



Title: Monitoring of Particulate and Gaseous Emissions

Permit Number: PPC/058
Operator: STADCO
Installation: ED Oven Exhaust Stack

Monitoring Dates: 29 January 2009
Reference Number: EI/4755

Client Organisation: STADCO
Address: Holbrook Lane
Coventry
CV6 4AW

Monitoring Organisation: CES Environmental Instruments Ltd
Address: Bretby Business Park
Ashby Road
Burton on Trent
Staffordshire
DE15 0YZ

Date of Report: 20 February 2009

Report Prepared By: David Slack
MCERTS Registration Number: MM 02 100 (Level 2, TE1, TE4)

Signed: [Redacted Signature]

Report Approved By: Robert Allen
MCERTS Registration Number: MM 02 009 (Level 2, TE1, TE2, TE3, TE4)

Signed: [Redacted Signature]

Part 1: Executive Summary

1.1 Monitoring Objectives

STADCO placed a contract with CES Environmental Instruments Ltd for the compliance check monitoring of emissions to air from the ED Oven Exhaust Stack.

ED Oven Exhaust Stack

The Contrapol incinerator installed by Stadco Coventry (Mayflower Vehicle Systems) has reached the end of its economic life. Heat for the process is derived via two Nu-Way burners, FMP15 (600KW) and FMP 25 (900KW) at a process temperature of 168 to 172 degrees centigrade. At present exhaust gases pass through the incinerator and are exhausted to atmosphere via the existing incinerator stack. The paint media has been upgraded to PPG'S next generation (6) of Powercron 6200. For the duration of the test the plant operated under normal working conditions with a cycle time of one load being dipped every 8 minutes.

The test work was undertaken on 29 January 2009 by CES Environmental Instruments Ltd Engineers and carried out as part of CES Environmental Instruments Ltd job reference EI/4755.

The substances monitored were:-

Particulate
Oxides of Nitrogen
Carbon Monoxide
Volatile Organic Compounds

On the day of testing there were no special requirements for the monitoring.

| Comparison of Operator CEMS and Periodic Monitoring Results | | | | | | | | |
|---|----------------------|----------------------------|-------------|-------------------|---------------------------|------------------|---------------------|----------------|
| Substance to be Monitored | Emission Limit Value | Periodic Monitoring Result | Uncertainty | Units | Reference Conditions | Date of Sampling | Start and End Times | CEMS Results |
| Particulate | Not Applicable | 2.2 | 0.73 | mg/m ³ | 273K, 101.3kPa, & Dry Gas | 29 January 2009 | 10:25-12:33 | None Available |
| Oxides of Nitrogen | 100 | 4.9 | 2.24 | mg/m ³ | 273K, 101.3kPa, & Dry Gas | 29 January 2009 | 12:55-14:54 | None Available |
| Carbon Monoxide | 100 | 25.2 | 1.61 | mg/m ³ | 273K, 101.3kPa, & Dry Gas | 29 January 2009 | 12:55-14:54 | None Available |
| Volatile Organic Compounds | Not Applicable | 69.6 | 2.33 | mg/m ³ | 273K, 101.3kPa, & Dry Gas | 29 January 2009 | 12:55-14:54 | None Available |

1.4 Monitoring Deviations

The sample plane does not comply upstream and downstream and does not have the appropriate sample ports fitted as per the requirements of BS EN 13284-1.

CES Environmental Instruments Ltd staff details

| Name | Role | MCERT Registration Number | Level 1 | Level 2 | TE1 | TE2 | TE3 | TE4 | Testing On Site |
|---------------|-------------|---------------------------|---------|-------------|-------------|-------------|-------------|-------------|-----------------|
| Robert Allen | Team Leader | MM 02 009 | | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| | | | | 20 Nov 2012 | 20 Nov 2012 | 03 Dec 2013 | 03 Dec 2013 | 20 Nov 2012 | |
| Shane Elton | Team Leader | MM 04 532 | | ✓ | ✓ | | | ✓ | ✓ |
| | | | | 14 Dec 2011 | 14 Dec 2011 | | | 14 Mar 2013 | |
| Adam Orme | Technician | MM 04 530 | ✓ | | | | | | ✓ |
| | | | | 20 Mar 2011 | | | | | |
| Robert Parker | Technician | MM 09 1009 Trainee | | | | | | | ✓ |
| Richard Allen | Technician | Trainee | | | | | | | ✓ |

