# HE 13 / 9139

# LA-PPC/EPR Compliance Monitoring

**at**

**David Smith St Ives Ltd**
**Marley Road**
**St Ives**
**Huntingdon**
**Cambs**
**PE27 3EX**

**for**

**RanHeat Engineering Limited**
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**Northampton**
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**Study Period; - 4th February 2013**

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| ISSUE STATUS | HE 12 / 8341 | |
| ISSUE 01 | CHECKED: S J LATHAM | APPROVED T GROWCOTT |
| ISSUED | 10.02.2013 | |

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10th February 2013

**FAO: Mr C Franklin - Director**

**REPORT REF: - HE 13 / 9139**

# LA-PPC/EPR COMPLIANCE MONITORING OF THE WIESS UNIT AT DAVID SMITH, ST IVES, CAMBRIDGESHIRE

## 1.1 INTRODUCTION

This study was undertaken to determine data as detailed by David Smith St Ives Limited's Local Authority Pollution Prevention and Control (LA-PPC/EPR) permit provisions, as defined by Local Authority Environmental Services personnel, to assess the releases sourced from the operation of the site's Weiss wood burning boiler unit.

The report relates to monitoring studies undertaken on 4th February 2013 by Mr T Growcott, BSc (Hons) MRSC C Sci C Chem, of Halcyon Environmental in respect of the determination of Process Guidance Note PG 1/12 (2012) defined analytes.

In this study the wood burning unit system was fully operational, burning the wood feed stocks sourced from site manufacturing activities. Monitoring was undertaken continuously over a 3-hour period during which time RanHeat personnel were on site.

The author was formally trained in source testing via Clean Air Engineering (CAe) (1991), Casella (1992) and SGS (1991) and is STA registered (MM 03/314). Monitoring was undertaken over a continuous period to determine the results quoted and in accordance with the following Source Testing Association (STA) codes of practice; -

| Document | Title |
|---|---|
| M 1054 | STA Minimum Standards of Testing and Reporting |
| M 1055 | STA Code of Practice |
| MIG001 | Measurement of Specific Organic Compounds in Source Releases |
| QGN001 | Guidance on Assessing Uncertainty in Stack Emission Monitoring |

The plant's monitoring portals were located on the exit side of the discharge fan in the main transfer duct leading to the stack. The portals were accepted as being located satisfactorily in the exhaust stack by Local Authority personnel.

Direct emissions were monitored in the stack as per ISO 9096:2003 protocol compliant 100 mm dia BSP capped portals.

## 1.2 SUMMARY

The sampling, monitoring and analytical procedures undertaken in this report have determined analyte data site sourced emissions relating to the Weiss unit as per PG 1/12 (2012) provisions.

The following results were determined; -

Sampling, monitoring and analytical procedures have determined process sourced direct releases from the Weiss unit's stack with respect to the concentration limits detailed under LA-PPC/EPR process documentation, and $SO_x$, $NO_x$ and Oxygen concentrations.

1. Emission discharge colour has been determined in accordance with LA-PPC/EPR protocol and established as less than Ringlemann Shade 0.5 throughout the study period.

| Analyte | Test 1 | Test 2 | Mean | PG 1/12 (2012) Max Limit |
|---|---|---|---|---|
| 1. Carbon Monoxide CO (mg/m$^3$) | 480 samples<br>(120 minutes at 15 second intervals) | | 169 | 250 |
| 2. TPM (mg/m$^3$) | 161.42<br>1 x 30 mins sample | 153.72<br>1 x 30 mins sample | 157.57 | 200 |
| 3. VOC as C (mg/m$^3$) | 480 samples<br>(120 minutes at 15 second intervals) | | 6.117 | 20 |
| 4. Oxygen (%) | 480samples<br>(120 minutes at 15 second intervals) | | 11.03 | - |
| 5. Water Vapour (%) | 2 x 60 mins sample | | 6.292 | - |
| 6. Oxides of Sulphur SOx (mg/m$^3$) | 480 samples<br>(120 minutes at 15 second intervals) | | 1.02 | - |
| 7. Oxides of Nitrogen NOx (mg/m$^3$) | 480 samples<br>(120 minutes at 15 second intervals) | | 52.0 | - |
| 8. Formaldehyde (mg/m$^3$) | 1.97<br>(1 x 30 min sample) | **-** | 0.972 | - |
| 9 Chlorides (as HCl) (mg/m$^3$) | (2 x 15 min sample) | - | 1.97 | - |

2. Emission discharges have been assessed and found to be free from droplets as defined within PG 1/12 (2012) note provisions.

3. Flow and mean velocity determinations have established data for the wood burner’s stack, which have indicated compliance above specified minimum efflux velocity requirements.

   The Weiss unit’s stack mean efflux velocity was determined to be 13.06 m/s its discharge temperature.

A copy of this report should be sent to Local Authority within 8 weeks of receipt.

Tim Growcott  B Sc (Hons) MRSC C Chem C Sci MIMF
Senior Partner

*RANH 9139 LAPPC REP*

# SECTION 2

# SAMPLING AND MONITORING STRATEGIES

# 2 SAMPLING AND MONITORING STRATEGIES

## 2.1 SAMPLING STRATEGY

The main sampling and monitoring studies were completed following initial determination of the wood burner unit’s stack thermal and flow profiles as detailed in ISO 9096:2003.

The data reported herein was compiled in accordance with the methodologies and procedures detailed in STA approved specifications, in addition to specific GC-MS methodologies and the use of approved Draeger tube methods and procedures.

The data reported herein was determined at the two stack portal locations, using the following instrumentation.

Velocity data was determined using a standard Airflow Developments model PVM 100 electronic micro-manometer, (HE 03-012) used in conjunction with a BS 1042 type 2.1 pitot system (HE 03-045), with in line thermocouple.

Calibrated flow, humidity, temperature and pressure measurement devices were also used in these procedures, using Huger-Sutronics and AGL instrumentation.

This procedure was based on US EPA Method 2, "The Determination of Stack Gas Velocity and Volumetric Flow Rates (Type S Pitot Tubes)", and EPA Method 3B "Gas Analysis for the Determination of Emission Rate Correction Factor or Excess Air".

## 2.2 SAMPLING EQUIPMENT

Sampling was undertaken using BMS high and low flow pumps as defined in the analytical methodology procedures detailed in the next section of this report.

Samples were obtained using conventional Andersen probes located in the stack. These were connected to insulated transfer lines, of less than 0.5 m. length, to minimise condensation losses.

The port sealing system was tested prior to each run, and a leak rate of less than 0.02 % was recorded.

### 2.2.1 ISO 9096:2003 TOTAL PARTICULATE MATTER DETERMINATION

The procedure employed was that detailed in ISO 9096:2003.

Air was extracted from the main stack isokinetically over 2 x 60 minute sampling periods and via a purpose built stack-sampling train located directly in the duct portals to minimise condensation losses. The filters were retained for gravimetric measurement in post sampling analysis.

### 2.2.2 BS 12619 VOC DETERMINATION

Both direct reading and post sampling laboratory-based procedures were used to produce the data reported herein. Direct measurements were determined via a sampling train located adjacent to the main stack portals.

Direct reading measurements were made as detailed in BS 12619 using a Signal Instruments 3030PM instrument with FID calibrated for 20 ppm propane in air - ex Air Products.

Indirect measurements were made using composite Activated Charcoal and Tenax adsorption tubes, used in conjunction with low flow pumps.

The tubes were then analysed in laboratory based procedures using Gas Chromatography + Mass Spectroscopy by Halcyon personnel. This analysis detailed the VOC emissions as Carbon residues.

Further procedures were involved in the determination of free Formaldehyde using direct reading Draeger tubes.

### 2.2.3 GAS COMPONENT DETERMINATIONS

The gaseous components of the emission stream were also determined.

Analyses were undertaken for $NO_x$, $SO_x$, CO, $CO_2$ and Oxygen using a Eurotron series 3000 Professional Combustion Gas Analyser. This instrument had its own probe system and operated by direct measurement of the stack emissions. These measurements were made via a number of on site analyses within the instrument using comparative assessments against pre conditioned calibrated internal standards. The instrument had its own gas conditioning system and pre calibrated internal measurement standards. This instrument was using for direct reading of the transfer duct emissions.

Water (moisture) content was determined in accordance with EPA Method 4 using Halcyon test equipment (HE 09-141).

### 2.2.4 CHLORIDES (as HCl) DETERMINATION

Total Chloride was determined in accordance with the latest standard method of determination, BS EN 1911-3. This methodology was supplied from the Source Testing Association as the most accurate procedure for the determination of HCl. The method provides procedures for isokinetic sampling, the suggest methodology when particulate matter is anticipated in the emission stream.

The procedure was adhered to in strict accordance with defined methodology other than in the use of a full heated sampling line due to space limitations. The sampling head was determined to be at temperatures in excess of 250 degrees C at the sampling tip, and in excess of 150 degrees C at the filter body. Simultaneous temperature measurements determined that the emission stream temp was in excess of 100 degrees C at the bubbler bottle and not less than 90 degrees C at both sampling pumps.

Chloride analyses were undertaken using the ion exchange chromatography procedure detailed in BS EN 1911-3. This procedure was considered to give identical results to the alternative mercuric thiocyanate methodology, and not have the significant interferences of the silver nitrate potentiometric methodology.

The ion exchange method is the only one of the three options, which also gives indicative distinction of the presence of volatile chlorides, which may be present in the sampling solutions.

Chloride determination was calculated using BS EN 1911 section 4.5 equations.

### 2.2.5 SAMPLING PROTOCOLS

All sampling and monitoring procedures were based on basic isokinetic sampling strategies, to assess process uniformity, with continuous on line assessment of flow rate and dynamic velocity measurements during unit operation.

All flow rate and velocity measurement instrumentation was calibrated prior to, during and after each sampling run.

All sampling planes and points of determination were corrected in accordance with isokinetic correction Ka coefficients as detailed in Source Testing Association protocols.

Monitoring was based on the Approved 1999 Code of Practice produced by the Source Testing Association.

**Calculation of Velocity of Flow:**

The basic formula for calculating velocity of flow from velocity pressure is:

$$\text{Velocity Pressure (Pv)} = \tfrac{1}{2}\,\rho\,V^2$$

Where:

Pv is Velocity Pressure in pascals.

$\rho$ is the density of dry air (free of $CO_2$) at 1013mb, 273K in Kg/m$^3$.
V is velocity in metres per second.

Dry air contains 78.1% Nitrogen (as $N_2$), 20.9% Oxygen (as $O_2$), 0.9% Argon (as Ar) and traces of $CO_2$ (0.03%), Ne, He, Kr, Xe, $H_2$, $CH_4$, $N_2O$, $O_3$, $SO_2$, $NO_2$, $NH_3$, CO, & $I_2$.

Atomic Weight of Nitrogen is 14, Oxygen is 16, and Argon is 40. Molecular Weight if Nitrogen ($N_2$) is 28, Oxygen ($O_2$) is 32 and Argon (Ar) is 40.

Molar Density of a complex gas mixture, such as air, can be calculated using the proportions of gas present, and the molecular weights of the component gases. Thus using the 3 principle components of dry air:

Molar gas density = 0.781 x 28 (for $N_2$) + 0.209 x 32 (for $O_2$) + 0.009 x 40 (for Ar)
= 28.916

When the figures are made more accurate, and all the other trace gases added into the equation, **Molar Gas Density of Air** works out to be **28.9644**. This is normally approximated to 29.

The following calculations can be utilised (in most cases), where molar gas density is in the range of 28-30, (see note on determination of flue gas density).

In some combustion stacks the density can be found to be outside this range, in which case the calculations need to be modified by substituting the actual value into the basic equation, and following the calculation through.

One mole of gas occupies 22.4136 litres at 273 K, 1013mb. (Normally approximated to 22.4). One mole of air occupies the same volume and weighs 28.9644 g. Thus the **Density of Dry Air** at 273 K, 1013 mb works out at 1.292 Kg /m$^3$. The precise figure is 1.2928 Kg/m$^3$.

