} = ((0.3592)(V_m)(P_b + (\Delta H/13.6))(Y_d)) / (T_m + 273)$ | $m^3$ | 2.0490 | |
| **Moisture content, $B_{wo}$ & $R_{wv}$** | | | |
| $B_{wo} = V_{wstd} / (V_{mstd} + V_{wstd})$ | $m^3$ | 0.0226 | |
| $B_{wo}$ as a percentage | % v/v | 2.26 | |
| Reported Water Vapour, checked with Tables in EN 14790, Rwv | % v/v | 2.26 | |
| **Volume of gas metered wet, $V_{mstw}$** | | | |
| $V_{mstw} = (V_{mstd})(100/(100 - R_{wv}))$ | $m^3$ | 2.0964 | |
| **Volume of gas metered at Oxygen Reference Conditions, $V_{mstd@X\%O_2}$ & $V_{mstw@X\%O_2}$** | | | |
| IED & Incinerates Hazardous Material? (Yes = no positive $O_2$ correction) | - | No | |
| % wet oxygen measured in gas stream, $ACT\%O_{2w}$ | % v/v | N/A | |
| % dry oxygen measured in gas stream, $ACT\%O_{2d}$ | % v/v | N/A | |
| % oxygen reference condition, $REF\%O_2$ | % v/v | N/A | |
| $O_2$ Reference Factor wet $(O_{2REFw}) = (21 - REF\%O_2) / (21 - ACT\%O_{2w})$ | - | N/A | |
| $O_2$ Reference Factor dry $(O_{2REFd}) = (21 - REF\%O_2) / (21 - ACT\%O_{2d})$ | - | N/A | |
| $V_{mstw@X\%oxygen} = (V_{mstw}) / (O_{2REFw})$ | $m^3$ | N/A | |
| $V_{mstd@X\%oxygen} = (V_{mstd}) / (O_{2REFd})$ | $m^3$ | N/A | |
| **Molecular weight of dry gas stream, $M_d$** | | | |
| $CO_2$ (Estimated) | % v/v | 2.00 | |
| $O_2$ (Estimated) | % v/v | 19.00 | |
| Total | % v/v | 21.00 | |
| $N_2$ | % v/v | 79.00 | |
| $M_d = 0.44(\%CO_2)+0.32(\%O_2)+0.28(\%N_2)$ | g/gmol | 29.08 | |
| **Molecular weight of stack gas (wet), $M_s$** | | | |
| $M_s = M_d(1 - (R_{wv}/100)) + 18(R_{wv}/100)$ | g/gmol | 28.83 | |
| **Velocity of stack gas, $V_s$** | | | |
| Pitot tube velocity constant, $K_p$ | - | 34.97 | |
| Velocity pressure coefficient, $C_p$ | - | 0.86 | |
| Average of velocity heads, $\Delta P_{avg}$ | $mmH_2O$ | 34.00 | |
| Average square root of velocity heads, √ΔP | $\sqrt{mmH_2O}$ | 5.83 | |
| Average stack gas temperature, $T_s$ | °C | 26.7 | |
| $V_s = ((K_p)(C_p)(\sqrt{\Delta P})(\sqrt{T_s} + 273)) / (\sqrt{(M_s)(P_s)})$ | m/s | 20.68 | |
| **Total flow of stack gas: Actual ($Q_a$), Wet ($Q_{stw}$), Dry ($Q_{std}$), Wet@$O_{2REF}$ ($Q_{stwO_2}$), Dry@$O_{2REF}$ ($Q_{stdO_2}$)** | | | |
| Area of stack, $A_s$ | $m^2$ | 0.06 | |
| $Q_a = (60)(A_s)(V_s)$ | $m^3$/min | 76.4 | |
| Conversion factor (K/mm.Hg), $C_f$ | - | 0.3592 | |
| $Q_{stw} = ((Q_a)(P_s)(C_f)) / ((T_s) + 273)$ | $m^3$/min | 68.0 | |
| $Q_{std} = ((Q_a)(P_s)(C_f)(1 - (R_{wv}/100))) / ((T_s) + 273)$ | $m^3$/min | 66.5 | |
| $Q_{stwO_2} = ((Q_a)(P_s)(C_f)) / ((T_s) + 273) / (O_{2REFw})$ | $m^3$/min | N/A | |
| $Q_{stdO_2} = ((Q_a)(P_s)(C_f)(1 - (R_{wv}/100))) / ((T_s) + 273) / (O_{2REFd})$ | $m^3$/min | N/A | |
| **Percent isokinetic, %I** | | | |
| Nozzle diameter, $D_n$ | mm | 4.95 | |
| Nozzle area, $A_n$ | $mm^2$ | 19.25 | |
| Total sampling time, q | min | 95 | |
| $\%I = (4.6398E^{6})(T_s+273)(V_{mstd}) / (P_s)(V_s)(A_n)(q)(1 - (R_{wv}/100))$ | % | 103.8 | |

