HE 15 / 0949

LA-PPC/EPR Compliance Monitoring of the MDF Section furnaces' releases

at

Federal Mogul

Holbrook Lane
Coventry
West Midlands
CV6 4BG

Study Period; – 20th April 2015

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FEDERAL MOGUL
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WEST MIDLANDS
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27th. April 2015

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REPORT REF - HE 15 / 0949

LA-PPC/EPR COMPLIANCE MONITORING OF THE MDF SECTION FURNACES' RELEASES

1 INTRODUCTION

This study was undertaken to determine the MDF Section furnace releases accordance with the site's Local Authority Pollution Prevention and Control/ Environmental Permitting Regulations (LA-PPC/EPR) permit; reference PPC/197 as issued by Coventry City Council.

The MDF Section has two furnaces currently operating. The section is a purpose built entity specifically developed to encompass research and production provisions.

Feedstock materials to this activity include C/Si, Fe/W, Fe/V, Fe/Cr, Fe/Mo, Fe flake and Mn alloys amongst others. The potential exists also for the use of Co based feed stocks. These are accurately weighed out to produce a melts of very specific composition.

Feed stocks are free of any oils, solvents, greases, lubricants, coatings etc; this produces a VOC free melt.

The small furnace holds an approx. 50 kg charge. The larger furnace has a capability to process up to 600 kgs of powder per week once on line. This is melted via induction. The melt is then tipped into equipment which essentially sprays it with water to produce a fine dust of known metallic composition. The wash/suspension is then transferred to a centrifuge, where the water is removed. The dried dust is then transferred to a double taper vacuum drier for final drying. Once dry the dust is then transferred to drum for future use.

The process cycle time for the small furnace operation from "load to dry dust" is approx. 60 minutes. The melting furnace has a dedicated lid which is maintained in a closed position whilst melting takes place; currently the only times the furnace lid is open are for temperature testing, slag removal, feedstock addition or pouring metal.

The report relates to studies undertaken on 20th April 2015 by Halcyon Environmental personnel in respect of the determination of PG 2/03 and 2/04 (2013) defined emissions.

The study was reported by Mr T Growcott BSc (Hons) MRSC. C Sci C Chem MIMF. The author was formally trained in source monitoring by Clean Air Engineering (CAe), Societe General de Surveillance (SGS) and BASF. Halcyon is a member of the Source Testing Association.

Emissions are abated by the use of a purpose built AAF Bag Filter Plant. The model is a Fabripulse M6 – 168 unit, serial number 118302 – M.

The unit utilises Ryton PPS filters with a quoted efficiency of approx. 99.9% at 0.5 microns.

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 Emissions
QGN001	Guidance On Assessing Uncertainty In Stack Emission Monitoring

There was no significant visual evidence of particulate in close proximity to the stack.

1.2 SUMMARY

The following results were determined; -

Test	**Units**	**Stack 1**	**Permit Limits**
		Mean	
TPM	mg/m^3	0.972	20
Co	mg/m^3	< 0.01	5 in total
Ni	mg/m^3	< 0.2	
Cr	mg/m^3	< 0.2	

The emissions sourced from the site's MDF Section melting facilities were measured were noted as extremely low and within current permit limits.

Emissions were determined to be free from persistent mists and water droplets.

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

FEDM0949 PPC/EPR REP

SECTION 2

SAMPLING AND MONITORING STRATEGIES

2 SAMPLING AND MONITORING STRATEGIES

2.1 SAMPLING STRATEGY

The main sampling and monitoring studies were based on the determination of airborne concentrations of Process Guidance Note PG 2/03 and 2/04 (2013) and LA-PPC/EPR Permit defined analytes sourced from melting and casting process activities.

The data reported herein was compiled in accordance with the methodologies and procedures detailed in BS 13284-1, and STA specifications, in addition to specific VDI procedures.

The sampling and monitoring strategy utilised for this study was based upon sampling using a range of sampling and analytical equipment to test emission losses to atmosphere.

2.2 SAMPLING EQUIPMENT

Sampling was based on the notes detailed in Process Guidance Notes M1 and M2. Sampling was undertaken using Gilaire pumps used in conjunction with specific sampling trains.

Calibrated air speed and direction equipment, ancillary temperature, humidity and pressure measurement devices were also used in these procedures. Pressure, humidity and temperature measurements were determined using standard Huger-Sutronics instrumentation.

Air flows and efflux velocities were measured using 2 off Airflow Developments model PVM 100 electronic micro-manometers, used in conjunction with 2 off 1 m. Airflow Developments BS 1042 type 2.1A pitot tubes.

Gas flows were determined using standard AGL instrumentation.

2.2.1 TOTAL PARTICULATE MATTER DETERMINATION

(i) TPM by BS 13284-1 PROCEDURE

The sampling procedure employed was based on that detailed in BS 13284-1.

Testing was isokinetic to collect particulates onto 47mm glass fibre filter papers. The filter papers are pre conditioned at 180º C and uniquely numbered.

The first requirement was to measure the exhaust velocity, stack size & geometry to determine the suitability of the location for sampling. The sampling line was a modified Italian system, using numbered 4, 6 & 8 mm diameter tips, a 47 mm in line filter holder, and a supported probe to allow correct positioning.

A pitot tube and thermocouple was attached to the probe tip to allow continuous monitoring of the stack conditions.