CES Environmental Instruments Ltd method details

| Pollutant | Method | CES Procedure |
|----------------------------|---------------|---------------|
| Particulate | BS EN 13284-1 | WI 4/1 |
| Oxides of Nitrogen | BS EN 14792 | WI 4/39 |
| Carbon Monoxide | BS EN 15058 | WI 4/42 |
| Volatile Organic Compounds | BS EN 12619 | WI 4/28 |

Monitoring Equipment Used

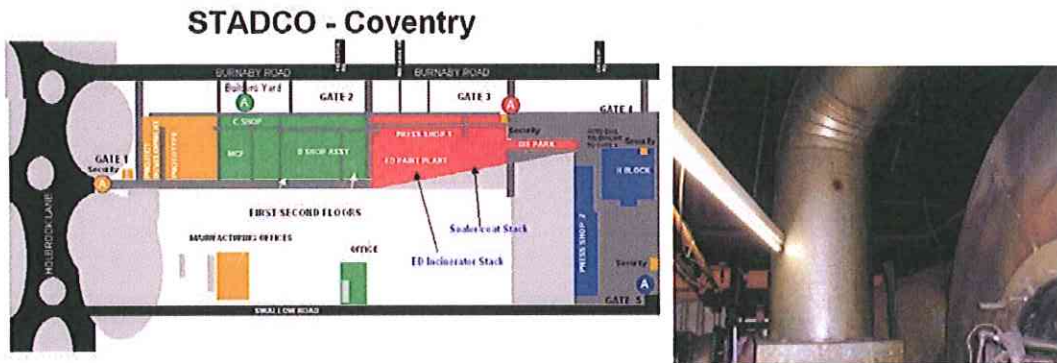
Gravimat CES Environmental Instruments Ltd Reference: C152
 Horiba PG-250 CES Environmental Instruments Ltd Reference: C190
 FID CES Environmental Instruments Ltd Reference: C232

Sampling Location

| Orientation | Dimensions | Cross Sectional Area | Sample Ports Available/Used | Sampling Positions Per Plane | Standard |
|---|------------|----------------------|-----------------------------|------------------------------|---------------|
| Vertical | Dia 550mm | 0.238m ² | 1/2 | 4 | BS EN 13284-1 |
| Comments: Sample ports: 1 off 4" BSP socket Sample times are calculated from the total sample time equally divided by the no. of sample positions per plane. Sample time per position must be greater than 3mins. Pitot Traverse Along lines A & B at positions consistent with BS 13284-1 these positions are: 6.7%, 25.0%, 75.0%, 93.3% (10 point traverse if required 2.6%, 8.2%, 14.6%, 22.6%, 34.2%, 65.8%, 77.4%, 85.4%, 91.8%, 97.4%) Sample Positions Along lines A & B at as many of the positions required within the standard method as can be achieved given the clearance limitations behind each socket. BS 13284-1 requires sampling at 8 points (4 on each of two lines) these positions are: 6.7%, 25.0%, 75.0%, 93.3% | | | | | |
| | | | | <u>Yes</u> | <u>No</u> |
| Does the sample plane comply upstream? | | | | | ✓ |
| Does the sample plane comply downstream? | | | | | ✓ |
| Are the appropriate sample ports fitted? | | | | | ✓ |
| Does the velocity air temperature profile comply? | | | ✓ | | |
| Minimum platform area >5m ² | | | ✓ | | |

N.B. Access only available on 1 of new ports. Have been fitted to low for second port access.

*The above requirements are generally fulfilled in sections of duct with at least five hydraulic diameters of straight duct upstream of the sampling plane and two hydraulic diameters downstream (five hydraulic diameters from the top of a stack). Therefore, it is strongly recommended to design sampling locations accordingly.



Site : Shell Stanlow
Date : 29 January 2009
Plant : ED Oven Exhaust Stack
File Ref. 4755

Mean Particulate Results

| Filter | Time | mg/m ³ (Actual Conditions) | m ³ /hr | mg/Nm ³ (Reference Conditions) | Nm ³ /hr | kg/hr |
|-------------|-------------|--|--------------------|--|---------------------|-------|
| 522199 | 10:25-11:26 | 1.3 | 11031 | 2.5 | 5778.1 | 0.015 |
| 52400 | 11:31-12:33 | 1.0 | 8718 | 1.9 | 4607.4 | 0.009 |
| Mean | | 1.2 | 9874.5 | 2.2 | 5192.8 | 0.012 |