If this figure is entered into the initial equation

$$Pv = \tfrac{1}{2}\,\rho\,V^2$$

It calculates out to; -

Velocity (metres per second) = 1.244 $\sqrt{Pv}$ (at 273 K, 1013 mb)

or

Velocity (metres per second) = 1.280 $\sqrt{Pv}$ (at ambient: 289 K, 1013mb)

This equation can be applied at or near standard conditions. Where conditions vary significantly from standard, corrections can be made according to the following formula:

$$V = 1.280 \sqrt{\frac{1013 \times T \times 101300}{Pa \times 289 \times (101300+Ps)}} \times Pv$$

This equation corrects for atmospheric pressure (Pa), expressed in millibars, Temperature expressed in Kelvin (T), and static pressure in the stack (Ps) in pascals. It multiplies out to give:

$$V = 762.7 \sqrt{\frac{T \times Pv}{Pa\ (101300+Ps)}} \quad \times Pv$$

Where:

V = Velocity of Flow on metres per second ($ms^{-1}$)
T = Temperature in Kelvin (Kelvin = $^{o}$ Celsius + 273) (K)
Pv = Velocity Pressure in pascals (Pa)
Ps = Static Pressure in pascals (Pa)
Pa = Atmospheric Pressure in millibars (1 millibars = 100 pascals) (mb)

To apply this equation, Pv should be entered as the root mean square of all velocity pressure readings. Where the majority of the readings do not vary by more than 25% from the mean figure, the mean provides a satisfactory answer. The equation gives velocity of flow at temperature T, static pressure Ps, and atmospheric pressure Pa.

## **Measurement of Air Flow in Stacks**:

Correct isokinetic sampling is dependent on accurate assessment of air velocity in the duct or flue. Because of the potentially hot, acid conditions found in flues, the instrument of choice for measuring flow is one that measures differential pressure, and does not insert an instrument with electronic or moving parts into the duct. There are several other types of instrument available for measuring airflow, but these should not, as a general rule, be used in flue stacks.

## **Pressure in Ducts:**

There are 4 factors that affect the perceived pressure in a duct:

1. Movement of air produces a measurable Velocity Pressure (also known as Dynamic Pressure).
2. Static Pressure, is exerted in all directions, by the compression, expansion, or heating process that is moving the air.
3. Atmospheric (Barometric) Pressure
4. Temperature.

## **Micro manometer & Pitot Tube:**

The pitot tube is the differential pressure probe, it is designed to create minimal turbulence in the flow. The British Standard design has an ellipsoidal nose, which is inserted to face the flow. The tube is very directional and needs to be accurately aligned into the flow, to produce the best result. Unfortunately the pressure bearing on the nose of the instrument is Velocity Pressure, but with the addition of static pressure.

To eliminate this problem, the pitot tube is made with a separate tapping to measure static pressure alone. The BS tube is made double, with tappings at right angles to the flow, whereas the American S type pitot consists of two separate tubes 180$^{o}$ opposed. The two types of pitot tube have different response factors (sometimes called the K factor), and this may require the use of a correction factor in calculating flow. The response factor for the BS type is 1.0 and for the S type is 0.85.

The original instrument for measuring air pressure is the U tube manometer. By attaching the two tappings of the pitot tube, one to each side of the manometer, Static pressure is applied to both sides, and its effect is eliminated, allowing a direct reading of Velocity pressure. The inclined manometer is an improvement on the U tube, because it allows for more accurate readings of pressure. However it does require careful leveling before use, and an electronic micro manometer is more user friendly.

With either type of instrument it is important that it is connected up with the Velocity pressure tapping bearing on the positive side of the instrument.

**Calculating & Presentation of Results (Measurements & Corrections):**

Particulate sampling is always assessed gravimetrically (by weight). Filter material of all types is pre weighed, exposed in the sampling line and re-weighed.

This procedure may require drying of the filter medium before re-weighing, if the sampling was conducted at a temperature below the dew point. In all circumstances, filters require careful handling to avoid loss particulate, and also loss of original fibrous material. Weight of particulate collected is thus derived from the difference of the two weights and is normally expressed in milligrams (g$^{-3}$) or micrograms (g$^{-6}$). The balance should be calibrated against a traceable standard before and after each batch of filters is weighed / re-weighed.

Volume of gas collected is normally determined either by multiplying sampling flow rate (litres/minute) by time elapsed (minutes) to get a final volume in litres, or by utilising a direct reading from a gas meter.

In both cases, volume calculated is at ambient temperature and pressure and requires correcting to standard conditions. The gas meter or flow meter should be regularly re-calibrated against a traceable standard, and this may impose an extra calibration factor on the results to obtain correct ambient volume.

If the sampling line, does not include a silica gel trap, but only a condensate trap, (as in the BCURA or CEGB Mk111A) the air passing to the meters can be assumed to be water saturated at ambient conditions, and this too required compensation.

Schedule A & B processes require presentation of results in milligrams per cubic metre, and / or parts per million, as standardised to the following conditions:

| | |
|---|---|
| Temperature | 273K (0$^{o}$ Celsius) |
| Barometric Pressure | 101.3KPa, (1013mb) |
| Humidity | Dry |
| Oxygen | 3%, 6%, 8%, 11%, 15%, 18% depending on combustion process |

The various calculations and conversions are explained in the subsequent paragraphs.

**Determination of Isokinetic Sampling Rate:**

To obtain correct samples of particulates, turbulence caused by sampling must be minimised. This is achieved by making the velocity of flow into the sampling probe equal to the velocity flow moving along the duct or stack. This sampling technique is called isokinetic sampling, and its use enables the collection of representative samples, by eliminating the distortion of sample reliability caused by variation in proportion of light particulates collected.

Velocity of flow is determined by the use of pitot tube and micro manometer. This is normally calculated at the stack temperature. The gas volume measuring equipment is normally functioning at about ambient temperature (Gas moving along the sampling line rapidly cools to ambient).

To calculate isokinetic flow rate, first the gas velocity must be calculated as at ambient. This is done using the standard gas equation (See Calculation of Results).

$$\frac{\text{Pressure x Volume}}{\text{Temperature}} = \text{Constant}$$

Thus for a stack of uniform width volume is proportional to velocity, hence:

$$\text{Velocity}_{\text{ambient}} = \frac{\text{pressure}_{\text{stack}} \text{ x Velocity}_{\text{stack}} \text{ x Temperature}_{\text{ambient}}}{\text{Temperature}_{\text{stack}} \text{ x Pressure}_{\text{ambient}}}$$

As atmospheric pressure remains equal this item cancels out of the equation.
**Sampling rate** (litres per minute) is a function of stack velocity (metres per second) and probe tip area (square centimetres), derived from $pr^2$. The rationale is as below:

$$\text{Metres per second (m/s) x } \frac{100}{60} = \text{centimetres per minute (cm/min)}$$

$$\text{Centimetres per minute (cm/min) x Square centimetres (cm}^2\text{) = Cubic Centimetres per minute (cm}^3\text{/min)}$$

$$\frac{\text{Cubic Centimetres per minute (cm}^3\text{/min)}}{1000} = \text{Litres per minute (l/min)}$$

Thus:

$$\textbf{Sampling Rate (l/min)} = \frac{\textbf{Ambient Stack Flow (m/s) x Tip area (cm}^2\textbf{)}}{\textbf{600}}$$

**Determination of Flue Gas Density:**

Stack gas density is determined by measuring the concentration of Carbon Dioxide, Carbon monoxide and Oxygen in the stack. This can be done using a combustion analyser.

The residual dry atmospheric gas is assumed for the purpose of this calculation to be Nitrogen. Nitrogen concentration is calculated as follows:

$$\% N_2 = 100 - (\% CO_2 + \% O_2 + \% CO)$$

The proportion if each gas in the dry mixture can then be utilised to calculate the dry molar gas density as shown previously:

$$\textbf{Molar Dry Gas Density (Dd)} = (\%CO_2 \times \frac{44}{100}) + (\%\ O_2 \times \frac{32}{100}) + (\%CO + \%N_2 \times \frac{28}{100})$$

Flue gases however also contain water. The water is condensed out of the sampling line, (to protect the sampling pump), and is weighted.

The volume of gas occupied by the collected condensate water can be calculated from the volume occupied by 1 mole of standard gas (ie. 22.4 litres at 273K, 1013mb).

$$\textbf{Gas Phase Volume of Water (litres)} = \textbf{Weight of Water (grams)} \times \frac{22.4}{28}$$

Dry gas volume of the sample is measured by the gas meter in the sampling line. Total gas volume (wet) collected is therefore the sum of the calculated water volume above and the dry gas volume measured.

**Total (Wet) Gas Volume = Dry Gas Volume + Gas phase Water Volume**

Using the above relationship, the proportion of dry gas in the total volume collected, (Mole Faction of Dry Gas), can be calculated as follows:

$$\textbf{Mole Fraction of dry gas (Md)} = \frac{\textbf{Dry gas volume}}{\textbf{Total gas volume}}$$

Mole fraction of wet gas can be calculated similarly, or as

**Mole fraction of wet gas (Mw) = 1 - Mole fraction of dry gas (Md)**

Density of stack gas can then be calculated from the density of dry stack gas calculated above, and the Mole Fractions calculated.

Thus:

**Molar Density**
**of dry gas (Dd) x Mole fraction of dry gas (Md) + 18 (1 - Md)**
**= Molar Stack gas density (Ds)**

This latter equation is identical in methodology to the earlier equation for deriving molar gas density of dry gas, but now includes an extra derived function for water

$$\text{Molar stack gas density (Ds)} = \text{Md}\ (\frac{\%CO2 \times 46}{100} + \frac{\%O2 \times 32}{100} + \frac{\%N2 + \%CO \times 28}{100}) + \text{Mw}\ (\frac{\%H2O \times 18}{100})$$

In most cases the Molar stack gas density will work out as 29 ± 1. In this case, the normal equation for stack flow will prove to be satisfactory.

**Calculation of Volume Flow:**

Volume flow is calculated from flow velocity and internal area of the stack or duct as follows:

Volume flow ($m^3$ /min) = Velocity ($ms^{-1}$) x Internal Area of Duct ($m^2$) x 60

Internal area of duct is calculated as:

$pr^2$ for a circular duct,
or base x height for a square duct.

To convert $m^3min^{-1}$ to cubic feet per minute (cfm) multiply by 35.315

**Oxygen Correction**:

The principal behind the oxygen correction is that a complete combustion process would consume all the oxygen, releasing only Carbon Dioxide and Water. Thus the more efficient the combustion process, the less Oxygen is released.

Many processes however function less efficiently than they should, and many others are designed to operate with a large excess of air, or additions of cool air to facilitate the erection of less heat resistant stacks.

The oxygen correction is designed to recalculate the concentration of pollutant gases found, assuming that the process if functioning at a reasonable efficiency for its type.

Thus Gas & Oil fired combustion plant are corrected to 3% $O_2$, Coal fired combustion plant at 6% $O_2$, Clinical Waste Incinerators at 11% $O_2$, and Gas Turbines at 15% $O_2$. Other processes may be standardised to other Oxygen concentrations.

Oxygen makes up about 20.9% of normal air; this is used in the correction factor, which is as follows:

$$\textbf{Corrected Pollutant Concentration (mg/m}^3\textbf{)} = \frac{\underline{(20.9 - \text{Standard } O_2\%)}}{(20.9 - \text{Measured } O_2\%)} \times \text{Measured Conc}^n$$

This means that where a combustion process is running more efficiently than required, the correction factor will effectively decrease the final corrected concentration of pollutant. Conversely, where the process is inefficient, the Oxygen correction can dramatically increase the final result.

The correction is only used in combustion processes, and is applied identically to all pollutant gases and particles.

**Conversion Factors (mg/m$^3$ and ppm):**

Final results of particulate concentrations in air are always presented as a weight by volume measure (e.g. milligrams per cubic metre).

Gases can be presented as a weight by volume, or as a volume measure (parts per million). Unfortunately, there is no standard methodology within the Process Guidance notes and both types of measure are used, often in the same note. It is thus, important to be able to change between the two methods of calculating gas concentration.

Hydrogen chloride will be used to illustrate the two methods as follows:

Hydrogen chloride has molecular weight of 36.5. 1 mole of HCl occupies 22.4 litres at s.t.p. 1 milli - mole of HCl occupies 22.4 millilitres at s.t.p. 1 millimole weighs 36.5 milligrams.

If 1 millimole of HCl is dispersed in 1 cubic metre of air then this is a concentration of 36.5 milligrams per cubic metre (mg/m$^3$) or 22.4 millimetres per cubic metre (parts per million) ppm.

So for HCl 36.5 mg/m$^3$ = 22.4 ppm

Specifically for HCl $\text{ppm} \times \frac{36.5}{22.4} = \text{mg/m}^3$

**In general** $\quad \text{ppm} \times \frac{\text{molecular weight}}{22.4} = \text{mg/m}^3$ **at standard conditions (273 K, 1013mb)**

The concept of parts per million is particularly useful, because gas volumes expand and contract with temperature and pressure. Because all gases occupy the same volume, ppm does not change with temperature.Thus a gas concentration recorded in ppm at high temperature, is still the same at low temperature, and at standard conditions, allowing a direct conversion to mg/m$^3$ without the worry of changing volumes.In the case of Nitric Oxide (NO) and Nitrogen Dioxide ($NO_2$), NO exists at high temperature, as a breakdown product of $NO_2$. When combined emissions are released to atmosphere, the NO cools and re-oxidises to form $NO_2$. Thus the PG notes required presentation of Nitrogen oxides (NOx) to be combined and expressed as $NO_2$.