A hose connected the high level probe to the low level equipment, which consists of a large in line silica gel trap, containing dry silica gel with a colour indicator. From here the line passed through an in line stainless steel mesh filter, (to prevent silica gel granules migrating into the sampling pump), to a sealed 110 (or 240V) diaphragm pump.

The exhaust from the pump passed through a rotameter flow meter, to a calibrated dry gas meter with an attached thermocouple, the final exhaust from the DGM is to atmosphere, so that the DGM reads at atmospheric pressure.

Sampling time is a minimum of 30 minutes per sample, and the system is arranged such that the maximum volume of sample air is collected.

Post sampling the filter paper is carefully extracted from the filter holder and returned to its uniquely labelled sample pot.

Any residual filter fibres and pre filter probe contamination were rinsed out of the filter holder & probe into a clean bottle, using deionised water & an acetone final rinse.

Metals were determined by ICPS.

2.2.2 ANALYTICAL PROCEDURES AND METHODS SUMMARY

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

Substance	Standard or Method	Uncertainty value
Metals	BS 13284-1	Method quotes “internal” and “external” uncertainty only
Particulate	BS 13284-1	Uc =1.19 mg/m^3 at a confidence of 95% or relative uncertainty of 23%

Halcyon systems also encompass the recent STA publication; -

“Guidance on Assessment Measurement Uncertainty in Stack Emissions Monitoring”
- STA Quality Task Group – Dr J Pullen.

2.2.3 STACK SAMPLING PROTOCOLS

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.

ρ 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 principal 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. But 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.

Location of Measuring Site:

The measuring site should be located in a region of linear flow. Smooth flow in a duct has a meniscus like profile, with maximum flow in the middle of the stack, which is unaffected by the surface roughness of the exterior walls, and a reduced flow at the edges.

Where the flow is turbulent, such as after a fan, a corner, a junction, or a damper, flow measurement is rendered impossible. Similarly before these obstacles airflow is broken up.

The measuring site (both for flow measurement and extractive sampling) should thus be located > 5 hydraulic diameters downstream of the last point creating turbulence.

It should also be at least two diameters upstream of the next point creating turbulence.

Measurements and Extractive Sampling:

Measurements are taken across the duct at points in the centre of a series of equal areas. In a square duct this is straightforward, but in a circular duct, it implies a series of points near to the edge of the stack, and very few measurements in the middle.

Extractive Sampling points are chosen on the same basis, and BS 13284-1 says that samples should be collected at 4 points across each of two traverses, in small stacks.Where the stack has an internal area greater than 2.5m^2, 4 sampling points should be used on each traverse.

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 levelling 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 of 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:

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

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, or if more accuracy is required, using an Infra Red Gas Analyser, such as a Miran.

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

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

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

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

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).

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

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.

$$\textbf{Total (Wet) Gas Volume} = \textbf{Dry Gas Volume} + \textbf{Gas phase Water Volume}$$

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

$$\textbf{Mole fraction of wet gas (Mw)} = 1 - \textbf{Mole fraction of dry gas (Md)}$$

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

$$\textbf{of dry gas (Dd)} \times \textbf{Mole fraction of dry gas (Md)} + 18\,(1 - \textbf{Md}) = \textbf{Molar Stack gas density (Ds)}$$

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

$$\text{Molar stack gas density (Ds)} = \text{Md}\ \frac{(\%CO_2 \times 46}{100} + \frac{\%O_2 \times 32}{100} + \frac{\%N_2 + \%CO \times 28}{100}) + \text{Mw}\ \frac{(\%H_2O \times 18}{100})$$

In most cases the Molar stack gas density will work out as 29 $\underline{+}$ 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:

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

Internal area of duct is calculated as:

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

To convert $m^3 min^{-1}$ 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:

$$\textbf{Corrected Pollutant Concentration (mg/m}^3\textbf{)} = \frac{\textbf{(20.9 - Standard O}_2\textbf{\%)}}{\textbf{(20.9 - Measured O}_2\textbf{\%)}} \textbf{ x Measured Conc}^{\textbf{n}}$$

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 millimole 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 $\text{ppm x } \frac{36.5}{22.4} = \text{mg/m}^3$

In general $\quad \textbf{ppm x } \frac{\textbf{molecular weight}}{\textbf{22.4}} = \textbf{mg/m}^3$ **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 NOx 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°C, 1013 mbs, occupies 24 litres, and is correct for use at ambient conditions.

It is not correct to use this equation at standard conditions.

Particulates:

The sampling of stack particulates is undertaken using an Andersen sampling line following the main procedural requirements of BS 13284-1.

Procedure is as follows:

1. Determine correct location of measuring and sampling points.

2. Measurement of stack flow using BS 1042 ellipsoidal nosed pitot tube, with electronic micro manometer and thermometer.

3. Calculation of flow rates, isokinetic sampling rates, sampling locations etc.

4. Sampling over 2 x 30 minute periods, to obtain optimum samples at the point specified by BS 13284-1. This included determination of a blank.

The sampling line includes a condensation trap, such that gas flow, gas volume, and gas temperature as measured at the pump all relate to dry gas.

Exposed filter samples are re-weighed, to obtain weight of particulate collected.

If required the filter material and particulate sample can be digested, prior to analysis of metals by Atomic absorption spectrophotometry (AA), or Inductively coupled plasma atomic emission spectrophotometry (ICP-AES).

This Introductory protocol is amplified, by a further series of protocols, including diagrams, copies of record sheets, and an explanation of the calculations involved in presenting results of extractive sampling methods.