Control Blank Filter

| Filter | Volume (m ³) | |
|-------------|-----------------------------|--|
| 522199 | 0.516 | |
| 52400 | 0.414 | |
| Mean | 0.465 | (Reference Conditions with no correction for Oxygen) |

| | | |
|------------------------|------------------------|---|
| Filter | 42950 | |
| Tare Weight | 17184.4 mg | |
| Gross Weight | 17184.7 mg | * |
| Gain | 0.3 mg | |
| Measured Oxygen | % | |
| Concentration | 0.5 mg/Nm ³ | |

Results Correct to

| Temperature | Pressure | Oxygen | Gas |
|-------------|------------|--------|-------------|
| °C/K | mbar/kPa | % | Wet/Dry Dry |
| 0/273 | 1013/101.3 | | |

* Indicates where a value less than the limit of detection of the weighing procedure (0.5mg) has been reported, the value lies somewhere between the detection limit and zero. A value of half the limit of detection (0.5mg) has been used to calculate the concentration.

protocol vT-measurement

29/01/2009 10:16

29/01/2009 10:22

measured values table

| axis | depth | T_probe [°C] | v_duct [m/s] | angle [grd] | Q_set [m³/h] | meas. time [H:M:S] | p10 [mbar] | density [kg/m³] |
|------|-------|-----------------|-----------------|----------------|-----------------|-------------------------|---------------|--------------------|
| 1 | 1 | 153 | 8.4 | 2.1 | 1.24 | 00:00:12 | 0.00 | 0.82 |
| 1 | 2 | 157 | 10.2 | 5.4 | 1.14 | 00:00:10 | 0.00 | 0.82 |
| 1 | 3 | 158 | 10.1 | 4.2 | 1.21 | 00:00:12 | 0.00 | 0.82 |
| 1 | 4 | 159 | 11.4 | -4.0 | 1.25 | 00:00:10 | 0.00 | 0.82 |
| 1 | 5 | 160 | 13.7 | 1.1 | 1.34 | 00:00:10 | 0.00 | 0.81 |
| 1 | 6 | 160 | 17.1 | 3.1 | 1.59 | 00:00:09 | 1.00 | 0.81 |
| 1 | 7 | 160 | 17.3 | -2.5 | 1.82 | 00:00:12 | 1.00 | 0.81 |
| 1 | 8 | 161 | 26.5 | 0.0 | 2.24 | 00:00:09 | 2.00 | 0.81 |
| 1 | 9 | 161 | 28.0 | 0.2 | 2.77 | 00:00:10 | 2.00 | 0.81 |
| 1 | 10 | 161 | 28.7 | 0.1 | 3.09 | 00:00:15 | 2.00 | 0.81 |
| 2 | 1 | 161 | 22.0 | -9.8 | 2.82 | 00:00:12 | 1.00 | 0.81 |
| 2 | 2 | 161 | 21.2 | -2.8 | 2.66 | 00:00:10 | 1.00 | 0.81 |
| 2 | 3 | 161 | 17.5 | 0.0 | 2.39 | 00:00:10 | 1.00 | 0.81 |
| 2 | 4 | 162 | 17.7 | -6.4 | 2.22 | 00:00:09 | 1.00 | 0.81 |
| 2 | 5 | 162 | 14.2 | -2.5 | 2.01 | 00:00:10 | 0.00 | 0.81 |
| 2 | 6 | 162 | 14.5 | 0.1 | 1.81 | 00:00:12 | 0.00 | 0.81 |
| 2 | 7 | 162 | 14.0 | -2.2 | 1.72 | 00:00:11 | 0.00 | 0.81 |
| 2 | 8 | 162 | 11.8 | -1.6 | 1.53 | 00:00:10 | 0.00 | 0.81 |
| 2 | 9 | 162 | 13.1 | 1.9 | 1.54 | 00:00:09 | 0.00 | 0.81 |
| 2 | 10 | 162 | 8.7 | -2.8 | 1.36 | 00:00:09 | 0.00 | 0.81 |
| | | 160 | 16.3 | -0.8 | 1.89 | | 0.60 | 0.81 |