Because both gases occupy the same volume the ppm concentrations can be directly added such that:

$$\textbf{ppm NO + ppm NO}_2 \textbf{ = ppm NOx (as NO}_2\textbf{)}$$

The combined $NO_x$ concentration as $NO_2$ can then be calculated as above using the molecular weight of $NO_2$ as the basis for the calculation.

Occasionally (for example in Occupational Hygiene applications), the conversion equation is presented as:

$$\text{mg/m}^3 = \text{ppm} \times \frac{\text{molecular weight}}{24}$$

This allows for the fact that 1 mole of gas at 20$^{\circ}$C, 1013 mb, occupies 24 litres, and is correct for use at ambient conditions. It is not correct to use this equation at standard conditions.

**Temperature and Pressure:**

Assuming that stack gases obey the standard Gas Laws, then:

$$\frac{\text{Atmospheric Pressure (mb)} \times \text{Volume (m}^3\text{)}}{\text{Temperature (K)}} = \text{Molar Gas Content}$$

or

$$\frac{PV}{T} = K$$

The Molar Gas Constant equals 8.3143 J $K^{-1}$ $mol^{-1}$

A more useful expression of the Gas Law is:

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

This can be expressed to find an unknown as; -

$$V1 = \frac{P_2V_2}{T_2} \times \frac{T_1}{P_1}$$

The correction equation can therefore be expressed as:

$$\text{Standardised Volume} = \frac{\text{Recorded Pressure}}{\text{Std Pressure (1013)}} \times \frac{\text{Std Temperature (273)}}{\text{Recorded Temperature}} \times \text{Recorded Volume}$$

For this correction to work, any unit of pressure can be utilised (inches of water, millimetres of mercury, millibars, kilopascals etc.) provided that the standard atmosphere is expressed in similar units. Temperature must however be worked in Absolute Units e.g. Kelvin (K = $^{o}$C + 273.15) or Rankine ($^{o}$R = $^{o}$F + 459.67)

### 2.2.6 INITIAL STACK PROFILE STUDY

As per the provisions ISO 9096:2003, a stack profile study was addressed prior to monitoring and sampling. This study was undertaken at ten points in two transaxial assessments at the sampling portal locations. Both temperature and velocity profiles were measured. The study determined that the temperature variance across the two measured planes was less than 10 C, and that velocity variances were within method tolerance specification. (Pre-test measurements determined that the sampling head was less than 10 % of the total stack cross sectional area as detailed in ISO 9096:2003).

### 2.2.7 CLIMACTIC CONDITIONS

The following climactic conditions were noted during the study; -

| | |
|---|---|
| Ambient Temperature - K | 280.8 |
| Atmospheric Pressure - kPas | 103.6 |
| Relative Humidity - % | 48 |
| Wind Speed - kph | < 10 |
| Wind Direction | NW |
| Visibility metres | > 1000 |
| Weather | Bright and clear |

### 2.2.8 QA - QC PROCEDURES

Halcyon operates QA - QC procedures following the guidelines of Halcyon QA.QC Doc 1. Halcyon is a member of the Source Testing Association.

### 2.2.9 UNCERTAINTY MEASUREMENTS

Halcyon operates the measurement of uncertainty in accordance with; -

**"Guidance on Assessing Uncertainty in Stack Emission Monitoring" Dr.J.Pullen STA Quality Task Group**

# SECTION 3

# ANALYTICAL PROCEDURES

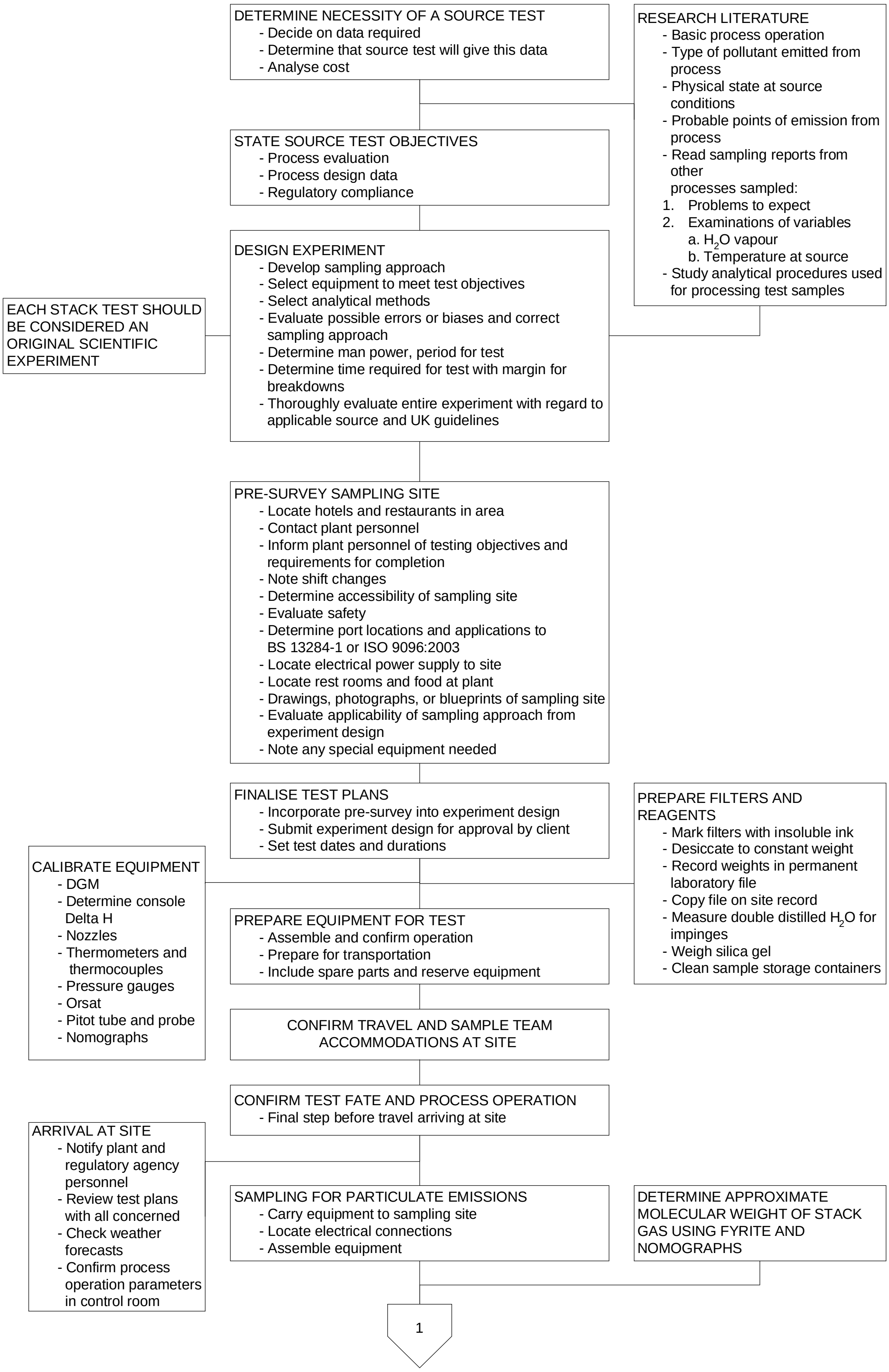
## 3 ANALYTICAL PROCEDURES AND METHODS

The following analytical methods were used to determine the data reported herein; -

| | **Analyte** | **Method Reference** |
|---|---|---|
| 1 | $CO$ / $CO_2$ | 1S0 15058 |
| 2 | Total Particulate Matter | ISO 9096:2003 |
| 3 | VOC | BS 12619 |
| 4 | VOC as Carbon | BS 12619 |
| 5 | Water Content | EPA Method 4 |
| 6 | Oxygen | **Direct reading |
| 7 | Free Formaldehyde | Halcyon Test Method HALC.EPA.HCHO 01<br>Impingers + automated dynamic titrimetry |
| 8 | Chlorides | BS 1911-3 |

**Eurotron Combustion Gas Analyser instrument

## Planning and performing a stack test



DETERMINE NECESSITY OF A SOURCE TEST
- Decide on data required
- Determine that source test will give this data
- Analyse cost

RESEARCH LITERATURE
- Basic process operation
- Type of pollutant emitted from process
- Physical state at source conditions
- Probable points of emission from process
- Read sampling reports from other processes sampled:
  1. Problems to expect
  2. Examinations of variables
     a. $H_2O$ vapour
     b. Temperature at source
- Study analytical procedures used for processing test samples

STATE SOURCE TEST OBJECTIVES
- Process evaluation
- Process design data
- Regulatory compliance

EACH STACK TEST SHOULD BE CONSIDERED AN ORIGINAL SCIENTIFIC EXPERIMENT

DESIGN EXPERIMENT
- Develop sampling approach
- Select equipment to meet test objectives
- Select analytical methods
- Evaluate possible errors or biases and correct sampling approach
- Determine man power, period for test
- Determine time required for test with margin for breakdowns
- Thoroughly evaluate entire experiment with regard to applicable source and UK guidelines

PRE-SURVEY SAMPLING SITE
- Locate hotels and restaurants in area
- Contact plant personnel
- Inform plant personnel of testing objectives and requirements for completion
- Note shift changes
- Determine accessibility of sampling site
- Evaluate safety
- Determine port locations and applications to BS 13284-1 or ISO 9096:2003
- Locate electrical power supply to site
- Locate rest rooms and food at plant
- Drawings, photographs, or blueprints of sampling site
- Evaluate applicability of sampling approach from experiment design
- Note any special equipment needed

FINALISE TEST PLANS
- Incorporate pre-survey into experiment design
- Submit experiment design for approval by client
- Set test dates and durations

CALIBRATE EQUIPMENT
- DGM
- Determine console Delta H
- Nozzles
- Thermometers and thermocouples
- Pressure gauges
- Orsat
- Pitot tube and probe
- Nomographs

PREPARE FILTERS AND REAGENTS
- Mark filters with insoluble ink
- Desiccate to constant weight
- Record weights in permanent laboratory file
- Copy file on site record
- Measure double distilled $H_2O$ for impinges
- Weigh silica gel
- Clean sample storage containers

PREPARE EQUIPMENT FOR TEST
- Assemble and confirm operation
- Prepare for transportation
- Include spare parts and reserve equipment