# HEAVY METALS: SAMPLING DETAILS



## Sample Runs

| Parameter | Units | Run 1 |
|---|---|---|
| Sampling Times | - | 10:54 - 12:29 |
| Sampling Dates | - | 15/10/2019 |
| Sampling Device | - | ISO |
| Volume Sampled (REF) | $m^3$ | 2.0964 |
| **Arsenic** | | |
| Mass on Filter / in Rinse | µg | < 0.50 |
| Mass in Front Impingers | µg | < 0.08 |
| Mass in Back Impinger | µg | 0.04 |
| Total Mass Collected | µg | 0.63 |
| Calculated Concentration | $mg/m^3$ | 0.0003 |
| Reported Concentration | $mg/m^3$ | 0.0003 |
| Mass Emission | g/hr | 0.00 |
| **Cobalt** | | |
| Mass on Filter / in Rinse | µg | 0.51 |
| Mass in Front Impingers | µg | 0.76 |
| Mass in Back Impinger | µg | 0.13 |
| Total Mass Collected | µg | 1.40 |
| Calculated Concentration | $mg/m^3$ | 0.0007 |
| Reported Concentration | $mg/m^3$ | 0.0007 |
| Mass Emission | g/hr | 0.00 |
| **Chromium** | | |
| Mass on Filter / in Rinse | µg | 0.95 |
| Mass in Front Impingers | µg | 0.52 |
| Mass in Back Impinger | µg | 0.30 |
| Total Mass Collected | µg | 1.77 |
| Calculated Concentration | $mg/m^3$ | 0.0008 |
| Reported Concentration | $mg/m^3$ | 0.0008 |
| Mass Emission | g/hr | 0.00 |
| **Copper** | | |
| Mass on Filter / in Rinse | µg | 11.09 |
| Mass in Front Impingers | µg | 0.61 |
| Mass in Back Impinger | µg | 0.10 |
| Total Mass Collected | µg | 11.80 |
| Calculated Concentration | $mg/m^3$ | 0.0056 |
| Reported Concentration | $mg/m^3$ | 0.0056 |
| Mass Emission | g/hr | 0.02 |
| **Manganese** | | |
| Mass on Filter / in Rinse | µg | 20.52 |
| Mass in Front Impingers | µg | 1.32 |
| Mass in Back Impinger | µg | 0.21 |
| Total Mass Collected | µg | 22.05 |
| Calculated Concentration | $mg/m^3$ | 0.0105 |
| Reported Concentration | $mg/m^3$ | 0.0105 |
| Mass Emission | g/hr | 0.04 |

## HEAVY METALS: SAMPLING DETAILS

(PAGE 2 OF 5)