protocol simultaneous isokinetic extraction measurement

29/01/2009 10:25

measured values table

29/01/2009 11:26

| axis | depth | T_probe [°C] | v_duct [m/s] | angle [grd] | Q_act. [m³/h] | volume [m³] | meas. time [H:M:S] | p10 [mbar] | p40 [mbar] |
|------|-------|-----------------|-----------------|----------------|------------------|----------------|-------------------------|---------------|---------------|
| 1 | 1 | 162 | 8.3 | 2.0 | 0.69 | 0.086 | 00:07:30 | 0.00 | -8 |
| 1 | 2 | 166 | 14.2 | -2.1 | 1.04 | 0.130 | 00:07:30 | 0.00 | -12 |
| 1 | 3 | 165 | 13.8 | -1.7 | 1.06 | 0.133 | 00:07:30 | 0.00 | -13 |
| 1 | 4 | 166 | 14.0 | -1.2 | 1.07 | 0.134 | 00:07:30 | 0.00 | -13 |
| 2 | 1 | 165 | 14.5 | -0.9 | 1.10 | 0.138 | 00:07:30 | 0.00 | -13 |
| 2 | 2 | 163 | 13.7 | -1.7 | 1.05 | 0.131 | 00:07:30 | 0.00 | -12 |
| 2 | 3 | 163 | 8.3 | -0.3 | 0.66 | 0.082 | 00:07:30 | 0.00 | -7 |
| 2 | 4 | 161 | 16.2 | -1.3 | 1.18 | 0.147 | 00:07:30 | 1.00 | -14 |
| | | 164 | 12.9 | -0.9 | 0.98 | 0.123 | | 0.13 | -12 |

protocol simultaneous isokinetic extraction measurement

29/01/2009 11:31

29/01/2009 12:33

measured values table

| axis | depth | T_probe [°C] | v_duct [m/s] | angle [grd] | Q_act. [m³/h] | volume [m³] | meas. time [H:M:S] | p10 [mbar] | p40 [mbar] |
|------|-------|-----------------|-----------------|----------------|------------------|----------------|-------------------------|---------------|---------------|
| 1 | 1 | 161 | 12.7 | -0.5 | 0.97 | 0.122 | 00:07:30 | 0.00 | -11 |
| 1 | 2 | 161 | 13.0 | 0.5 | 0.99 | 0.124 | 00:07:30 | 0.00 | -11 |
| 1 | 3 | 161 | 13.2 | 0.8 | 1.02 | 0.127 | 00:07:30 | 0.00 | -12 |
| 1 | 4 | 163 | 12.9 | 0.6 | 0.98 | 0.123 | 00:07:30 | 0.00 | -11 |
| 2 | 1 | 162 | 7.5 | -3.9 | 0.60 | 0.075 | 00:07:30 | 0.00 | -6 |
| 2 | 2 | 162 | 7.8 | -4.1 | 0.59 | 0.074 | 00:07:30 | 0.00 | -6 |
| 2 | 3 | 164 | 7.2 | -5.6 | 0.55 | 0.069 | 00:07:30 | 0.00 | -6 |
| 2 | 4 | 162 | 7.1 | -5.5 | 0.55 | 0.069 | 00:07:30 | 0.00 | -6 |
| | | | | | | | | | |
| | | 162 | 10.2 | -2.2 | 0.78 | 0.098 | | | -9 |

Site : STADCO Coventry
Date : 29 January 2009
Plant : ED Incinerator
File Ref. 4755

| Date | Oxygen | Carbon | Carbon | Nitric | Oxides of | VOCs | VOCs |
|--------------------------|--------|----------|-------------------|--------|-------------------|------|-------------------|
| 29/01/09 | | Monoxide | Monoxide | Oxide | Nitrogen (NO2) | | |
| Time | % | ppm | mg/m ³ | ppm | mg/m ³ | ppm | mg/m ³ |
| Mean Value (12:55-13:54) | 19.5 | 19 | 24 | 3 | 5 | 46 | 74 |
| Mean Value (13:55-14:54) | 19.4 | 21 | 26 | 2 | 5 | 40 | 65 |
| Max Test Result | 19.5 | 21.1 | 26.3 | 2.5 | 5.2 | 46.2 | 74.2 |
| Min Test Result | 19.4 | 19.2 | 24.0 | 2.3 | 4.6 | 40.5 | 65.1 |
| Mean Test Result | 19.5 | 20.1 | 25.2 | 2.4 | 4.9 | 43.3 | 69.6 |

Results correct to

| Temperature | | Pressure | | Oxygen | | Gas | |
|-------------|-------|----------|------------|--------|--|-----|-----|
| °C/K | 0/273 | mbar/kPa | 1013/101.3 | % | | Dry | Dry |