CONFIRM TRAVEL AND SAMPLE TEAM ACCOMMODATIONS AT SITE

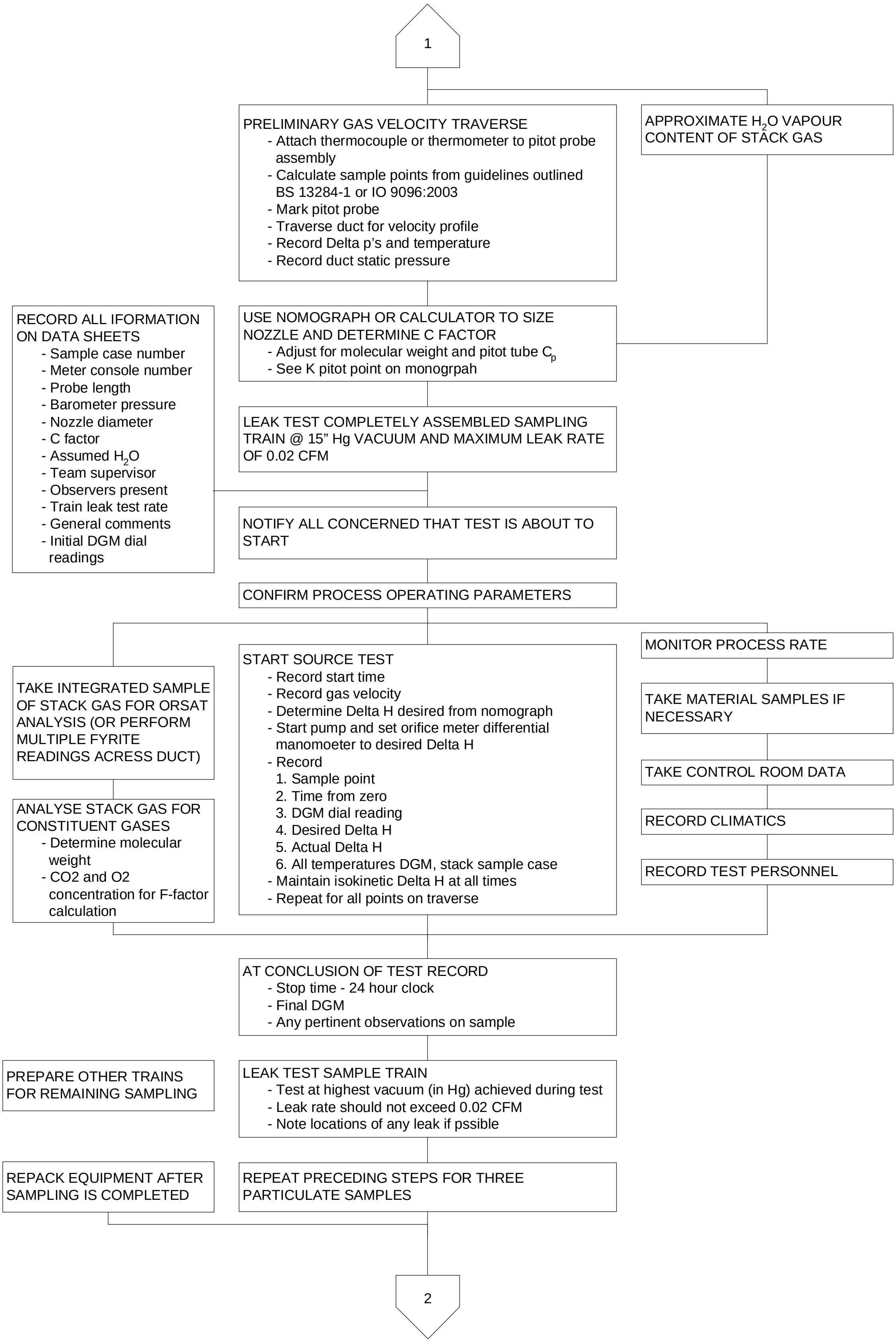
CONFIRM TEST FATE AND PROCESS OPERATION
- Final step before travel arriving at site

ARRIVAL AT SITE
- Notify plant and regulatory agency personnel
- Review test plans with all concerned
- Check weather forecasts
- Confirm process operation parameters in control room

SAMPLING FOR PARTICULATE EMISSIONS
- Carry equipment to sampling site
- Locate electrical connections
- Assemble equipment

DETERMINE APPROXIMATE MOLECULAR WEIGHT OF STACK GAS USING FYRITE AND NOMOGRAPHS

1



PRELIMINARY GAS VELOCITY TRAVERSE
- Attach thermocouple or thermometer to pitot probe assembly
- Calculate sample points from guidelines outlined BS 13284-1 or IO 9096:2003
- Mark pitot probe
- Traverse duct for velocity profile
- Record Delta p's and temperature
- Record duct static pressure

APPROXIMATE $H_2O$ VAPOUR CONTENT OF STACK GAS

RECORD ALL IFORMATION ON DATA SHEETS
- Sample case number
- Meter console number
- Probe length
- Barometer pressure
- Nozzle diameter
- C factor
- Assumed $H_2O$
- Team supervisor
- Observers present
- Train leak test rate
- General comments
- Initial DGM dial readings

USE NOMOGRAPH OR CALCULATOR TO SIZE NOZZLE AND DETERMINE C FACTOR
- Adjust for molecular weight and pitot tube $C_p$
- See K pitot point on monogrpah

LEAK TEST COMPLETELY ASSEMBLED SAMPLING TRAIN @ 15" Hg VACUUM AND MAXIMUM LEAK RATE OF 0.02 CFM

NOTIFY ALL CONCERNED THAT TEST IS ABOUT TO START

CONFIRM PROCESS OPERATING PARAMETERS

TAKE INTEGRATED SAMPLE OF STACK GAS FOR ORSAT ANALYSIS (OR PERFORM MULTIPLE FYRITE READINGS ACRESS DUCT)

ANALYSE STACK GAS FOR CONSTITUENT GASES
- Determine molecular weight
- CO2 and O2 concentration for F-factor calculation

START SOURCE TEST
- Record start time
- Record gas velocity
- Determine Delta H desired from nomograph
- Start pump and set orifice meter differential manomoeter to desired Delta H
- Record
  1. Sample point
  2. Time from zero
  3. DGM dial reading
  4. Desired Delta H
  5. Actual Delta H
  6. All temperatures DGM, stack sample case
- Maintain isokinetic Delta H at all times
- Repeat for all points on traverse

MONITOR PROCESS RATE

TAKE MATERIAL SAMPLES IF NECESSARY

TAKE CONTROL ROOM DATA

RECORD CLIMATICS

RECORD TEST PERSONNEL

AT CONCLUSION OF TEST RECORD
- Stop time - 24 hour clock
- Final DGM
- Any pertinent observations on sample

LEAK TEST SAMPLE TRAIN
- Test at highest vacuum (in Hg) achieved during test
- Leak rate should not exceed 0.02 CFM
- Note locations of any leak if pssible

PREPARE OTHER TRAINS FOR REMAINING SAMPLING

REPEAT PRECEDING STEPS FOR THREE PARTICULATE SAMPLES

REPACK EQUIPMENT AFTER SAMPLING IS COMPLETED

2

SAMPLE CLEAN-UP AND RECOVERY

- Clean samples in laboratory or other clean area removed from site and protected from the outdoors
- Note sample conditions
- Store samples in quality assurance containers
- Mark and label all samples
- Pack carefully for shipping if analysis is not done on site

ANALYSE SAMPLES

- Follow BS 13284-1, ISO 9096:2003, EA, A1, A2, M1, M2 guidelines
- Document procedures and any variations employed
- Prepare analytical Report Data

CALCULATE

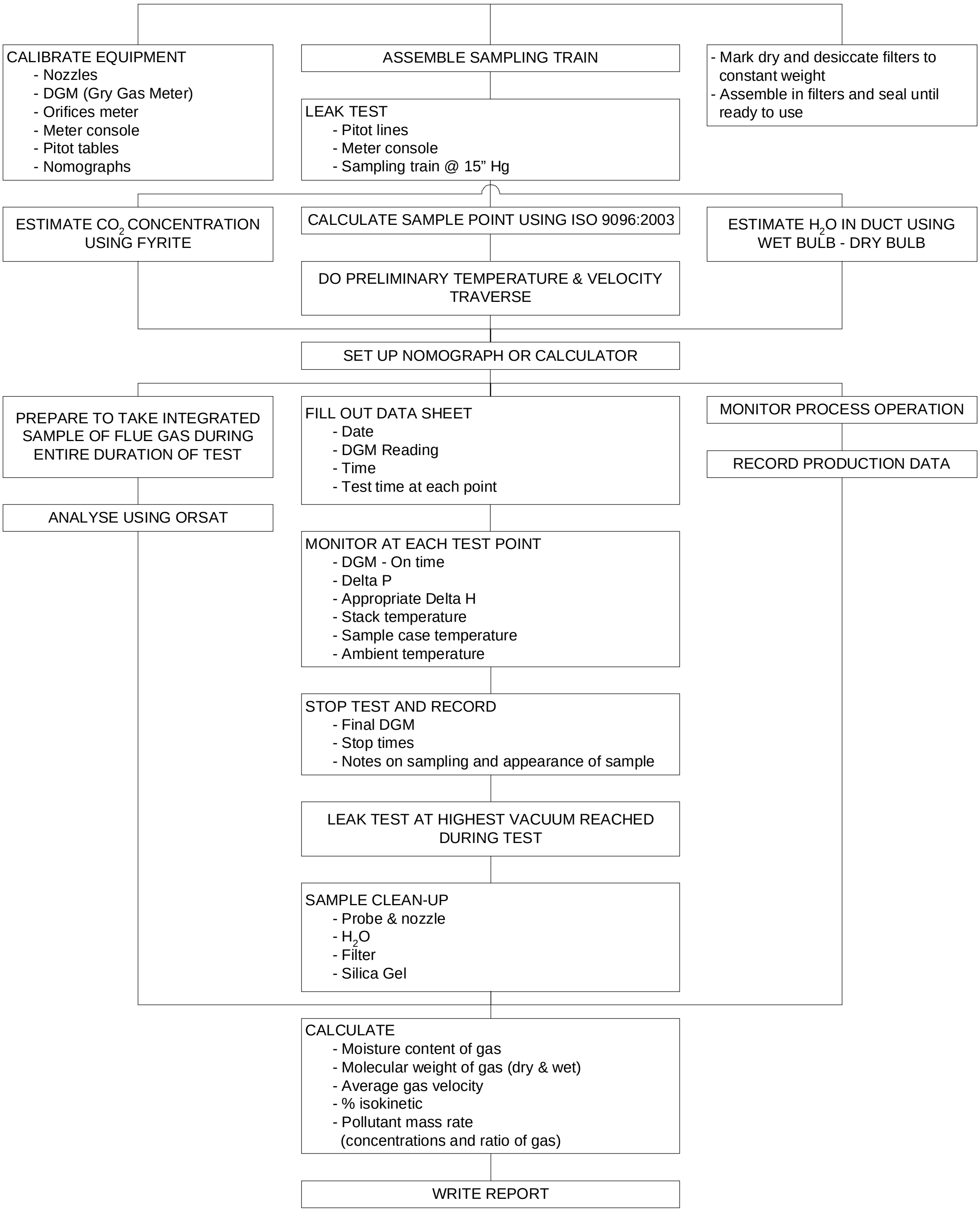
- Moisture content of stack gas
- Molecular weight of gas
- Volume sampled at standard conditions
- Concentration / standard volume
- Control device efficiency
- Volumetric flow rate of stack gas
- Calculate pollutant mass rate

WRITE REPORT

- Prepare as possible legal document
- Summarise results
- Illustrate calculations
- Give calculated results
- Include all raw data (process & test)
- Attach descriptions of testing and analytical methods
- Signature of analytical and test personnel

SEND REPORT WITHIN MAXIMUM TIME TO INTERESTED PARTIES

# Source Test Outline



CALIBRATE EQUIPMENT
- Nozzles
- DGM (Gry Gas Meter)
- Orifices meter
- Meter console
- Pitot tables
- Nomographs

ASSEMBLE SAMPLING TRAIN

LEAK TEST
- Pitot lines
- Meter console
- Sampling train @ 15” Hg

- Mark dry and desiccate filters to constant weight
- Assemble in filters and seal until ready to use

ESTIMATE $CO_2$ CONCENTRATION USING FYRITE

CALCULATE SAMPLE POINT USING ISO 9096:2003

DO PRELIMINARY TEMPERATURE & VELOCITY TRAVERSE

ESTIMATE $H_2O$ IN DUCT USING WET BULB - DRY BULB

SET UP NOMOGRAPH OR CALCULATOR

PREPARE TO TAKE INTEGRATED SAMPLE OF FLUE GAS DURING ENTIRE DURATION OF TEST

ANALYSE USING ORSAT

FILL OUT DATA SHEET
- Date
- DGM Reading
- Time
- Test time at each point

MONITOR PROCESS OPERATION

RECORD PRODUCTION DATA

MONITOR AT EACH TEST POINT
- DGM - On time
- Delta P
- Appropriate Delta H
- Stack temperature
- Sample case temperature
- Ambient temperature

STOP TEST AND RECORD
- Final DGM
- Stop times
- Notes on sampling and appearance of sample