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:

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

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)

SECTION 3

MEAN EFFLUX VELOCITY RESULTS

3 MEAN EFFLUX VELOCITY RESULTS

The stack's mean efflux velocities were measured as detailed in the following table at its discharge temperature.

Test Location	Date of Test	Deviation	Vmax:Vmin	Tmax:Tmin	Mean Efflux Velocity m/sec at the ports
Stack 1	20.06.2014	Non Standard Portals	Pass	Pass	12.44 @ 310K @ port

Test Location	Date of Test	Duration of Test	Release Colour Ringlemann	Droplet Test	Odour at ports
Stack 1	20.06.2014	09.34 – 10.35	< 0.5	0 droplets	No mal odour

Mean efflux velocity is specifically determined using BS 13284 - 1 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.

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 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.

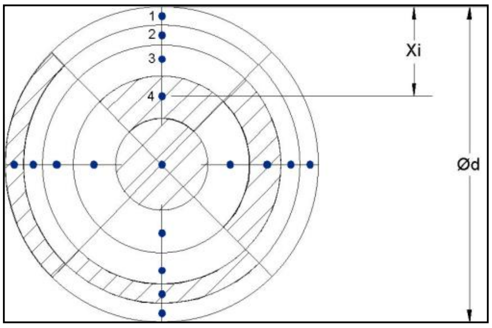
Halcyon personnel normally utilise the STA Guidance documentation, Disclosure of Hazards document and Risk Assessment format as a condition of their site activities.

Pitot Measurements

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

Client:	*Federal Mogul*	**Date:**	*20th April 2015*	
Address:	*Holbrook Lane*	**Operator:**	*T Growcott*	
	Coventry	**Job Number:**	*HE 15 / 0949*	
	West Midlands	**Location:**	*S1*	
	CV6 4BG	**Instruments:**	*BS 1042-2A 1M Pitot + PVM 100*	
Details of Duct:	*Steel*		**Atmos. P (pa)**	**Atmos. Temp K**
Duct Shape:	*Circular*	**Initial:**	102	296
Dimension / Dia.:	**0.3m**	**Final:**	104	298
Area:	**0.07068m^2**	**Mean:**	*103*	*297*
	Axis 1:	**Axis 2:**	**Gas Homogeneity Check:**	20 Point CO Check

Traverse Point	**Temp C**	**Temp C^2**	**Velocity kPa**	**V^2**
1	37.2	1383.84	91	8281
2	37.2	1383.84	94	8836
3	37.2	1383.84	98	9604
4	37.3	1391.29	108	11664
5	37.1	1376.41	100	10000
6	37.2	1383.84	103	10609
7	37.2	1383.84	109	11881
8	37.4	1398.76	112	12544
9	37.4	1398.76	95	9025
10	37.4	1398.76	99	9801
11	37.3	1391.29	102	10404
12	37.3	1391.29	104	10816
13	37.4	1398.76	90	8100
14	37.4	1398.76	93	8649
15	37.4	1398.76	98	9604
16	37.4	1398.76	100	10000
17	37.5	1406.25	103	10609
Total	***634.3***	***23667.05***	***1699***	***170427***
Average	***37.3117647***	***1392.179412***	***99.94117647***	***10025.11765***
RMS		**37.3119205**		**100.1255095**



O2 reference	N/A
Humidity %	59.7
Ambient K	297
Negative Pressure	Y
Drift Angle	<15^{O}
Dry Gas Correction	N/A
Pitot Correction	N/A
T Correction	N/A
Vmax : Vmin	Pass
Tmax : Tmin	Pass
V$_{rms}$	100.1255095
Pitot Calibration	*1.002*
Static Pressure Pv (Pascals)	-1.09
Mean Stack Temperature K	310.3119205
Moisture Content %	N/A

SECTION 4

ANALYTICAL RESULTS

4 ANALYTICAL SEQUENCE AND RESULTS

The monitoring strategy for the study was undertaken over one half standard working day.

During this period the batches and material grades processed were determined to be typical of the site's production and throughput.

Continuous assessment of emission clarity and smoke colour from the site's extraction systems were also undertaken.

4.1 CLIMACTIC CONDITIONS

Monitoring was undertaken under the following atmospheric and climactic conditions; -

Parameter	20.04.2015
Atmospheric Pressure kPa	103
Ambient Temperature K	297
Relative Humidity %	59.7
Wind Speed kph	<5
Wind Direction	SW
Prevailing Conditions	Prolonged sunny periods

4.2 RESULTS

The following data tables are included.

These results are reported in accordance with the protocol defined by the relevant Process Guidance Note PG 2/03 and 2/04 (2013) and are expressed at standard reference conditions of 273K and 101.3 kPa, without correction for water vapour.