**Sample Runs (continued)**

| Parameter | Units | Run 1 | |
|---|---|---|---|
| **Nickel** | | | |
| Mass on Filter / in Rinse | µg | 1.16 | |
| Mass in Front Impingers | µg | 0.19 | |
| Mass in Back Impinger | µg | < 0.03 | |
| Total Mass Collected | µg | 1.37 | |
| Calculated Concentration | mg/m³ | 0.0007 | |
| Reported Concentration | mg/m³ | 0.0007 | |
| Mass Emission | g/hr | 0.00 | |
| **Lead** | | | |
| Mass on Filter / in Rinse | µg | 3.99 | |
| Mass in Front Impingers | µg | 1.65 | |
| Mass in Back Impinger | µg | 0.46 | |
| Total Mass Collected | µg | 6.10 | |
| Calculated Concentration | mg/m³ | 0.0029 | |
| Reported Concentration | mg/m³ | 0.0029 | |
| Mass Emission | g/hr | 0.01 | |
| **Antimony** | | | |
| Mass on Filter / in Rinse | µg | < 0.60 | |
| Mass in Front Impingers | µg | < 0.06 | |
| Mass in Back Impinger | µg | < 0.03 | |
| Total Mass Collected | µg | < 0.69 | |
| Calculated Concentration | mg/m³ | < 0.0003 | |
| Reported Concentration | mg/m³ | < 0.0003 | |
| Mass Emission | g/hr | < 0.00 | |
| **Vanadium** | | | |
| Mass on Filter / in Rinse | µg | < 0.40 | |
| Mass in Front Impingers | µg | < 0.03 | |
| Mass in Back Impinger | µg | < 0.01 | |
| Total Mass Collected | µg | < 0.44 | |
| Calculated Concentration | mg/m³ | < 0.0002 | |
| Reported Concentration | mg/m³ | < 0.0002 | |
| Mass Emission | g/hr | < 0.00 | |

# HEAVY METALS: SAMPLING DETAILS



## Sample Runs (continued)

| Parameter | Units | Run 1 |
|---|---|---|
| **Heavy Metals Combined** | | |
| Total Mass Collected | µg | 46.25 |
| Calculated Concentration | mg/m³ | 0.0221 |
| Reported Concentration | mg/m³ | 0.0221 |

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

## Blank Runs

| Parameter | Units | Blank 1 |
|---|---|---|
| Blank Dates | - | 15/10/2019 |
| Average Volume Sampled (REF) | m³ | 2.0964 |
| **Arsenic** | | |
| Mass on Filter / in Rinse | µg | < 0.50 |
| Mass in Front Impingers | µg | < 0.06 |
| Mass in Back Impinger | µg | < 0.03 |
| Total Mass Collected | µg | < 0.59 |
| Calculated Concentration | mg/m³ | < 0.0003 |
| Reported Concentration | mg/m³ | < 0.0003 |
| **Cobalt** | | |
| Mass on Filter / in Rinse | µg | < 0.50 |
| Mass in Front Impingers | µg | < 0.04 |
| Mass in Back Impinger | µg | < 0.02 |
| Total Mass Collected | µg | < 0.56 |
| Calculated Concentration | mg/m³ | < 0.0003 |
| Reported Concentration | mg/m³ | < 0.0003 |