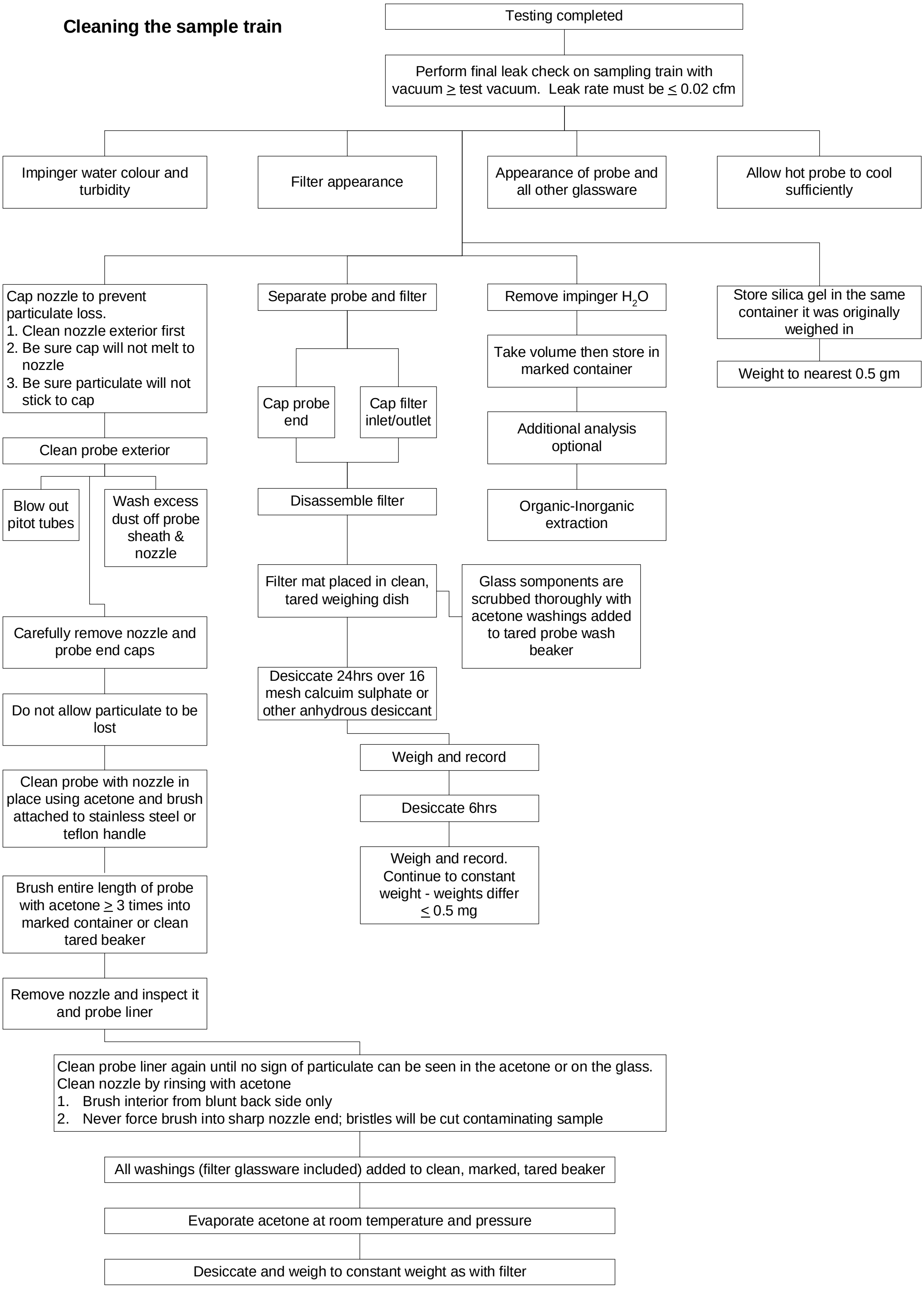
LEAK TEST AT HIGHEST VACUUM REACHED DURING TEST

SAMPLE CLEAN-UP
- Probe & nozzle
- $H_2O$
- Filter
- Silica Gel

CALCULATE
- Moisture content of gas
- Molecular weight of gas (dry & wet)
- Average gas velocity
- % isokinetic
- Pollutant mass rate (concentrations and ratio of gas)

WRITE REPORT

## Cleaning the sample train



Testing completed

Perform final leak check on sampling train with vacuum ≥ test vacuum. Leak rate must be ≤ 0.02 cfm

Impinger water colour and turbidity

Filter appearance

Appearance of probe and all other glassware

Allow hot probe to cool sufficiently

Cap nozzle to prevent particulate loss.
1. Clean nozzle exterior first
2. Be sure cap will not melt to nozzle
3. Be sure particulate will not stick to cap

Clean probe exterior

Blow out pitot tubes

Wash excess dust off probe sheath & nozzle

Carefully remove nozzle and probe end caps

Do not allow particulate to be lost

Clean probe with nozzle in place using acetone and brush attached to stainless steel or teflon handle

Brush entire length of probe with acetone ≥ 3 times into marked container or clean tared beaker

Remove nozzle and inspect it and probe liner

Separate probe and filter

Cap probe end

Cap filter inlet/outlet

Disassemble filter

Filter mat placed in clean, tared weighing dish

Glass somponents are scrubbed thoroughly with acetone washings added to tared probe wash beaker

Desiccate 24hrs over 16 mesh calcuim sulphate or other anhydrous desiccant

Weigh and record

Desiccate 6hrs

Weigh and record. Continue to constant weight - weights differ ≤ 0.5 mg

Remove impinger $H_2O$

Take volume then store in marked container

Additional analysis optional

Organic-Inorganic extraction

Store silica gel in the same container it was originally weighed in

Weight to nearest 0.5 gm

Clean probe liner again until no sign of particulate can be seen in the acetone or on the glass. Clean nozzle by rinsing with acetone
1. Brush interior from blunt back side only
2. Never force brush into sharp nozzle end; bristles will be cut contaminating sample

All washings (filter glassware included) added to clean, marked, tared beaker

Evaporate acetone at room temperature and pressure

Desiccate and weigh to constant weight as with filter

### Table 1: Simple error analysis for particulate measurement, 4 Point Sampling (or 10 Point Sampling when Pitot Ratios >4:1≤9:1)

| Type of Error | Source of Error | Quoted uncertainty | Estimate of component standard uncertainty (1SD) | Combined uncertainties (1SD) | Combined uncertainty (1SD) | Expanded uncertainty (95% confidence limits) |
|---|---|---|---|---|---|---|
| Precision-like Errors | | | | | ±13.03% | ±25.5% |
| Random | Errors in setting to isokinetic conditions | ≤±1% | ≤±0.58% | ±4.66% | | |
| | Minimum sampling time of 3 minutes | ±8% | ±4.62% | | | |
| Systematic | | | | | | |
| Accuracy-like Errors | | | | | | |
| Random | Measure flue dimensions to ±10mm/m | ±2% | ±1.15% | ±1.15% | | |
| Systematic | Number of sampling points (see note below) | ±13% | ±6.63% | ±7.22% | | |
| | Minimum weight gain | assume ±2% | ±1.5% | | | |
| | Pre=/Post-pitot reading within 10% | ±2.5% | ±1.44% | | | |
| | Temperature variations of 10% on $150^{o}$C | ±1/5% | ±0.87% | | | |
| | Gas flow axis deviates up to $30^{o}$ | ≤±3.5% velocity | ≤±2.02% velocity | | | |

*Note: Type A component uncertainty, quoted at 95% confidence limits. All other component uncertainties assumed to be Type B.*

### Table 2: Simple error analysis for measurement of mass flow particulates when not all the requirements of ISO 9096:2003 are met.

Deviation from standard: Only nearest 2 points of 4 on each of sampling lines can be reached (circular duct); pre/post sampling velocities differed by 20%; Highest to lowest pitot reading 15:1.

| Type of Error | Source of Error | Quoted uncertainty | Estimate of component standard uncertainty (1SD) | Combined uncertainties (1SD) | Combined uncertainty (1SD) | Expanded uncertainty (95% confidence limits) |
|---|---|---|---|---|---|---|
| Precision-like Errors | | | | | ±20.7% | ±40.8% |
| Random | Errors in setting to isokinetic conditions | ≤±1% | ≤±0.58% | ±4.66% | | |
| | Minimum sampling time of 3 minutes | ±8% | ±4.62% | | | |
| Systematic | | | | | | |
| Accuracy-like Errors | | | | | | |
| Random | Measure flue dimensions to ±10mm/m | ±2% | ±1.15% | ±1.15% | | |
| Systematic | Number of sampling points, and highest:lowest pitot readings 15:1 (see note below) | ±(13+12)%=25% | ±12.78% | ±14.88% | | |
| | Bias due to non-symmetrical points | ±7.5% | ±4.33% | | | |
| | Minimum weight gain | assume ±2% | ±1.5% | | | |
| | Pre/Post-pitot readings differ by 20% | ±10% | ±5.77% | | | |
| | Temperature variation of 10% on 150$^{o}$C | ±1.5% | ±0.87% | | | |
| | Gas flow axis deviates up to 30$^{o}$ | ≤±3.5% velocity | ≤±2.02% velocity | | | |

*Note: Type A component uncertainty, quoted at 95% confidence limits. All other component uncertainties assumed to be Type B.*

## Introduction

The total uncertainty of measurements for BS EN 1911 (parts 1 – 3) (Measurement of Chlorides as HCl) are defined within key areas which are a combination of uncertainty values. Therefore all values must be in common unit before combining, in this case percentages %. The aim of this addendum is to provide an uncertainty value that can be used easily when reporting and to prove our execution conforms with the standard *ie*. within the general stated uncertainty associated with the method.

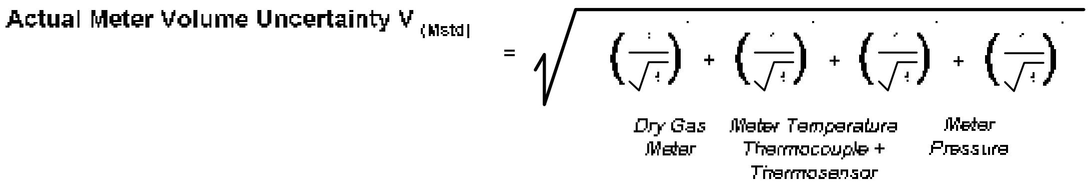
All of our instruments are calibrated to be within the standard set out by the method in use or a method which uses the same instruments *eg* dry gas meter uncertainty in BS EN 13284-1 low particulate to be under 2%. This means the worst case scenario of uncertainty will be to use these maximum limits. All of the data and assumptions are supported by our calibration documents, which is made up of internal calibrations by trained staff using internal or external calibrations.

As for calculations used to work out uncertainty, the following example uses real and accurate figures to produce 95% confidence limits which are then halved to give standard uncertainty.

The calculations used to work out uncertainty values are based on NPL's Measurement Good Practice Guide No. 11, 1999 Page 14 & 15 and STA Guide to Uncertainty.

## Calculations

The three key areas of uncertainty linked to this type of sampling (non-isokinetic) are analysis, actual meter volume (gas volume) and sample solution volume. A combined standard uncertainty for the method can then be worked out from these figures. As the uncertainty can change with the scale of measurement, such as volume etc.; typical figures will be applied such as 100 lt. meter volume, 100 mls sample volume.



Values are divided by square root of three in order to give standard uncertainty, as the measured values are tolerances (+/-) percentages, therefore having a rectangular/uniform distribution. -Type B evaluation NPL Guide.

Standard Uncertainty (s.u )= **1.53%**
To 95% confidence (where k=2) = **3.06%**

**Sample Solution Volume Uncertainty** is assumed to arise from the resolution/scaling precision deficiencies of the measuring cylinder used. As the graduations go to nearest 1ml, the uncertainty +/- 0.5 ml.

$$= \frac{0.5}{\boxed{\sqrt{3}}}$$

Standard Uncertainty (s.u) = **0.29%**
To 95% confidence (where K=2) = **0.58%**

**Standard Uncertainty =**

$$\sqrt{\underset{\substack{\text{Actual}\\\text{Volume}\\\text{Measured}}}{(1.53)^2} + \underset{\text{Analysis}}{(7.5)^2} + \underset{\substack{\text{Solution}\\\text{Volume}}}{(0.29)^2}}$$

Standard Uncertainty (s.u) = **Emission Concentration (mg/m$^3$) +/- 7.66%**
Expanded Standard Uncertainty (k=2) = **Emission Concentration (mg/m$^3$) +/- 15.32%**

**Combined Standard Uncertainty =** Emission Concentration (mg/m$^3$) +/- 7.66%
**Expanded Standard Uncertainty (k=2) =** Emission Concentration (mg/m$^3$) +/- 15.32%

## SECTION 4

## MEAN EFFLUX VELOCITY DATA

## 4 FLOW DYNAMICS RESULTS

The following results were determined using the calculations and correction coefficients detailed in ISO 9096:2003.

The following results were determined at the portal locations; -

**TABLE 4.1 MEAN EFFLUX VELOCITY RESULTS.**

| Sampling Location | Mean Efflux Velocity m/sec @ T | Discharge Temp K |
|---|---|---|
| Portal | 12.99 | 396.65 |

Mean efflux velocity is specifically determined as the initial criteria to all subsequent sampling work, this being fully dependent upon the reported value being obtained correctly. Errors included in this initial measurement may be significant if not correctly identified and eliminated from the test procedure. The errors associated within any typical test are reported in the standard Halcyon Test Report.

Sampling locations are generally defined in Technical Guidance Notes M1 and M2, as are the access portal descriptions.