Stack S1- Total Particulate Matter

Job Number:	HE 15 / 0949
Client:	Federal Mogul
Date:	20th April 2015
Release Point Stack Ref	S1 Fabrupulse M6 – 168 BFP Stack port
Instrument Type	Anderson Portable
Tester	T Growcott
STA Ref	MM03 / 314
Test Method	BS 13284-1
MID Guidance	Duplicate Samples + Blank
-ve Pressure Test	Pass
Vmax:Vmin	<3:1
Min Pressure Test	Pass
Tmax:Tmin	Pass
Drift Angle	< 15^o
Droplet Test	Pass
Homogeneity Test	Pass 20 point CO check
Leak Test	<0.2
DGM Inlet C	45
DGM Outlet C	46
Samples	4 points
Sample Number	0949I/TPM/001/2
Test Start (Ti)	10.35.00
Test Finish (Tf)	11.47.00
Test Duration (mins)	72
No. of Samples	2 x 30 mins
Maximum Reading TPM (mg/m^3)	0.987
Minimum Reading TPM (mg/m^3)	0.867
Mean Reading TPM (mg/m^3)	0.927
Mean Reading Ni (mg/m3)	< 0.2
Mean Reading Co (mg/m3)	< 0.01
Mean Reading Cr (mg/m3)	< 0.2

Releases Summary Table

Test	Units	Stack 1 Mean	Permit Limits
TPM	mg/m^3	0.972	20
Co	mg/m^3	< 0.01	5 in total
Ni	mg/m^3	< 0.2	
Cr	mg/m^3	< 0.2	

APPENDIX ONE

CALIBRATION RECORD LOG

HALCYON ENVIRONMENTAL CALIBRATION RECORD LOG

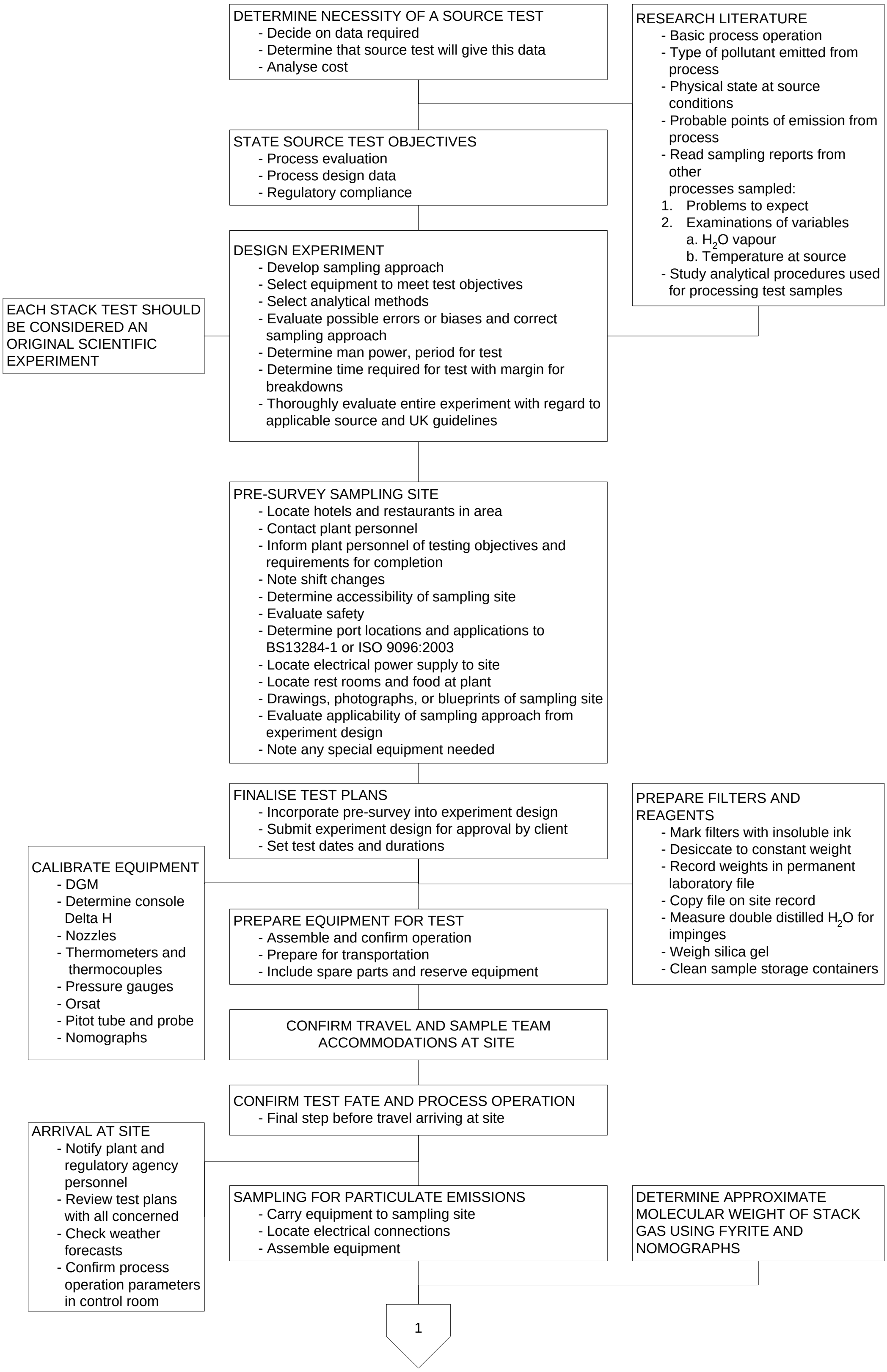
	Doc. Ref:	*CL001*

No.	Equipment	Serial Number	Model	Date of Calibration	Certificate Number
01	Airflow Developments	114575	PVM 100	14.12.2014	IC1146P
02	Airflow Developments	N / A	BS1042 2A	14.12.2014	IC1147P
03	Eurotron Gas Analyser	00724899	3000 Professional	18.12.2014	JMW
04	Eurotron	N / A	Probe	23.07.2014	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	20.08.2014	10712
14	Digitron with pitot and thermo micro anemometer	451097801	PM 80	12.12.2014	ATP
15	Bubble Meter	22806	Optiflow 420	Monthly	HE 09 / 22714