## HEAVY METALS: SAMPLING DETAILS



**Blank Runs (continued)**

| Parameter | Units | Blank 1 | |
|---|---|---|---|
| **Chromium** | | | |
| Mass on Filter / in Rinse | µg | < 0.60 | |
| Mass in Front Impingers | µg | < 0.02 | |
| Mass in Back Impinger | µg | < 0.01 | |
| Total Mass Collected | µg | < 0.63 | |
| Calculated Concentration | mg/m³ | < 0.0003 | |
| Reported Concentration | mg/m³ | < 0.0003 | |
| **Copper** | | | |
| Mass on Filter / in Rinse | µg | < 0.60 | |
| Mass in Front Impingers | µg | < 0.08 | |
| Mass in Back Impinger | µg | < 0.04 | |
| Total Mass Collected | µg | < 0.73 | |
| Calculated Concentration | mg/m³ | < 0.0003 | |
| Reported Concentration | mg/m³ | < 0.0003 | |
| **Manganese** | | | |
| Mass on Filter / in Rinse | µg | < 0.40 | |
| Mass in Front Impingers | µg | < 0.04 | |
| Mass in Back Impinger | µg | 0.03 | |
| Total Mass Collected | µg | < 0.48 | |
| Calculated Concentration | mg/m³ | < 0.0002 | |
| Reported Concentration | mg/m³ | < 0.0002 | |
| **Nickel** | | | |
| Mass on Filter / in Rinse | µg | 0.75 | |
| Mass in Front Impingers | µg | < 0.04 | |
| Mass in Back Impinger | µg | < 0.02 | |
| Total Mass Collected | µg | 0.81 | |
| Calculated Concentration | mg/m³ | 0.0004 | |
| Reported Concentration | mg/m³ | 0.0004 | |
| **Lead** | | | |
| Mass on Filter / in Rinse | µg | < 0.50 | |
| Mass in Front Impingers | µg | < 0.04 | |
| Mass in Back Impinger | µg | < 0.02 | |
| Total Mass Collected | µg | < 0.56 | |
| Calculated Concentration | mg/m³ | < 0.0003 | |
| Reported Concentration | mg/m³ | < 0.0003 | |
| **Antimony** | | | |
| Mass on Filter / in Rinse | µg | < 0.60 | |
| Mass in Front Impingers | µg | < 0.04 | |
| Mass in Back Impinger | µg | < 0.02 | |
| Total Mass Collected | µg | < 0.66 | |
| Calculated Concentration | mg/m³ | < 0.0003 | |
| Reported Concentration | mg/m³ | < 0.0003 | |
| **Vanadium** | | | |
| Mass on Filter / in Rinse | µg | < 0.40 | |
| Mass in Front Impingers | µg | < 0.02 | |
| Mass in Back Impinger | µg | < 0.01 | |
| Total Mass Collected | µg | < 0.43 | |
| Calculated Concentration | mg/m³ | < 0.0002 | |
| Reported Concentration | mg/m³ | < 0.0002 | |

# HEAVY METALS: SAMPLING DETAILS



**Blank Runs (continued)**

| Parameter | Units | Blank 1 | |
|---|---|---|---|
| **Heavy Metals Combined** | | | |
| Total Mass Collected | µg | 5.46 | |
| Calculated Concentration | mg/m³ | 0.0026 | |
| Reported Concentration | mg/m³ | 0.0026 | |

# HEAVY METALS: QUALITY ASSURANCE



## Sample Runs

| Leak Test Results | Units | Run 1 |
|---|---|---|
| Mean Sampling Rate | l/min | 23.7 |
| Pre-Sampling Leak Rate | l/min | 0.10 |
| Post-Sampling Leak Rate | l/min | 0.10 |
| Allowable Leak Rate | l/min | 0.47 |
| Leak Test Acceptable | - | Yes |

| Absorption Efficiency | Units | Run 1 |
|---|---|---|
| Arsenic | % | 93.0 |
| Cobalt | % | 91.0 |
| Chromium | % | 82.9 |
| Copper | % | 99.2 |
| Manganese | % | 99.1 |
| Nickel | % | 100.0 |
| Lead | % | 92.4 |
| Antimony | % | 100.0 |
| Vanadium | % | N/A <1% Total |
| Allowable Absorption Efficiency | % | 90 |
| Absorption Efficiency Acceptable | - | No |

| Detection Limit | Units | Run 1 |
|---|---|---|
| Arsenic | µg/m³ | 0.3 |
| Cobalt | µg/m³ | 0.3 |
| Chromium | µg/m³ | 0.3 |
| Copper | µg/m³ | 0.4 |
| Manganese | µg/m³ | 0.2 |
| Nickel | µg/m³ | 0.3 |
| Lead | µg/m³ | 0.3 |
| Antimony | µg/m³ | 0.3 |
| Vanadium | µg/m³ | 0.2 |
| Allowable Detection Limit | µg/m³ | 5 |
| Detection Limit Acceptable | - | Yes |

| Water Droplets | Units | Run 1 |
|---|---|---|
| Are Water Droplets Present | - | No |

| MU (Concurrent Water Vapour) | Units | Run 1 |
|---|---|---|
| Measurement Uncertainty (MU) | % | 6.3 |
| Allowable MU | % | 20.0 |
| MU Acceptable | % | Yes |