When undertaking mean efflux velocity, the standard working tool in the pitot tube; descriptions of various pitots are defined in TGN M1. All pitot tubes must be in good working order, with current calibration and with use of the correct sampling nozzles for static and dynamic pressure determinations. Results are normally displayed on a suitable electronic micro-manometer. Many of these devices are equipped with basic calculation software such that once the stack dimensions have been entered and the procedure completed, the velocity, mass flow at T and at reference conditions can all be completed from pre-programmed calculation matrices. Data determined in the field can be directly transposed into standard document formats to simplify the calculation tasks.

The supporting kit equipment that is used will determine ambient and stack temperature, ambient barometric pressure, relative humidity and oxygen levels; again this information can be entered into pre-programmed calculator matrices to establish data at T and reference conditions as required by permit provisions.

The standard methods of determination are defined in the relevant ISO or BS protocol, typically ISO 9096: 2003 of BS 13284 – 1: 2002. The test statement should be included whether the testing is supporting isokinetic sampling or not.

Essentially the pitot is used to traverse the stack during testing, normally across at least 2 sampling planes. From the initial study the tester confirms that Vmax:Vmin, Tmax:Tmin, drift angle, gas homogeneity and droplet tests are completed and met. The typical working area of the stack is usually > 5 hydraulic diameters above a bend or joint, in a straight section of the stack. The probe is inserted at the correct location and allowed to monitor for approx. 2 – 3 minutes before the reading is determined.

Normally up to 16 or 17 test locations are measured within a circular stack and 4 or 8 locations in a square or rectangular stack. All locations are reported in the standard Halcyon Test Report as are any determined Uncertainty values.

Velocity measurements are obtained and then stored in the electronics and a mean value calculated. The meeting of the sampling provisions is normally deemed more relevant than the geometry of the sampling port; if the sampling plane criteria are met then a non-standard port is usually considered as secondary. As such for part A2 and B processes the use of the BS 3405 portal is still considered as acceptable.

The formula for the determination on MEV is defined within the standard Halcyon format.

Of critical importance is the safety of and Stack Tester; this being implicit within the standard sampling procedure. The stack tester's safe working is defined within STA guidance and often a compromise must be considered in full compliance with TGN M1 and the significance of the Working at Height Regulations.

TGN M1 defines the configuration of the approved stack sampling platform, and this is applied strictly to A1 permitted sites, however A2 and B permitted sites often do not have such platforms in place. It is then necessary for the tester to complete a suitable risk assessment and minimise any risks.

The current STA view is that sampling must only take place from safe locations; the use of ladders is strictly prohibited and the use of cherry pickers only considered appropriate once a safe working evaluation and full risk assessment have been completed. The STA regards the formal and documented training for Working at height as an implicit provision on any stack testers' portfolio.

Halcyon personnel normally utilise the STA Guidance documentation, Disclosure of Hazards document and Risk Assessment format as a condition of their site activities.

The duct airflow stream temperature was measured continuously using a Casella W1720 thermo - anemometer probe (HE 03-034) in the stack portals.

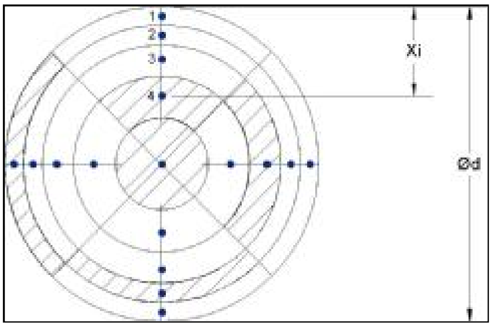
The implicit ISO 9096:2003 error factor of +/- 12 % was considered as satisfactory, as was the + 7% isokinetic correction factor applied to the calculation.

# Pitot Measurements

| | | | |
|---|---|---|---|
| **BS 13284-1** | | **ISO 9096:2003** | **Y** |
| **BS6069:** | | *Please tick the relevant box* | |

| | | | |
|---|---|---|---|
| **Client:** | *David Smith St Ives Limited* | **Date:** | *4th February 2013* |
| **Address:** | *Marley Road* | **Operator:** | *T Growcott* |
| | *St Ives* | **Job Number:** | *HE 13/9139* |
| | *Huntingdon* | **Location:** | *Wood Burner* |
| | *Cambs PE 27 3EX* | **Instruments:** | *!M Pitot + BS 1042 Pitot* |

| | | | | | |
|---|---|---|---|---|---|
| **Details of Duct:** | *Insulated Steel* | | | **Atmos. P (pa)** | **Atmos. Temp K** |
| **Duct Shape:** | *Circular* | | **Initial:** | 103.4 | 280.4 |
| **Dimension / Dia.:** | 0.3 | | **Final:** | 103.8 | 281.2 |
| **Area:** | | | **Mean:** | *103.6* | *280.8* |
| | **Axis 1:** | | **Axis 2:** | **Gas Homogeneity Check:** | Pass |



| **Traverse Point** | **Temp K** | **Temp $K^2$** | **Velocity kPa** | **$V^2$** | | |
|---|---|---|---|---|---|---|
| **1** | 123.4 | 15227.56 | 89 | 7921 | | |
| **2** | 123.5 | 15252.25 | 96 | 9216 | | |
| **3** | 123.6 | 15276.96 | 99 | 9801 | | |
| **4** | 123.8 | 15326.44 | 119 | 14161 | | |
| **5** | 123.4 | 15227.56 | 101 | 10201 | | |
| **6** | 123.8 | 15326.44 | 109 | 11881 | | |
| **7** | 123.8 | 15326.44 | 113 | 12769 | **O2 reference** | 11% |
| **8** | 124 | 15376 | 121 | 14641 | **Humidity %** | 48 |
| **9** | 123.4 | 15227.56 | 91 | 8281 | **Ambient K** | 283.8 |
| **10** | 123.5 | 15252.25 | 98 | 9604 | **Negative Pressure** | Pass |
| **11** | 123.7 | 15301.69 | 107 | 11449 | **Drift Angle** | <15° |
| **12** | 123.8 | 15326.44 | 116 | 13456 | **Dry Gas Correction** | Y |
| **13** | 123.4 | 15227.56 | 98 | 9604 | **Pitot Correction** | Y |
| **14** | 123.4 | 15227.56 | 113 | 12769 | **T Correction** | Y |
| **15** | 123.7 | 15301.69 | 117 | 13689 | **Vmax : Vmin** | Pass |
| **16** | 123.8 | 15326.44 | 126 | 15876 | **Tmax : Tmin** | Pass |
| **17** | 124.1 | 15400.81 | 131 | 17161 | **$V_{rms}$** | 109.1356415 |
| **Total** | ***2102.1*** | ***259931.65*** | ***1844*** | ***202480*** | **Pitot Calibration** | *1.003* |
| **Average** | ***123.652941*** | ***15290.09706*** | ***108.4705882*** | ***11910.58824*** | **Static Pressure Pv (Pascals)** | -1.67 |
| **RMS** | | **123.653132** | | **109.1356415** | **Mean Stack Temperature K** | 396.653132 |
| | | | | | **Moisture Content %** | 5.472 |

# SECTION 5

# ANALYTICAL RESULTS

## 5 ANALYTICAL SEQUENCE AND RESULTS

The monitoring strategy was undertaken over one day.

An ongoing continuous assessment of emission clarity, colour and odour at the point of discharge were also undertaken. At no time during this study was there any indication of colouration by dense or black smoke.

Periodic monitoring of $O_2$, water vapour, CO, SOx, NOx and VOC were undertaken.

TPM measurement was undertaken on 2 x 30 minute sampling schedules with the filters located outside of the stack. A blank was performed for each test scenario.

### 5.1 ANALYTICAL RESULTS

Analytical mean result data is detailed below: -

| Analyte | Test 1 | Test 2 | Mean | PG 1/12 (2012) Max Limit |
|---|---|---|---|---|
| 1. Carbon Monoxide CO (mg/m$^3$) | 480 samples (120 minutes at 15 second intervals) | | 169 | 250 |
| 2. TPM (mg/m$^3$) | 161.42<br>1 x 30 mins sample | 153.72<br>1 x 30 mins sample | 157.57 | 200 |
| 3. VOC as C (mg/m$^3$) | 480 samples (120 minutes at 15 second intervals) | | 6.117 | 20 |
| 4. Oxygen (%) | 480samples (120 minutes at 15 second intervals) | | 11.03 | - |
| 5. Water Vapour (%) | 2 x 60 mins sample | | 6.292 | - |
| 6. Oxides of Sulphur SOx (mg/m$^3$) | 480 samples (120 minutes at 15 second intervals) | | 1.02 | - |
| 7. Oxides of Nitrogen NOx (mg/m$^3$) | 480 samples (120 minutes at 15 second intervals) | | 52.0 | - |
| 8. Formaldehyde (mg/m$^3$) | 1.97<br>(1 x 30 min sample) | - | 0.972 | - |
| 9 Chlorides (as HCl) (mg/m$^3$) | (2 x 15 min sample) | - | 1.97 | - |

## Stack S1 – Volatile Organic Compounds (VOC as C)

| | |
|---|---|
| **Job Number:** | HE 12/9139 |
| **Client:** | David Smith St Ives |
| **Date:** | 4th February 2013 |
| **Release Point Stack Ref** | S1 |
| **Instrument Type** | FID |
| **Calibration Gas** | Methane |
| **Sample Number** | 9139/VOC/001 - 480 |
| **Test Start (Ti)** | 07.25.00 |
| **Test Finish (Tf)** | 09.25.00 |
| **Test Duration (mins)** | 120 |
| **% Carbon** | 75 |
| **Sampling Rate Interval (secs)** | 15 |
| **No. of Samples** | 480 |
| **Maximum Reading (mgC/m$^3$)** | 9 |
| **Minimum Reading (mgC/m$^3$)** | 0 |
| **Mean Reading (mgC/m$^3$)** | 6.117 |

## Stack S1 – Total Particulate Matter

| | |
|---|---|
| **Job Number:** | HE 13 / 9139 |
| **Client:** | David Smith St Ives |
| **Date:** | 4th February 2013 |
| **Release Point Stack Ref** | S1 |
| **Tester** | T Growcott |
| **Test Method** | ISO 9096:2003 |
| **STA Reference** | MM 03 / 314 |
| **-ve Pressure Test** | Pass |
| **Droplet Test** | Pass |
| **Vmax:Vmin Test** | Pass |
| **Tmax:Tmin Test** | Pass |
| **Pressure Differential Test** | Pass |
| **Drift Angle** | <15° |
| **Gas Homogeneity Test** | 20 point CO Pass |
| **Instrument Type** | Anderson Portable |
| **Sample Number** | 9139/TPM/001/2 |
| **Test Start (Ti)** | 07.40.00 |
| **Test Finish (Tf)** | 08.50.00 |
| **Test Duration (mins)** | 70 |
| **Heater Box Inlet C** | 19 |
| **Heater Box Outlet C** | 20 |
| **MID 1 Correction** | Duplicate Samples |
| **Sampling Head** | TPM 002 |
| **Sampling Points** | 4 |
| **No. of Samples** | 2 x 30 mins |
| **Maximum Reading (mg/m$^3$)** | 161.42 |
| **Minimum Reading (mg/m$^3$)** | 153.72 |
| **Mean Reading (mg/m$^3$)** | 157.57 |

## Stack S1 – Water Vapour

| | |
|---|---|
| **Job Number:** | HE 13 / 9139 |
| **Client:** | David Smith St Ives |
| **Date:** | 4th February 2013 |
| **Release Point Stack Ref** | S1 |
| **Instrument Type** | EN 14710 |
| **Sample Number** | 9139/Water/001/2 |
| **Test Start (Ti)** | 07.30.00 |
| **Test Finish (Tf)** | 09.30.00 |
| **Test Duration (mins)** | 120 |
| **No. of Samples** | 2 x 60 mins |
| **Mean Reading (%)** | 6.292 |

## Stack S1 – Formaldehyde

| | |
|---|---|
| **Job Number:** | HE 13 / 9139 |
| **Client:** | David Smith St Ives |
| **Date:** | 4th February 2013 |
| **Release Point Stack Ref** | S1 |
| **Instrument Type** | Halcyon Test Box |
| **Sample Number** | 9139HCHO/001/2 |
| **Test Start (Ti)** | 10.00.00 |
| **Test Finish (Tf)** | 10.35.00 |
| **Test Duration (mins)** | 35 |
| **No. of Samples** | 1 x30 mins |
| **Mean Reading (mg/m$^3$)** | 0.972 |