APPENDIX 2

STACK SAMPLING SCHEMATICS

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 BS13284-1 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

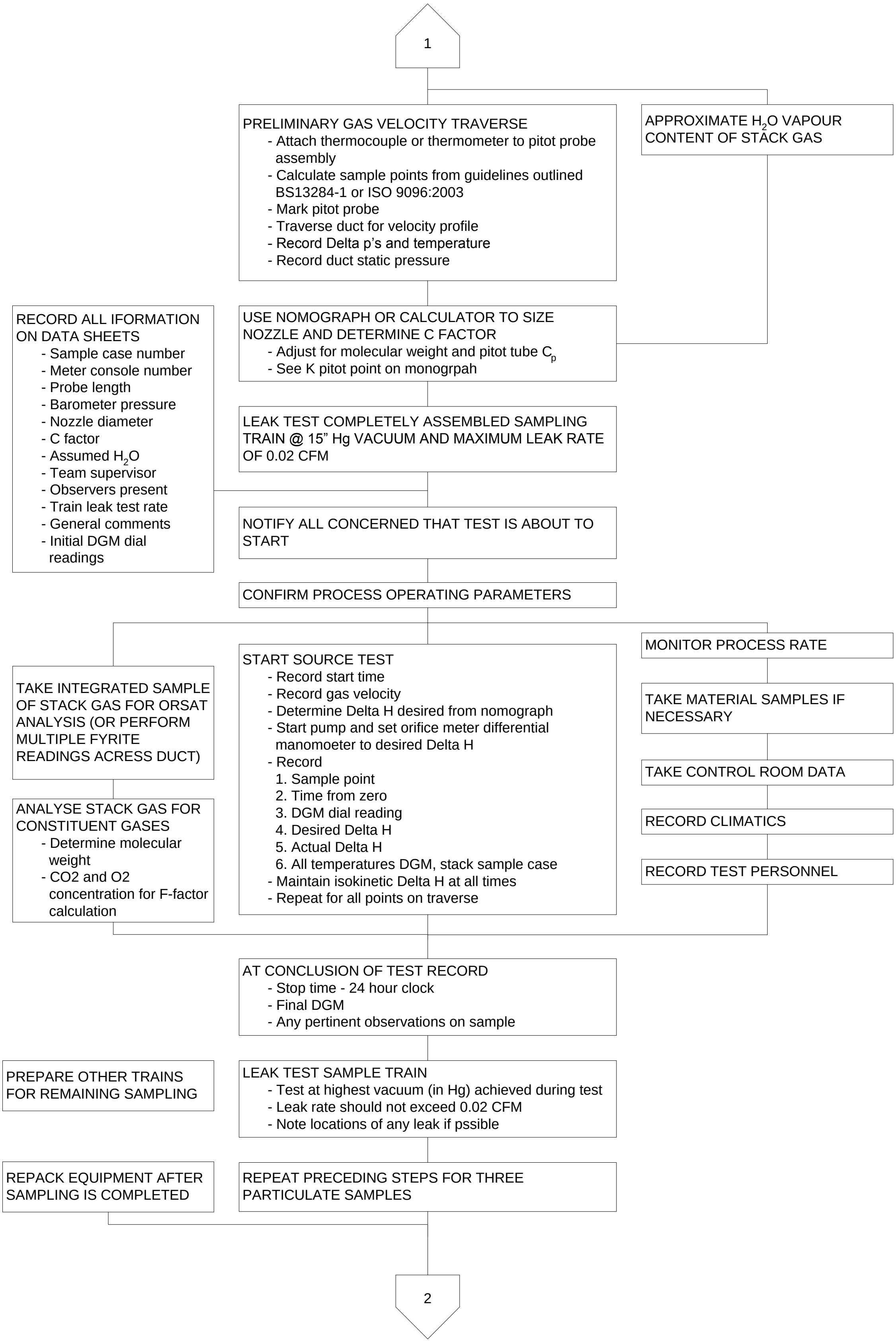
CONFIRM TEST FATE AND PROCESS OPERATION
- Final step before travel arriving at site

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 BS13284-1 or ISO 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