Site : STADCO Coventry
Date : 29 January 2009
Plant : ED Incinerator
File Ref. 4755

| Date 14/01/2008 | Oxygen | Carbon Monoxide | Carbon Monoxide | Nitric Oxide | Oxides of Nitrogen (NO2) | VOCs | VOCs |
|-------------------------|--------|--------------------|--------------------|-----------------|-----------------------------|------|-------------------|
| Time | % | ppm | mg/m ³ | ppm | mg/m ³ | ppm | mg/m ³ |
| 13:55 | 19.4 | 18 | 23 | 2 | 5 | 34 | 55 |
| 13:56 | 19.5 | 18 | 22 | 2 | 5 | 33 | 53 |
| 13:57 | 19.5 | 17 | 21 | 2 | 5 | 33 | 53 |
| 13:58 | 19.5 | 16 | 20 | 2 | 5 | 33 | 53 |
| 13:59 | 19.5 | 14 | 18 | 2 | 5 | 33 | 53 |
| 14:00 | 19.5 | 14 | 18 | 3 | 5 | 32 | 52 |
| 14:01 | 19.6 | 14 | 17 | 3 | 6 | 32 | 51 |
| 14:02 | 19.6 | 14 | 17 | 3 | 6 | 33 | 52 |
| 14:03 | 19.4 | 17 | 21 | 3 | 6 | 33 | 54 |
| 14:04 | 19.3 | 21 | 27 | 3 | 6 | 35 | 56 |
| 14:05 | 19.3 | 23 | 29 | 3 | 5 | 36 | 58 |
| 14:06 | 19.3 | 22 | 28 | 3 | 5 | 38 | 61 |
| 14:07 | 19.3 | 21 | 26 | 3 | 5 | 41 | 66 |
| 14:08 | 19.3 | 25 | 31 | 3 | 6 | 41 | 66 |
| 14:09 | 19.4 | 20 | 26 | 3 | 6 | 40 | 65 |
| 14:10 | 19.4 | 19 | 24 | 3 | 6 | 40 | 65 |
| 14:11 | 19.4 | 18 | 23 | 3 | 6 | 40 | 64 |
| 14:12 | 19.5 | 19 | 23 | 2 | 5 | 39 | 62 |
| 14:13 | 19.5 | 19 | 24 | 2 | 5 | 40 | 64 |
| 14:14 | 19.5 | 19 | 24 | 2 | 4 | 40 | 64 |
| 14:15 | 19.5 | 18 | 22 | 2 | 4 | 43 | 69 |
| 14:16 | 19.6 | 18 | 22 | 2 | 4 | 45 | 72 |
| 14:17 | 19.6 | 17 | 21 | 2 | 4 | 46 | 74 |
| 14:18 | 19.6 | 16 | 20 | 2 | 4 | 46 | 73 |
| 14:19 | 19.6 | 16 | 20 | 2 | 5 | 46 | 74 |
| 14:20 | 19.6 | 18 | 22 | 2 | 5 | 44 | 71 |
| 14:21 | 19.5 | 20 | 25 | 3 | 5 | 42 | 68 |
| 14:22 | 19.5 | 23 | 29 | 2 | 5 | 42 | 68 |
| 14:23 | 19.4 | 25 | 31 | 2 | 5 | 43 | 70 |
| 14:24 | 19.4 | 23 | 29 | 2 | 4 | 42 | 68 |
| 14:25 | 19.5 | 22 | 27 | 2 | 4 | 41 | 66 |
| 14:26 | 19.5 | 21 | 26 | 2 | 4 | 41 | 66 |
| 14:27 | 19.5 | 21 | 26 | 2 | 4 | 40 | 65 |
| 14:28 | 19.5 | 20 | 25 | 2 | 4 | 38 | 60 |
| 14:29 | 19.5 | 22 | 27 | 2 | 4 | 37 | 59 |
| 14:30 | 19.4 | 27 | 33 | 2 | 4 | 38 | 60 |
| 14:31 | 19.4 | 28 | 35 | 2 | 4 | 40 | 65 |
| 14:32 | 19.4 | 28 | 35 | 2 | 4 | 42 | 67 |
| 14:33 | 19.4 | 27 | 34 | 2 | 4 | 42 | 67 |
| 14:34 | 19.4 | 24 | 30 | 2 | 4 | 40 | 64 |
| 14:35 | 19.5 | 24 | 30 | 2 | 4 | 39 | 63 |
| 14:36 | 19.5 | 22 | 28 | 2 | 4 | 40 | 64 |
| 14:37 | 19.5 | 22 | 27 | 2 | 4 | 38 | 61 |
| 14:38 | 19.5 | 21 | 27 | 2 | 4 | 37 | 59 |
| 14:39 | 19.4 | 22 | 28 | 2 | 4 | 38 | 62 |
| 14:40 | 19.4 | 24 | 30 | 2 | 4 | 41 | 66 |
| 14:41 | 19.4 | 22 | 28 | 2 | 4 | 47 | 75 |
| 14:42 | 19.4 | 21 | 26 | 2 | 4 | 51 | 81 |
| 14:43 | 19.5 | 20 | 25 | 2 | 4 | 51 | 82 |
| 14:44 | 19.5 | 20 | 24 | 2 | 5 | 49 | 79 |
| 14:45 | 19.5 | 20 | 25 | 2 | 5 | 46 | 74 |
| 14:46 | 19.4 | 21 | 26 | 2 | 4 | 45 | 73 |
| 14:47 | 19.3 | 25 | 31 | 2 | 4 | 44 | 71 |
| 14:48 | 19.2 | 28 | 35 | 2 | 4 | 43 | 70 |
| 14:49 | 19.2 | 29 | 36 | 2 | 4 | 44 | 71 |
| 14:50 | 19.3 | 26 | 33 | 2 | 4 | 47 | 75 |
| 14:51 | 19.3 | 26 | 32 | 2 | 4 | 46 | 74 |
| 14:52 | 19.4 | 25 | 31 | 2 | 4 | 43 | 69 |
| 14:53 | 19.4 | 23 | 28 | 2 | 4 | 40 | 65 |
| 14:54 | 19.5 | 23 | 29 | 2 | 4 | 40 | 64 |
| Max Test Result | 19.6 | 28.6 | 35.8 | 3.0 | 6.1 | 50.8 | 81.6 |
| Min Test Result | 19.2 | 13.7 | 17.1 | 1.9 | 3.9 | 31.6 | 50.7 |
| Mean Test Result | 19.4 | 21.1 | 26.3 | 2.3 | 4.6 | 40.5 | 65.1 |