## Stack S1 – Chlorides (as HCl)

| | |
|---|---|
| **Job Number:** | HE 13 / 9139 |
| **Client:** | David Smith St Ives |
| **Date:** | 4th February 2013 |
| **Release Point Stack Ref** | S1 |
| **BS 1911-3 Sampling Train** | Test Box 2 |
| **Sample Number** | 9139/HCl/001/2 |
| **Test Start (Ti)** | 10.00.00 |
| **Test Finish (Tf)** | 10.34.00 |
| **Test Duration (mins)** | 34 |
| **Sampling Rate Interval (mins)** | 15 |
| **No. of Samples** | 2 x 15 |
| **Mean Reading (mg/m$^3$)** | 1.97 |

## Stack S1 – Gaseous Components

| | | | |
|---|---|---|---|
| **Job Number:** | HE 13 / 9139 | HE 13 / 9139 | HE 13 / 9139 |
| **Client:** | David Smith St Ives | David Smith St Ives | David Smith St Ives |
| **Date:** | 4th February 2013 | 4th February 2013 | 4th February 2013 |
| **Release Point Stack Ref** | S1 | S1 | S1 |
| **Instrument Type** | Eurotron Combustion Gas Analyser | | |
| **Calibration Gas** | Self Calibrating Cells | | |
| **Sample Number** | 9139/CO/001 - 240 | 9139/NOx/001 - 240 | 9139/SOx/001 - 240 |
| **Test Start (Ti)** | 08.00.00 | 08.00.00 | 08.00.00 |
| **Test Finish (Tf)** | 10.00.00 | 10.00.00 | 10.00.00 |
| **Test Duration (mins)** | 120 | 120 | 120 |
| **Sampling Rate Interval (secs)** | 15 | 15 | 15 |
| **No. of Samples** | 480 | 480 | 480 |
| **Maximum Reading (mg/m$^3$)** | 347 | 89 | 2 |
| **Minimum Reading (mg/m$^3$)** | 81 | 64 | 1 |
| **Mean Reading (mg/m$^3$)** | 169 | 71 | 1.02 |

These results are reported in accordance with the protocol defined by LA-PPC/EPR and are expressed at standard reference conditions of 273K and 101.3 k Pa, with correction for 11 % oxygen content. The main VOC components determined in post sampling analyses were hydrocarbons and pyrolysis fragments as anticipated from wood feeds stocks. The TPM components determined in the duct air stream emission were composed mainly of carbonised soots.

# SECTION 6

# VISUAL ASSESSMENT

# 6 VISUAL ASSESSMENT

## 6.1 VISUAL ASSESSMENT

In accordance with the provisions of LA-PPC/EPR an assessment of discharge emissions was undertaken throughout the monitoring period.

The assessment was carried out with reference to the methods and procedures detailed in BS 2742C:1969.

The process related emissions were evaluated; the emission discharge colour for the stack was determined as < Ringlemann shade 0.5 throughout the study period.

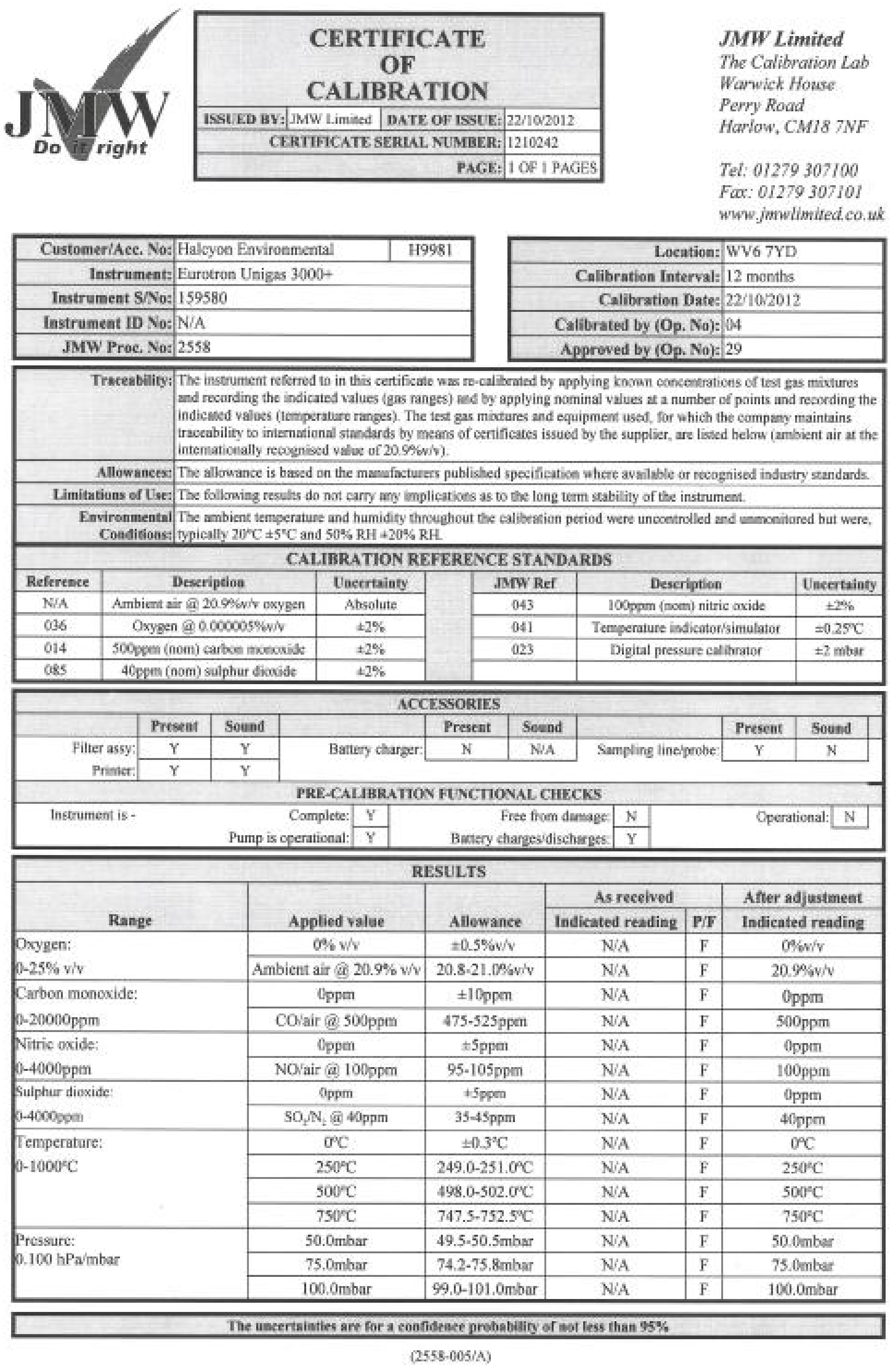
# APPENDIX 1

# INSTRUMENT CALIBRATION LOG

# HALCYON ENVIRONMENTAL CALIBRATION RECORD LOG

| | | |
|---|---|---|
| | **Doc. Ref:** | *CL001* |

| No. | Equipment | Serial Number | Model | Date of Calibration | Certificate Number |
|---|---|---|---|---|---|
| **01** | Airflow Developments | 114575 | PVM 100 | 22.10.2012 | IC1145P |
| **02** | Airflow Developments | N / A | BS1042 2A | 22.10.2012 | IC1145P |
| **03** | Eurotron Gas Analyser | 00724899 | 3000 Professional | 29.10.2012 | JMW |
| **04** | Eurotron | N / A | Probe | 27.10.2012 | 20615 |
| **05** | Rothero and Mitchell | 7173 | Airflow 3 | Calibrated Internally Against Standard | HE 09 / 22612 |
| **06** | Rothero and Mitchell | 6886 | Airflow 3 | “ | HE 09 / 22613 |
| **07** | Rothero and Mitchell | 4130 | Airflow 3 | “ | HE 09 / 22614 |
| **08** | Rothero and Mitchell | 5217 | Airflow 3 | “ | HE 09 / 22616 |
| **09** | Rothero and Mitchell | 9413 | Airflow 3 | “ | HE 09 / 22617 |
| **10** | Rothero and Mitchell | 9228 | Airflow 3 | “ | HE 09 / 22618 |
| **11** | Rothero and Mitchell | 1927 | Airflow 3 | “ | HE 09 / 22615 |
| **12** | Rothero and Mitchell | 1567 | Airflow 3 | “ | HE 09 / 22610 |
| **13** | SKC | 22721 | 22549 Rotameter 0.300mls/min | 22.10.2012 | 10712 |
| **14** | Knauer Modular HPLC System | 162217 | | Daily Using Supelco Standards | |
| **15** | Digitron with pitot and thermo micro anemometer | 451097801 | PM 80 | 15.10.2012 | ATP |
| **16** | Signal Instruments 3030 | IHS | | Hire certification | |
| **17** | Bubble Meter | 22806 | Optiflow 420 | Monthly | HE 09 / 22714 |
| **18** | Perkin Elmer 8600 GC | 1092 | S410 9C | Monthly | HE 09 / 22617 |



# CERTIFICATE OF CALIBRATION

| | | | |
|---|---|---|---|
| **ISSUED BY:** | JMW Limited | **DATE OF ISSUE:** | 22/10/2012 |
| | **CERTIFICATE SERIAL NUMBER:** | | 1210242 |
| | **PAGE:** | | 1 OF 1 PAGES |

JMW Do it right

*JMW Limited*
*The Calibration Lab*
*Warwick House*
*Perry Road*
*Harlow, CM18 7NF*

*Tel: 01279 307100*
*Fax: 01279 307101*
*www.jmwlimited.co.uk*

| | | |
|---|---|---|
| **Customer/Acc. No:** | Halcyon Environmental | H9981 |
| **Instrument:** | Eurotron Unigas 3000+ | |
| **Instrument S/No:** | 159580 | |
| **Instrument ID No:** | N/A | |
| **JMW Proc. No:** | 2558 | |

| | |
|---|---|
| **Location:** | WV6 7YD |
| **Calibration Interval:** | 12 months |
| **Calibration Date:** | 22/10/2012 |
| **Calibrated by (Op. No):** | 04 |
| **Approved by (Op. No):** | 29 |

| | |
|---|---|
| **Traceability:** | The instrument referred to in this certificate was re-calibrated by applying known concentrations of test gas mixtures and recording the indicated values (gas ranges) and by applying nominal values at a number of points and recording the indicated values (temperature ranges). The test gas mixtures and equipment used, for which the company maintains traceability to international standards by means of certificates issued by the supplier, are listed below (ambient air at the internationally recognised value of 20.9%w/v). |
| **Allowances:** | The allowance is based on the manufacturers published specification where available or recognised industry standards. |
| **Limitations of Use:** | The following results do not carry any implications as to the long term stability of the instrument. |
| **Environmental Conditions:** | The ambient temperature and humidity throughout the calibration period were uncontrolled and unmonitored but were, typically 20°C ±5°C and 50% RH +20% RH. |

## CALIBRATION REFERENCE STANDARDS

| Reference | Description | Uncertainty | JMW Ref | Description | Uncertainty |
|---|---|---|---|---|---|
| N/A | Ambient air @ 20.9%w/v oxygen | Absolute | 043 | 100ppm (nom) nitric oxide | ±2% |
| 036 | Oxygen @ 0.000005%w/v | ±2% | 041 | Temperature indicator/simulator | ±0.25°C |
| 014 | 500ppm (nom) carbon monoxide | ±2% | 023 | Digital pressure calibrator | ±2 mbar |
| 085 | 40ppm (nom) sulphur dioxide | ±2% | | | |

## ACCESSORIES

| | Present | Sound | | Present | Sound | | Present | Sound |
|---|---|---|---|---|---|---|---|---|
| Filter assy: | Y | Y | Battery charger: | N | N/A | Sampling line/probe: | Y | N |
| Printer: | Y | Y | | | | | | |

## PRE-CALIBRATION FUNCTIONAL CHECKS

Instrument is -

| | | | | | |
|---|---|---|---|---|---|
| Complete: | Y | Free from damage: | N | Operational: | N |
| Pump is operational: | Y | Battery charges/discharges: | Y | | |