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

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

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

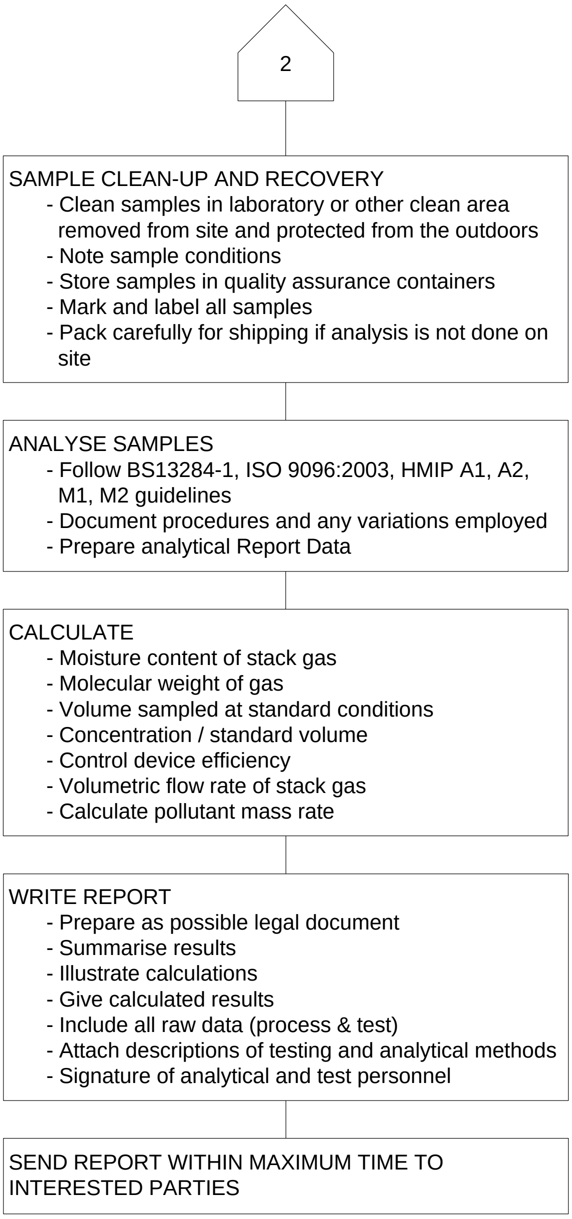
AT CONCLUSION OF TEST RECORD
- Stop time - 24 hour clock
- Final DGM
- Any pertinent observations on sample

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



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

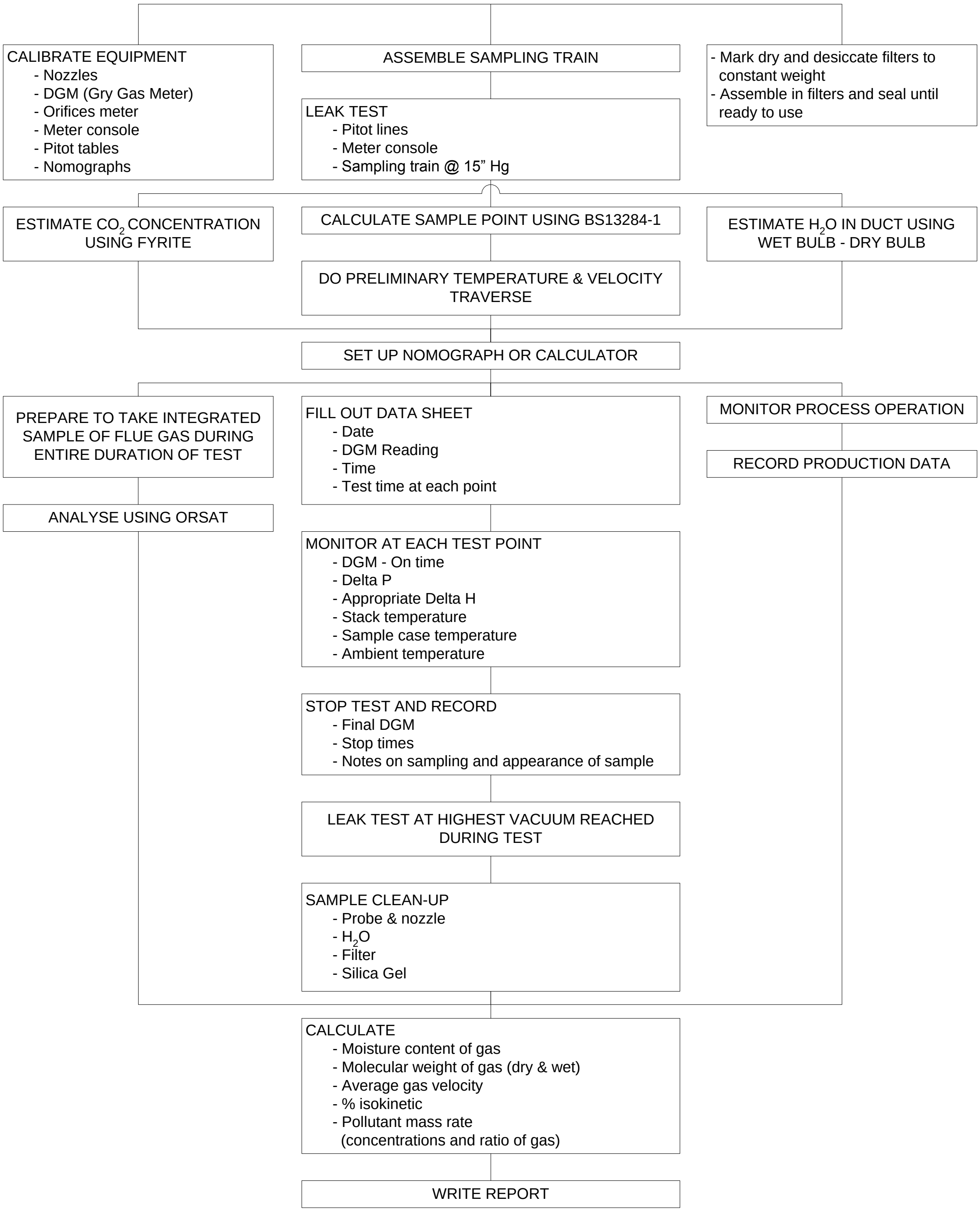
ANALYSE SAMPLES
- Follow BS13284-1, ISO 9096:2003, HMIP A1, A2, M1, M2 guidelines
- Document procedures and any variations employed
- Prepare analytical Report Data

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 BS13284-1

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 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