Results Correct to

| Temperature °C/K | Pressure mbar/kPa | Oxygen % | Gas Wet/Dry |
|---------------------|----------------------|-------------|----------------|
| 0/273 | 1013/101.3 | | Dry |

Certificate of Calibration

Date of Issue: 4 July 2008

Certificate No. CES0503

page 1 of 2

CES Environmental Instruments Ltd
Bretby Business Park, Ashby Road
Burton-on-Trent, Staffordshire, DE15 0YZ
Tel: 01283 216334 Fax: 01283 550939

.....
Certified By

Instrument Details

| | |
|-----------------------|------------------|
| Instrument Type | Gravimat SHC-502 |
| Instrument Make | Ervin Sick |
| Instrument Serial No. | 96008705 |
| Quality No. | C152 |
| Calibration Date | 04/07/08 |
| Calibrated By Name | M.Rodgers |

Ambient Conditions

| | |
|----------------------------|------|
| Air Temperature (°C) | 26 |
| Barometric Pressure (mbar) | 1000 |
| Relative Humidity (%) | 49 |

Instruments used to undertake calibration

| | | |
|----------------------|--------------------------------|----------------|
| E Type Pitot | UKAS Certificate No. N15781/08 | (Qu. No. C136) |
| Manometer Type FC012 | UKAS Certificate No. 04486 | (Qu. No. C082) |
| Manometer Type FC012 | UKAS Certificate No. 04485 | (Qu. No. C081) |
| Barometer Type 104 | UKAS Certificate No. N3052156P | (Qu. No. C138) |
| Gallus Dry Gas Meter | UKAS Certificate No. N3045066F | (Qu. No. C125) |
| RIS Supercal XT | UKAS Certificate No. N3045065E | (Qu. No. C014) |

* Not UKAS traceable

** Indication only

Flow and Extraction

The reference pitot was placed in a wind tunnel located at Bretby Business Park. The Gravimat SHC-502 Sampling Probe under test was mounted within the same wind tunnel in close proximity to the reference pitot. The wind tunnel was operated to generate a differential pressure across each pitot, a direct comparison was made. The differential pressures measured were in the region of the calibration points of the reference pitot. Correction factors were applied to the reference pitot and compared to the differential pressure shown for the pitot under test. The extraction system of the unit was operated for a period of one minute.

Volume Flow

A calibrated dry gas meter was connected to the sampling nozzle of the Gravimat SHC-502. A volume of air is pulled through the sampling system. The measured value shown on the calibrated dry gas meter is then compared to the indicated value on the Gravimat SCH-5 display.

Barometric Pressure

The barometric pressure was measured using a calibrated barometer. The indicated pressure was compared to the Gravimat SHC-502 display.

Temperature

The probe thermocouple was placed in a thermocouple oven and heated. The temperature was measured using a calibrated thermocouple and temperature indicator. The resultant temperature was compared to the Gravimat SHC-502 display.