# HEAVY METALS: QUALITY ASSURANCE

(PAGE 2 OF 2)

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

| Isokinetic Criterion Compliance | Units | Run 1 |
|---|---|---|
| Isokinetic Variation | % | 103.8 |
| Allowable Isokinetic Range | % | 95 - 115 |
| Isokineticity Acceptable | - | Yes |

| Filter Temperatures | Units | Run 1 |
|---|---|---|
| Maximum Filter Temperature | °C | 160 |

| Impingers Exit Temperature | Units | Run 1 |
|---|---|---|
| Maximum Temperature Recorded | °C | 18 |
| Maximum Allowable Temperature | °C | 30 |
| Exit Temperature Acceptable | - | Yes |

| Test Conditions | Units | Run 1 |
|---|---|---|
| Ambient Temperature Recorded? | - | Yes |

## Blank Runs

| Leak Test Results | Units | Blank 1 |
|---|---|---|
| Expected Sampling Rate | l/min | 20.0 |
| Pre-Sampling Leak Rate | l/min | 0.10 |
| Post-Sampling Leak Rate | l/min | 0.10 |
| Allowable Leak Rate | l/min | 0.40 |
| Leak Test Acceptable | - | Yes |

| Validity of Blank vs ELV | Units | Blank 1 |
|---|---|---|
| Allowable Blank | $mg/m^3$ | 0.01 |
| Blank Acceptable | - | Yes |

## Method Deviations

| Nature of Deviation (x = deviation applies to the associated run, wx = deviation also applies to the concurrent water vapour run) | Run Number 1 |
|---|---|
| The absorption efficiency was less than the required 90%. [75 - 90%] | wx |

## HEAVY METALS: MEASUREMENT UNCERTAINTY CALCULATIONS

| | Value | | | Standard uncertainty | | |
|---|---|---|---|---|---|---|
| **Measured Quantities** | **Symbol** | **Run 1** | | **Symbol** | **Units** | **Run 1** |
| Sampled Volume (Actual) | $V_m$ | 2.2990 | | $uV_m$ | $m^3$ | 0.0460 |
| Sampled Gas Temperature | $T_m$ | 294.3 | | $uT_m$ | K | 2.0 |
| Sampled Gas Pressure | $\rho_m$ | 99.0 | | $u\rho_m$ | kPa | 0.5 |
| Sampled Gas Humidity | $H_m$ | 0.0 | | $uH_m$ | % v/v | 1.0 |
| Leak | L | 0.42 | | uL | % | - |
| Laboratory Result | $L_r$ | 9.60 | | $uL_r$ | % | - |

| | Uncertainty as a Percentage | | |
|---|---|---|---|
| **Measured Quantities** | **Units** | **Run 1** | **Requirement of Standard** |
| Sampled Volume (Actual) | % | 2.00 | ≤2% |
| Sampled Gas Temperature | % | 0.68 | ≤1% |
| Sampled Gas Pressure | % | 0.50 | ≤1% |
| Sampled Gas Humidity | % | 1.00 | ≤1% |
| Leak | % | 0.42 | ≤2% |
| Laboratory Result | % | 9.60 | No Requirement |

| | Uncertainty in Measurement Units | | | Sensitivity Coefficient |
|---|---|---|---|---|
| **Measured Quantities** | **Symbol** | **Units** | **Run 1** | **Run 1** |
| Sampled Volume (STP) | $V_m$ | $m^3$ | 2.0490 | 0.01 |
| Leak | L | $mg/m^3$ | 0.000 | 1.00 |
| Laboratory Result | $L_r$ | $mg/m^3$ | 0.002 | 1.00 |