## RESULTS

| Range | Applied value | Allowance | As received<br>Indicated reading | As received<br>P/F | After adjustment<br>Indicated reading |
|---|---|---|---|---|---|
| Oxygen: | 0% v/v | ±0.5%v/v | N/A | F | 0%v/v |
| 0-25% v/v | Ambient air @ 20.9% v/v | 20.8-21.0%v/v | N/A | F | 20.9%v/v |
| Carbon monoxide: | 0ppm | ±10ppm | N/A | F | 0ppm |
| 0-20000ppm | CO/air @ 500ppm | 475-525ppm | N/A | F | 500ppm |
| Nitric oxide: | 0ppm | ±5ppm | N/A | F | 0ppm |
| 0-4000ppm | NO/air @ 100ppm | 95-105ppm | N/A | F | 100ppm |
| Sulphur dioxide: | 0ppm | ±5ppm | N/A | F | 0ppm |
| 0-4000ppm | $SO_2/N_2$ @ 40ppm | 35-45ppm | N/A | F | 40ppm |
| Temperature: | 0°C | ±0.3°C | N/A | F | 0°C |
| 0-1000°C | 250°C | 249.0-251.0°C | N/A | F | 250°C |
| | 500°C | 498.0-502.0°C | N/A | F | 500°C |
| | 750°C | 747.5-752.5°C | N/A | F | 750°C |
| Pressure: | 50.0mbar | 49.5-50.5mbar | N/A | F | 50.0mbar |
| 0.100 hPa/mbar | 75.0mbar | 74.2-75.8mbar | N/A | F | 75.0mbar |
| | 100.0mbar | 99.0-101.0mbar | N/A | F | 100.0mbar |

**The uncertainties are for a confidence probability of not less than 95%**

(2558-005/A)

# APPENDIX 2

## STATEMENT OF COMPETENCY

# Tim Growcott Curriculum Vitae Statement of Competency

Halcyon Environmental
27 Brunel Grove
The Woodlands
Perton
Wolverhampton
WV6 7YD

**Mobile:** 07779 008725

**E-Mail:** tim@halcyon-environmental.co.uk

| | |
|---|---|
| **Age:** | 60 |
| **Qualifications:** | B Sc (Hons) Applied Chemistry<br>Member of the Royal Society of Chemistry MRSC<br>Chartered Chemist C.Chem<br>Chartered Scientist C.Sci<br>Member of the Institute of Metal Finishing (MIMF)<br>Member of the Source Testing Association (STA)<br>STA registration MM 03/314 |

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***Current Position***

*Halcyon Environmental: Senior Partner*

Responsible for the operation of a specialist environmental consultancy including sales and marketing, presentations, technical procedures, litigation protocol, analytical strategies and Environmental Management Systems Protocols.

Halcyon Environmental is a consultancy specifically committed to advise and support Industrial and Private Sector clients in achieving and effectively maintaining compliance with existing and new environmental legislation.

Halcyon is a member of the Metal Finishing Association and Surface Engineering Association.

***Courses Attended***

| | | |
|---|---|---|
| 2009 | Lanyard Training and Working at Height – Kingfisher Access Course | |
| 2008 | STA M Certs Level 1 Training Course | |
| 2008 | STA M Certs TE3 Revision Training; Gases and Vapours by Extractive Manual Measurement | |
| 2008 | IEMA presentations | |
| | Introduction to the REACH Regulations | Rolls Royce Sinfin |
| | Introduction to the EUPD | Environment Agency |
| | Introduction to EPP | Environment Agency |
| 2001/2/3/4/7/8 | PCME; Total Particulate Monitoring – Isokinetic, Triboelectric, Tribostatic, Scintillation, Optical and CEM methods and systems | |

| | |
|---|---|
| 2007 | PCME; On Line, Real Time Monitoring and Calibration |
| 2007 | Environmental Compliance (ECL): An Introduction to BS 14181 |
| 2007 | Environmental Compliance (ECL): Gas Monitoring Systems |
| 2007 | CBiss - Instrumental Continuous Gas Monitoring Applications |
| 2006 | PCME; Particulate Monitoring Techniques and Calibration Methods |
| 2006 | Turbidity Monitoring Techniques; Partech Instruments |
| 2006 | PCME; Dust Reporter 2 Software and Filter Management |
| 2006 | PCME; Improving OMA Score/ Interpreting Guidance Notes |
| 2006 | PCME; PMT in the Metal Industries – Case Studies |
| 2006 | MCERT for Effluent Monitoring; Partech Instruments |
| 2005 | PCME; – Continuous Particulate Monitoring Systems (CEMS) |
| 2002 | PCME; Optical and Probe based Technologies for Emission Monitoring |
| 2002 | PCME; CEMS Analyser Systems |
| 2002 | PCME / C Biss; Cross Duct, Heated Extractive and Drying Extractive Techniques and the requirements of CEMS Systems, MCERTS and OMA |
| 2001 | Disa An Introduction to Abatement Systems |
| 2001 | PCME Particulate Monitoring Solutions FMC |
| 2001 | PCME; Particle Velocity and Mass Monitoring Techniques FMC |
| 2001 | PCME; Ambient Monitoring Techniques FMC |
| 2001 | PCME; MCERTS and TUV Accreditation Schemes FMC |
| 2000 | PCME; Practical Demonstrations for TSP PM-10 and Pm 2.5 monitoring |
| 2000 | PCME; Monitoring of Suspended Solids in Gas Streams |
| 2000 | PCME; System Configuration and Reporting |
| 2000 | Servomex; The Continuous Monitoring of Gaseous Emissions |
| 2000 | PCME; Particulate Monitoring and the Workplace |
| 1997 | Air Pollution Standing Conference – NEC |
| 1997 | Monitoring as a Management Tool; SEC/ MFA Workshop |
| 1997 | FMEA to Design – Out Problems MFA / Ad – Qual Workshop |
| 1997 | Practical Application of Personal Protective Equipment – MFA / Racal Workshop |

| | |
|---|---|
| 1997 | Solid Wastes – A Finisher's Perspective MFA |
| 1997 | Oven Temperature Control using Radio Telemetry; Grant Instruments |
| 1997 | Introduction to Air Sampling; SKC Ltd |
| 1997 | Profitability and the Monitoring and Control of Energy and Water; Marquis Associates |
| 1996 | European Perspectives on Environmental Best Practice; ERM |
| 1996 | Regulatory Developments in the UK WM Hazardous Waste Unit |
| 1996 | Thermal Sand Reclamation – Economic Drivers Towards Installation, Landfill Tax and its Consequences; Thermofire |
| 1996 | Metal Screen Filters as a Candidate for Best Practice; Air Filters |
| 1996 | Ceramic Filters and Secondary Metal Processing; Withers Metals |
| 1996 | Environmental Technology Best Practice Programme; ETSU |
| 1996 | Accounting for Environmental Performance; MRC |
| 1996 | Principle and Practice of Waste Management; Wedge Holdings |
| 1996 | The Waste Minimisation Agenda; UOW Workshop |
| 1995 | Air Pollution Standing Conference; NEC |
| 1994 | Eurosafe - Personal Protective Equipment; Assessing Needs and Choice |
| 1994 | GEC A Practical Approach to Health and Safety Management |
| 1994 | MOHS – Health Surveillance |
| 1994 | Government Policy Towards Business and the Environment – MFA Conference |
| 1994 | Engineering Industry and Environmental Pressure – MFA Conference /EEF |
| 1994 | Is BS 7750 Relevant to Metal Finishing; MFA Workshop |
| 1994 | EPA and the Metal Finishing Sector; MFA Workshop |
| 1994 | Environmental Management; Practical Implementation and Action; Business Link |
| 1993 | Environmental Education – WALCAT Workshop |
| 1991 | Clean Air Engineering: Environmental Source Monitoring |
| 1991 | Clean Air Engineering: Isokinetic Emission Monitoring |
| 1991 | SGS "Green Dove - EMS Sales Strategy" |
| 1990 | SGS "Principles of International Trade" |

| | |
|---|---|
| 1990 | SGS "Sales and Marketing - Value Added Strategies" |
| 1990 | SGS Yarsley "TQM Principles and Practices" |
| 1990 | SGS “Principles of Environmental Auditing” |
| 1990 | SGS “BS 5750 Auditing Protocols” |
| 1990 | SGS “Introduction to Green Dove” |
| 1990 | SGS "BS 5750 Management Systems; Planned strategy" |
| 1989 | BASF – Source Testing |
| 1989 | BASF International Analytical Conference |
| 1989 | BASF – Principles of LIMS |
| 1988 | Qualified First Aider CPR Procedures |
| 1986 | Management and Motivation |
| 1980 | Paint Research Association: Paint Formulation |
| 1979 | Wolverhampton Polytechnic: Advanced Analytical Procedures |

### *Recent Awards, Presentations And Publications*

| | |
|---|---|
| 2008 | Road Show Speaker – West Bromwich Albion; REACH and its Implications |
| 2007 | Williams Alloys and Residues – support to ISO 14001 |
| 2006 – 2009 | Monthly contributor to Corporate Times |
| 2006 | SEA meeting; House of Lords |
| 2006 | PCME Road Show Speaker – Ricoh Stadium |
| 2005 | Tonge & Taylor ISO 14001 |
| 2003 | Calcast Limited ISO 14001 |
| 2003 | C E Marshall (Wolverhampton) Ltd ISO 14001 |
| 2003 | PCME Road Show Speaker; Celtic SFC |
| 2002 | Speaker – Cortec Seminar, University of Coventry – An Introduction to IPPC |
| 2002 | PCME Road Show Speaker; Manchester United FC |
| 2002 | Kings Triplex Holdings – ISO 14001 |
| 2001/4 | PCME Road Show – Monitoring of Particulates – Workplace and Environment |
| 2001 | Lanstar ISO 14001 |

| | |
|---|---|
| 2001 | Yale Security Products UK Ltd – ISO 14001 |
| 2001 | Oldbury Aluminium Alloys Ltd. – ISO 14001 |
| 1998 | World Metals Congress - Budapest. First 10 ISO 14001 foundries - Consultancy support to Transtec Group. |
| 1998 | Transtec Group - ISO 14001 - Birmingham, Droitwich, Llanidloes. |
| 1998 | Johnson Controls - ISO 14001 - Silloth and Wednesbury. |
| 1998 | MPL-Key Group - 1st Plastic Moulder to ISO14001 - Tamworth. |
| 1998 | MFA - Waste management and minimisation seminar. |
| 1998 | ISO14001 -The Environmental Standard - BLB. |
| 1997 | JRI Technologies - 1st. Foam producer to ISO 14001. |
| 1995 | BS 7750 - A practical guide to compliance. Various industrial sites. |
| 1995 | "Environmental by Design" - fundamentals of design strategy seminars |
| 1995 | “Design for Disassembly” - fundamentals of product recycling and reuse. |
| 1995 | “Product Finite Life Analysis - Environmental Aspects” - GEC Group. |
| 1995 | Wolverhampton Centre of Engineering Excellence: "Safe usage, storage, handling and disposal of industrial liquids" seminars. |
| 1995 | Wolverhampton Centre of Engineering Excellence: EPA "Directors in the Dock" seminars. |
| 1994 | Wolverhampton Centre of Engineering Excellence: EPA Awareness workshop training. |
| 1994 | BLB: Practical Environmental Management. |
| 1994 | Birmingham Chamber of Commerce: EHS Management. |
| 1994 | Speaker - MPS “Environmental Awareness” Seminars. |
| 1994 | Inst. Elec. Engineers: EPA Evening presentation. |
| 1994 | Inst. Met. Finishing: Instrumentation and Capability. |
| 1992 | Metal Finishing Association: EPA Awareness Seminars. |
| 1994 | Transactions on the Inst. Met. Finishing: EHS legislation, effects on the M F Industry - Annual Technical Conference article. |
| 1992 | Ceramic Industries International: " Not Entailing Excessive Cost" EPA article. |

***Career Resume***

Tim Growcott is the Senior Partner in Halcyon Environmental, a UK based consultancy, which specialises in Environmental Consulting Services. The consultancy works with around 500 company customers, from engineering to chemical specialists, foam and plastic users, MOD and RAF site’s and specialist operators.

Trained formally as an Industrial Chemist, he has worked with companies including Mander Brothers in paints, BL Heavy Vehicles Division at Guy Motors in heavy vehicle manufacturing and Wilkins & Mitchell in domestic appliance manufacturing.

Latterly he worked with the Inmont Corporation and BASF in automotive and printing industry coatings development, and SGS in specialist environmental roles, undertaking diverse environmental issues including sales, marketing, site investigation work, litigation and liability, the development of environmental systems including EN ISO 14001.

Halcyon has undertaken specific and broad spectrum environmental issues with regard to environmental compliance, forward business environmental planning, and cradle to grave strategies that include environmental significance in product design and manufacturing, product finite life analysis, design for disassembly and renewable and recyclable resources.

Halcyon was recognised by the World Metal Congress, held in Budapest in achieving EN ISO 14001 with one of its customers as one of the world’s first 10 foundries to achieve the standard.

Halcyon personnel have supported the recent transfer of business from the mainland UK to the Czech Republic, Norway and Bulgaria and are developing business in Portugal.