Current

A mA current source was injected into the Gravimat SHC-502 using a mA current generator. The injected current was compared to the Gravimat SHC-502 display.

Appendix 6
(Uncertainty Calculations)

Uncertainty calculation for Gaseous Measurement Oxygen EN14789
V2.2 Jul-08

| | | | | |
|------------------------|-------|------|----|------|
| Limit value | n/a | %vol | 12 | %vol |
| Measured concentration | 19.50 | %vol | 25 | %vol |

| Performance characteristic | Value | Specification |
|--|---|-----------------------|
| Response time | 60 seconds | < 200 s |
| Logger sampling interval | 60 seconds | |
| Measurement period | 120 minutes | |
| Number of readings in measurement | Assuming 1 minute collected over 1 hour | |
| Repeatability at zero | 0.015 % by volume | < 0.2 % range |
| Repeatability at span level | 0.014 % by volume | < 0.4 % range |
| Deviation from linearity | 0.13 % vol | < 0.3 % volume |
| Zero drift (during measurement period) | 0 % vol at zero level | < 2% of volume / 24hr |
| Span drift (during measurement period) | 0 % vol at span level | < 2% volume/24hr |
| volume or pressure flow dependence | 0 % of fs / 10l/h | < 1% range |
| atmospheric pressure dependence | 0.3 % of fs/kPa | < 1.5 % range |
| ambient temperature dependence | -0.07 % by volume / 10K | < 0.3% volume / 10 K |
| CO ₂ (% vol) | 15 | |
| NO _x (mg/m ³) | 300 | |
| NO _x (mg/m ³) | 0 | |
| Combined interference | 0.56 % range | < 2% range |
| Dependence on voltage | 0.1 % by volume / 10V | < 0.1%vol / 10 volt |
| Losses in the line (leak) | 2 % of value | < 2% of value |
| Uncertainty of calibration gas | 0.5 | |

| | |
|-----------------|--------------|
| Effect of drift | 0.00 % vol |
| | 0.00 % value |

| | range of variation from conditions at calibration | |
|-----------------------|---|-------|
| | min | max |
| flow | 18 | 30 |
| pressure | 100.00 | 100.3 |
| temp | 298 | 305 |
| CO ₂ range | 0 | 1 |
| NO range | 0 | 5 |
| NO _x range | 0 | 0 |
| Voltage | 105 | 115 |

| Performance characteristic | Uncertainty | Value of uncertainty quantity | % vol |
|---|-------------------|-------------------------------|-------|
| Standard deviation of repeatability at zero | U _{rep} | for mean | 0.00 |
| Standard deviation of repeatability at span level | U _{rs} | for mean | 0.08 |
| Lack of fit | U _{lf} | | 0.00 |
| Drift | U _{dr} | | 0.00 |
| volume or pressure flow dependence | U _{vol} | | 0.01 |
| atmospheric pressure dependence | U _{atm} | | 0.00 |
| ambient temperature dependence | U _{atmp} | | -0.12 |
| CO ₂ | | | 0.00 |
| NO _x | | | 0.00 |
| Combined interference (from meats) | | | 0.08 |
| dependence on voltage | U _{vol} | | 0.03 |
| losses in the line (leak) | U _{leak} | | 0.23 |
| Uncertainty of calibration gas | U _{cal} | | 0.06 |

| | | |
|---|---------------|--------------|
| Use largest of sum of all positive or all negative influences | 0.00 all +ves | 0.00 largest |
| Criteria | 0 all -ves | 0.00 largest |
| sum -2% value | | 0.39 |

| | | |
|--|-------|------------|
| Measurement uncertainty | 19.50 | %vol |
| Combined uncertainty | 0.27 | %vol |
| % of value | 1.40 | % |
| Coverage factor: k = | 2 | |
| Expanded uncertainty expressed with a level of confidence of 95% | 2.79 | % of value |
| Expanded uncertainty expressed with a level of confidence of 95% | 0.54 | % vol |

Requirement for SRM is that Uncertainty should be < 6% of value, on a dry gas basis

Note: Enter values into green boxes
Dark blue boxes indicate information that can be obtained from MCERTS tests
Purple boxes are from manufacturer specification, or CEN standard as MCERTS data not available