| | Uncertainty in Result | |
|---|---|---|
| **Measured Quantities** | **Units** | **Run 1** |
| Sampled Volume (STP) | $mg/m^3$ | 0.001 |
| Leak | $mg/m^3$ | 0.0001 |
| Laboratory Result | $mg/m^3$ | 0.0021 |

| | Oxygen Correction Part of MU Budget | |
|---|---|---|
| **Measured Quantities** | **Units** | **Run 1** |
| $O_2$ Correction Factor | - | N/A |
| Stack Gas $O_2$ Content | % v/v | N/A |
| MU for $O_2$ Correction | - | N/A |
| Overall MU For $O_2$ Measurement | % | N/A |

| **Parameter** | **Units** | **Run 1** |
|---|---|---|
| Combined uncertainty | $mg/m^3$ | 0.002 |
| Expanded uncertainty (95% confidence), without Oxygen Correction | $mg/m^3$ | 0.004 |
| Expanded uncertainty (95% confidence), with Oxygen Correction | $mg/m^3$ | N/A |
| Expanded uncertainty (95% confidence), estimated with Method Deviations | $mg/m^3$ | 0.005 |
| Reported Uncertainty | $mg/m^3$ | 0.005 |
| Expanded uncertainty (95% confidence), without Oxygen Correction | % | 19.5 |
| Expanded uncertainty (95% confidence), with Oxygen Correction | % | N/A |
| Expanded uncertainty (95% confidence), estimated with Method Deviations | % | 23.4 |
| Reported Uncertainty | % | 23.4 |

# HYDROGEN SULPHIDE: RESULTS SUMMARY

Federal-Mogul Coventry Ltd, Coventry

Main Stack

## Sample Runs

| Parameter | Units | Run 1 | | Mean |
|---|---|---|---|---|
| Concentration | mg/m³ | < 0.34 | | < 0.34 |
| Uncertainty | ±mg/m³ | 0.04 | | 0.04 |
| Mass Emission | g/hr | < 1.4 | | < 1.4 |
| Uncertainty | ±g/hr | 0.19 | | 0.19 |

NOTE: Where the maximum Blank concentration is higher than the Sample concentration, the Blank concentration has been reported.

| Parameter | Units | Run 1 | | Mean |
|---|---|---|---|---|
| Water Vapour | % v/v | 1.5 | | 1.5 |
| Uncertainty | ±% v/v | 0.07 | | 0.07 |

## Blank Runs

| Parameter | Units | Blank 1 | | Maximum |
|---|---|---|---|---|
| Concentration | mg/m³ | < 0.34 | | < 0.34 |

## General Sampling Information

| Parameter | Value | |
|---|---|---|
| Standard | US EPA M11 | |
| Technical Procedure | CAT-TP-15 | |
| Name of Analytical Laboratory | RPS | |
| Analytical Laboratory's Procedure | M120 | |
| ISO 17025 Accredited Analysis? | Yes | |
| Date of Sample Analysis | 13/11/2019 | |
| Probe Material | Titanium | |
| Filter Housing Material | Titanium | |
| Impinger Material | Borosilicate Glass | |
| Absorption Solution | Zinc Acetate 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 | B1 | |