MONITOR PROCESS OPERATION

RECORD PRODUCTION DATA

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

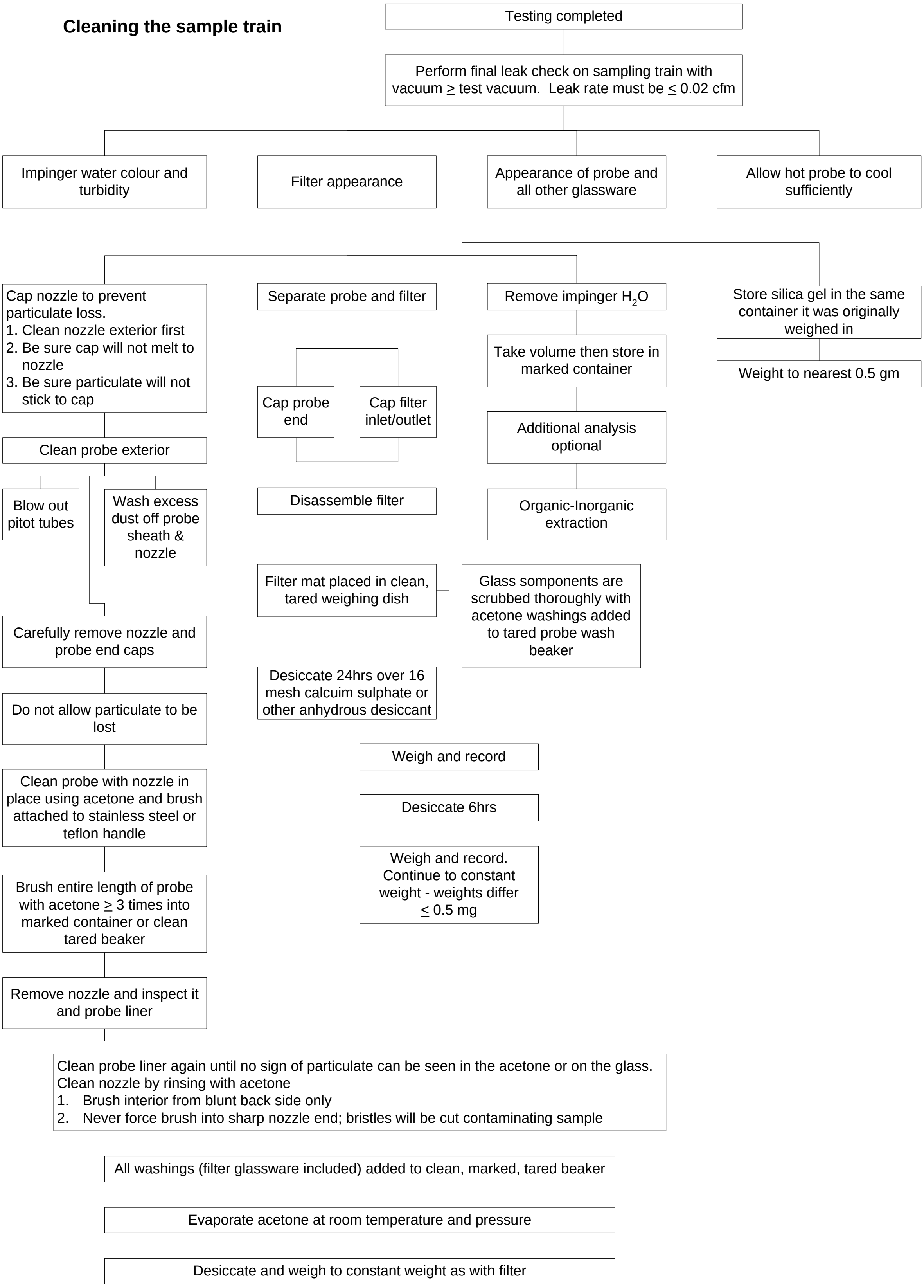


Table 1: Simple error analysis for particulate measurement, 4 Point Sampling (or 10 Point Sampling when Pitot Ratios >4:1≤9:1)

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 Minimum sampling time of 3 minutes	≤±1% ±8%	≤±0.58% ±4.62%	±4.66%		
Systematic						
Accuracy-like Errors						
Random	Measure flue dimensions to ±10mm/m	±2%	±1.15%	±1.15%		
Systematic	Number of sampling points (see note below) Minimum weight gain Pre=/Post-pitot reading within 10% Temperature variations of 10% on 150^{o}C Gas flow axis deviates up to 30^{o}	±13% assume ±2% ±2.5% ±1/5% ≤±3.5% velocity	±6.63% ±1.5% ±1.44% ±0.87% ≤±2.02% velocity	±7.22%		

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 BS 13284 - 1 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 Minimum sampling time of 3 minutes	≤±1% ±8%	≤±0.58% ±4.62%	±4.66%		
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) Bias due to non-symmetrical points Minimum weight gain Pre/Post-pitot readings differ by 20% Temperature variation of 10% on 150°C Gas flow axis deviates up to 30°	±(13+12)%=25% ±7.5% assume ±2% ±10% ±1.5% ≤±3.5% velocity	±12.78% ±4.33% ±1.5% ±5.77% ±0.87% ≤±2.02% velocity	±14.88%		