Developed for the STA by R Robinson, NPL

Uncertainty calculation for Gaseous Measurement BS EN 15058 Carbon Monoxide

| | | | | |
|------------------------|---|------------|---------------|---------------------------|
| Limit value | 100 mg.m ⁻³ (corrected) CO | Gas | CO | 200 ppm |
| Measured concentration | 20.13 ppm | Full Scale | Cal gas conc | 1.79 ppm |
| Measured concentration | 25.16 mg.m ⁻³ (273K, 101.3kPa) | Conversion | Full Scale | 1.25 mg.m ⁻³ |
| | | Full Scale | Call gas conc | 223.75 mg.m ⁻³ |

| Performance characteristics | Value | specification |
|------------------------------------|-------|---------------------|
| Response time | 60 | seconds |
| Number of readings in measurement | 120 | 180,000 |
| Repeatability at zero | 0.15 | % full scale |
| Repeatability at span level | 0.8 | % full scale |
| Deviation from linearity | 0.4 | % of value |
| Zero drift | 0 | 2,000 |
| Span drift | 0.5 | % full scale |
| Volume or pressure flow dependence | 0.02 | % of full scale/kPa |
| atmospheric pressure dependence | 0.8 | % of value/kPa |
| ambient temperature dependence | 0.01 | % full scale/10K |
| N2O (20 mg/m3) | 1.2 | mg/m3 |
| CH4 (50 mg/m3) | 1.2 | mg/m3 |
| CO2 (15%) | 1.2 | % by vol |
| H2O (30%) | 1.2 | % by vol |
| dependence on voltage | 0.1 | % full scale/10V |
| losses in the line (leak) | | |
| Uncertainty of calibration gas | 2 | % of value |

| Performance characteristic | Uncertainty | Value of uncertainty quantity for mean |
|---|------------------|--|
| | | |
| Standard deviation of repeatability at zero | U ₀ | 0.07 |
| Standard deviation of repeatability at span level | U _s | 0.58 |
| Lack of fit | U _{lf} | 0.07 |
| Drift | U _{dr} | 0.02 |
| volume or pressure flow dependence | U _{vps} | 0.35 |
| atmospheric pressure dependence | U _{aps} | 0.02 |
| ambient temperature dependence | U _{ats} | 0.05 |
| CO2 (15%) | U _{co2} | 0.02 |
| H2O (30%) | U _{h2o} | 0.00 |
| N2O (20 mg/m3) | U _{n2o} | 0.00 |
| CH4 (50 mg/m3) | U _{ch4} | 0.03 |
| Dependence on voltage | U _{uv} | 0.29 |
| losses in the line (leak) | U _{ul} | 0.29 |
| Uncertainty of calibration gas | U _{cal} | |

| | | | |
|-------------------------|---|-------|--------------------------------|
| Measurement uncertainty | Result | 25.16 | mg/m ³ |
| Combined uncertainty | k = | 0.80 | mg/m ³ |
| Expanded uncertainty | | 1.80 | mg/m ³ |
| Expanded uncertainty | expressed with a level of confidence of 95% | 1.61 | mg.m ⁻³ (corrected) |
| Expanded uncertainty | expressed with a level of confidence of 95% | 1.61 | % ELV |
| Expanded uncertainty | | 1.61 | mg.m ⁻³ at ELV |

Note: Enter values into green boxes
Dark blue boxes indicate information that can be obtained from MCERTS tests

| Correction for reference conditions | | | |
|-------------------------------------|--------------------|-------------|----------------|
| | O ₂ , % | Moisture, % | Pressure, kPa |
| ref | 0.00 | 0.00 | 101.30 |
| measured | 0.00 | 0.60 | 101.30 |
| Correction Factor | 1.00 | 1.01 | 1.00 |
| | | | Temperature, K |
| | | | 273.00 |
| | | | 273.00 |

| | |
|-----------------|--------------|
| Effect of drift | 0.13 mg/m3 |
| | 0.50 % value |

| | ranges min | max | value at call |
|---------------------------|------------|-------|---------------|
| flow | 18 | 30 | 24 l/hr |
| pressure | 100.00 | 100.3 | 100 kPa |
| temp | 298 | 305 | 285 K |
| NH3 range | 0 | 0 | 0 mg/m3 |
| N2O range | 0 | 0 | 0 mg/m3 |
| CH4 range | 0 | 0 | 0 mg/m3 |
| CO2 range | 0 | 1 | 0 %vol |
| H2O range | 0 | 0.8 | 0 %vol |
| Instrument Voltage Rating | 104.5 | 115.5 | 110 V |
| Voltage | | | 110 V |

| | Use largest negative or positive interferent effect |
|--------------------------|---|
| NH3 | 0 |
| CO2 | 0.05 |
| H2O | 0 |
| N2O | 0.00 |
| CH4 | 0 |
| Interference uncertainty | 0.06 |

**Appendix 7
(CEMs & Process Data)**