## Reference Conditions

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

# HYDROGEN SULPHIDE: SAMPLING DETAILS

## Sample Runs

| Parameter | Units | Run 1 |
|---|---|---|
| Sampling Times | - | 10:54 - 12:29 |
| Sampling Dates | - | 15/10/2019 |
| Sampling Device | - | MFC / MV |
| Duration | mins | 95 |
| Volume Sampled (STP, Dry) | $m^3$ | 0.9234 |
| Volume Sampled (STP, Wet) | $m^3$ | 0.9379 |
| Volume Sampled (REF) | $m^3$ | 0.9379 |
| Sample Flow Rate | l/min | 9.66 |
| Laboratory Result for Front Impingers | µg/ml | < 1.00 |
| Laboratory Result for Back Impinger | µg/ml | < 1.00 |
| Volume in Front Impingers | ml | 206.6 |
| Volume in Back Impinger | ml | 104.9 |
| Mass in Front Impingers | µg | < 206.6 |
| Mass in Back Impinger | µg | < 104.9 |
| Total Mass Collected | µg | < 311.5 |
| Calculated Concentration | $mg/m^3$ | < 0.33 |
| Liquid Trap Start Mass | g | 3833.9 |
| Liquid Trap End Mass | g | 3839.3 |
| Silica Trap Start Mass | g | 796.0 |
| Silica Trap End Mass | g | 802.2 |
| Total Mass Of Water Vapour | g | 11.6 |
| Calculated Water Vapour | % v/v | 1.54 |

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

## Blank Runs

| Parameter | Units | Blank 1 |
|---|---|---|
| Blank Dates | - | 15/10/2019 |
| Average Volume Sampled (REF) | $m^3$ | 0.9379 |
| Laboratory Result for Impingers | µg/ml | < 1.00 |
| Volume in Impingers | ml | 321.0 |
| Total Mass Collected | µg | < 321.0 |
| Calculated Concentration | $mg/m^3$ | < 0.34 |

# HYDROGEN SULPHIDE: QUALITY ASSURANCE

## Sample Runs

| Leak Test Results | Units | Run 1 |
|---|---|---|
| Mean Sampling Rate | l/min | 9.7 |
| Pre-Sampling Leak Rate | l/min | 0.01 |
| Post-Sampling Leak Rate | l/min | 0.01 |
| Allowable Leak Rate | l/min | 0.19 |
| 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) | % | 4.5 |
| Allowable MU | % | 20.0 |
| MU Acceptable | % | Yes |

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

| Test Conditions | Units | Run 1 |
|---|---|---|
| Ambient Temperature Recorded? | - | Yes |

## Blank Runs

| Leak Test Results | Units | Blank 1 |
|---|---|---|
| Expected Sampling Rate | l/min | 9.0 |
| Pre-Sampling Leak Rate | l/min | 0.01 |
| Post-Sampling Leak Rate | l/min | 0.01 |
| Allowable Leak Rate | l/min | 0.18 |
| Leak Test Acceptable | - | Yes |

| Validity of Blank vs ELV | Units | Blank 1 |
|---|---|---|
| Allowable Blank | mg/m³ | 0.5 |
| Blank Acceptable | - | Yes |

## Method Deviations

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

## HYDROGEN SULPHIDE: MEASUREMENT UNCERTAINTY CALCULATIONS

| | Value | | Standard uncertainty | | |
|---|---|---|---|---|---|
| **Measured Quantities** | **Symbol** | **Run 1** | **Symbol** | **Units** | **Run 1** |
| Sampled Volume (STP) | $V_m$ | 0.9234 | $uV_m$ | $m^3$ | 0.0185 |
| Leak | L | 0.10 | 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 | % | 0.10 | ≤2% |
| Laboratory Result | % | 6.00 | No Requirement |

| | Uncertainty in Measurement Units | | | Sensitivity Coefficient |
|---|---|---|---|---|
| **Measured Quantities** | **Symbol** | **Units** | **Run 1** | **Run 1** |
| Sampled Volume (STP) | $V_m$ | $m^3$ | 0.9234 | 0.37 |
| Leak | L | $mg/m^3$ | 0.000 | 1.00 |
| Laboratory Result | $L_r$ | $mg/m^3$ | 0.021 | 1.00 |

| | Uncertainty in Result | |
|---|---|---|
| **Measured Quantities** | **Units** | **Run 1** |
| Sampled Volume (STP) | $mg/m^3$ | 0.007 |
| Leak | $mg/m^3$ | 0.0002 |
| Laboratory Result | $mg/m^3$ | 0.0205 |