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

APPENDIX 3

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: 62

Qualifications:
B Sc (Hons) Applied Chemistry
Member of the Royal Society of Chemistry MRSC
Chartered Chemist C.Chem
Chartered Scientist C.Sci
Member of the Institute of Metal Finishing (MIMF)
Member of the Source Testing Association (STA)
STA registration MM 03/314
Member of the American Chemical Society (MACS)

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

Courses Attended

2011	Bruker; Introduction of Infra Red Spectroscopy	
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 - Sports Ground Services – Introduction to Barrier Testing
1991	SGS - Hillsborough Barrier Enquiry – Measurement and Reporting
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 ”module 1”
1990	SGS “BS 5750 Auditing Protocols”
1990	SGS “Introduction to the Green Dove Strategy”
1990	SGS "BS 5750 Management Systems; Planned strategy"
1990	SGS Principles of Environmental Auditing “module 2”
1990	SGS CoSHH LEV Regulation 9.2 Inspection and Testing
1990	SGS -Statutory Inspection and Testing of LEVs (In house course)
1990	SGS - Principles of Cargo Full Out Turn Guarantee (FOG)
1990	SGS - Analysis of Fragrances and Perfumes
1990	SGS - Perfumes; Olfactory Odour Analysis
1989	SGS/Polymer Laboratories - Method derivation for the analysis of perfume samples
1989	SGS/Dyson - Method derivation for the analysis of perfume samples
1989	SGS - Method derivation for the olfactory analysis of perfume and fragrance samples
1989	SGS - Method derivation for the reporting of olfactory assessment of perfume and fragrance samples
1990	SGS - Analysis of Precious and Semi - Precious Metals (London Metals Exchange)
1990	SGS - Analysis of Gold and its alloys (London Metals Exchange)
1990	SGS - Analysis of Heavy Metals (Toy Testing Division)
1990	SGS - Analysis of Heavy Metals (Soil Testing)
1990	SGS - Analysis of Water Samples (Soil and Groundwater Testing)
1990	SGS - Litigation and International Liability - Perfume Fraud Investigations
1990	SGS - Analysis of Fuels (Aviation and Automotive)
1990	SGS - Vehicle Repair Centres; EPA Support and Monitoring
1990	SGS - Analysis of Cements and Concrete Testing
1990	SGS - Principles of Calibration and Metrology
1989	BASF - Source Testing

1989	BASF International Analytical Conference
1989	BASF - Principles of LIMS
1989	BASF - Selective Ion Electrode Analytical Methods
1989	BASF - HPLC Analytical Methods
1989	BASF - Gas Chromatography Analytical Methods; Column Selection
1989	BASF - Gas Chromatography Analytical Methods; Calibration
1989	BASF - Gas Chromatography Analytical Methods; Detector Selection
1989	BASF - Gas Chromatography Analytical Methods; Principles of Integration
1989	BASF - Infra Red Spectroscopy Analytical Methods
1989	BASF - Measurement of Molecular Weight Distribution by HPLC
1989	BASF/Polymer Laboratories – Method derivation for the analysis of acrylic resins; column selection and analytical methodology
1989	BASF/polymer laboratories – Knauer Instrumentation familiarisation
1989	BASF/Casella Environmental Monitoring Methods; Selection of Absorption Media
1989	BASF/Casella Environmental Monitoring Methods; Pumped and Passive sampling
1989	BASF/Casella – Field sampling of Acrylate Monomers
1989	BASF/Casella – Method derivation for the analysis of airborne Acrylate Monomers and Pre-polymers
1989	BASF/Casella – Method derivation for the analysis of airborne solvents
1989	BASF/Casella – Method derivation for the analysis of airborne Isocyanate Monomers and Pre-polymers
1989	BASF/Casella – Method derivation for the analysis of airborne Urethane Monomers and Pre-polymers
1989	BASF - Method derivation for the analysis of Polysiloxane Pre-polymers
1989	BASF - Method derivation for the analysis of Rolls Royce Paint and subsequent solvent adjustments
1989	BASF - Method derivation for the analysis of Vauxhall Motors Paint and subsequent solvent adjustments
1989	BASF - Method derivation for the analysis of Ford Motor Company Paint and subsequent solvent adjustments
1989	BASF - Method derivation for the analysis of Can Coating solvent / odour emissions
1989	BASF - Method derivation for the analysis of electrophoretic oven emissions

1989	BASF - Method derivation for the analysis of DETA/TETA electrophoretic solvent analysis and subsequent solvent adjustments
1989	BASF/Casella - Method derivation for the analysis of BL paints – site based
1989	BASF/Casella - Reporting of Environmental Emissions
1989	BASF/Perkin Elmer – GC/FID/ECD systems familarisation
1988	Qualified First Aider CPR Procedures
1986	Management and Motivation
1980	BASF/ Paint Research Association: Paint Formulation
1980	Wilkins and Mitchell/PPJ – Paint Management and Process Optimisation
1980	Wilkins and Mitchell/ICI VDU Management and Process Optimisation
1980	Wilkins and Mitchell/Tecalamit – Paint Management and Process Optimisation
1979	Wolverhampton Polytechnic: Advanced Analytical Procedures

Recent Awards, Presentations And Publications

2012	Alwin Metals ISO 14001 and 9001 – 2008 support
2010	Sealine International ISO 14001 support
2009	Coram Showers ISO 14001 support
2009	Kaby Engineers Ltd ISO 14001 support
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	Lanstar ; Introduction to the Principles of Gas Chromatography
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	ISO 14001 -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 Bulgaria and are developing business in Portugal.