| | 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 | $mg/m^3$ | 0.02 |
| Expanded uncertainty (95% confidence), without Oxygen Correction | $mg/m^3$ | 0.04 |
| Expanded uncertainty (95% confidence), with Oxygen Correction | $mg/m^3$ | N/A |
| Expanded uncertainty (95% confidence), estimated with Method Deviations | $mg/m^3$ | 0.04 |
| Reported Uncertainty | $mg/m^3$ | 0.04 |
| Expanded uncertainty (95% confidence), without Oxygen Correction | % | 12.4 |
| Expanded uncertainty (95% confidence), with Oxygen Correction | % | N/A |
| Expanded uncertainty (95% confidence), estimated with Method Deviations | % | 12.4 |
| Reported Uncertainty | % | 12.4 |

APPENDIX 2

# ODOUR: RESULTS SUMMARY

Federal-Mogul Coventry Ltd, Coventry

Release Point 1 - Main Stack

## Results Summary

| Parameter | Units | Bag 1 | Bag 2 | Bag 3 | GEO Mean |
|---|---|---|---|---|---|
| Concentration | ouE/m³ | 383 | 181 | 182 | 233 |
| Lower CI | ouE/m³ | | | | 147 |
| Upper CI | ouE/m³ | | | | 368 |
| Mass Emission | ouE/s | 432 | 204 | 205 | 263 |
| Lower CI | ouE/s | | | | 166 |
| Upper CI | ouE/s | | | | 415 |

## General Sampling Information

| Parameter | Value | |
|---|---|---|
| Standard | BS EN 13725 | |
| Technical Procedure | CAT-TP-30 | |
| Probe Material | PTFE | |
| Odour Presentation Mode | Yes / No | |
| Equipment Used | Odour Barrel | |
| Calibration Status of Olfactometer | 0.055 | |
| 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: 293K, 101.3kPa, without correction for water vapour content

## Sampling & Result Information

| | Parameter | Units | Bag 1 | Bag 2 | Bag 3 |
|---|---|---|---|---|---|
| Main Stack | Sampling Times | - | 09:00 - 09:06 | 09:07 - 09:13 | 09:15 - 09:21 |
| | Sampling Dates | - | 15/10/2019 | 15/10/2019 | 15/10/2019 |
| | Sample ID | - | EST-5182-Bag 1 | EST-5182-Bag 2 | EST-5182-Bag 3 |
| | Duration | mins | 6 | 6 | 6 |
| | Oxygen Content of the Stack Gas | % v/v | N/A | N/A | N/A |
| | Oxygen Content of the Odour Bag | % v/v | N/A | N/A | N/A |
| | Calculated Dilution Factor | : 1 | N/A | N/A | N/A |
| | Special Process Conditions | - | Pouring Process | | |
| | Date of Olfactometric Measurement | - | 16/10/2019 | 16/10/2019 | 16/10/2019 |
| | Times of Ofactometric Measurement | - | 12:06 | 12:19 | 12:28 |
| | Temperature of Olfactometric Lab | - | $25^{o}C \pm 3^{o}C$ | | |
| | ID of Olfactometer | - | EO9008 | | |
| | Calculated Panel Threshold | ouE/m³ | 383 | 181 | 182 |
| | Reference Odourant Used | - | n-butanol in $N_2$ | | |
| | Accepted Reference Value Used | ppb | 40 | | |
| | Analysis Result from Laboratory | ouE/m³ | 383 | 181 | 182 |
| | Analysis Result including Dilution Factor | ouE/m³ | 383 | 181 | 182 |

# ODOUR: METHOD DEVIATIONS

Federal-Mogul Coventry Ltd, Coventry

All Release Points

## Method Deviations

| Nature of Deviation (x = deviation applies to the associated bag/s) | Bag Numbers | | | |
|---|---|---|---|---|
| | 1 | 2 | 3 | |
| There are no deviations associated with the sampling employed. | x | x | x | |