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HE 03/3868

LA-APC Compliance Monitoring

at

David Smith St.Ives Ltd
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PE27 3EX

for

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Study Period; - 4th. February 2003

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SECTION CONTENTS

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12.02.2002.

F.a.o. Mr C Franklin - Director.

REPORT REF: - HE 03/ 3868

LA-APC 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 Limiied's Local Authority Air Pollution Control (LA-APC) part B authorisation 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 February 4th 2003 by Mr T Growcott, BSc (Hons) MRSC C Chem, of Halcyon Environmental in respect of the determination of Process Guidance Note PG 1/12 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 2-hour period during which time RanHeat and Local Authority personnel were on site.

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, although their position was not strictly compliant with the provisions of BS 3405:1983.

Direct emissions were monitored in the stack as per BS 3405 protocol (4 and 8 point locations across two sampling planes) and via the 2 BS 3405 compliant 100 mm dia BSP capped portals.

1.2 SUMMARY

1) 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 provisions.

The results of this study have determined that releases sourced from operation of the plant were non-compliant with the provisions of the site's EPA documentation.

Site sourced V.O.C. was measured at 45.9 mg/m3, (cf. 20mg/m3 max. as per PG 1/12).

TPM was measured at 387.7 mg/m3, (cf. 200mg/m3 max. as per PG 1/12).

Mean CO was measured at 2176 mg/m3, (cf. 250 mg/m3 max. as per PG 1/12).

2) 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-APC process documentation, and SO_x, CO_2 ,NO_x and Oxygen concentrations.

Free Formaldehyde was also measured and found to be < 1 mg/m3.

All other gaseous emissions were measured as within the site's authorisation provisions and below the maximum consents.

3) Perimeter visual and olfactory subjective and quantitative procedures have established minimal perceived odour proximal at the point of discharge, and at ground level, from process related compounds.

4) Emission discharge colour has been determined in accordance with LA-APC protocol and established as less than Ringlemann Shade 1 throughout the study period.

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

6) 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 19.1 m/s at discharge temperature.

The cause of the compliance failure was thought o be a failure of the unit's refractory lining with a possible failure of an internal steel plate. As such the combustion chemistry was nor at its most efficient.

This failure will require appropriate repair.

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

Tim Growcott

Tim Growcott
Senior Partner.

RANH3868.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 BS 3405.

The data reported herein was compiled in accordance with the methodologies and procedures detailed in BS 3405, and US EPA method 1, 2, 3, 4 and 25 specifications, in addition to specific GC-MS methodologies and the use of approved Draeger tube methods and procedures.

The sampling and monitoring strategy utilised for this study was based upon remote sampling using the statistical linear log procedure detailed in BS 3405:1983.

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

Velocity data was determined using a standard Solomat Zephyr model 510 electronic micro-manometer, (HE 03-012) used in conjunction with a BS 1042 type 2A 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 U.S. E.P.A. 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 convention Aquaria 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 TOTAL PARTICULATE MATTER DETERMINATION

The procedure employed was that detailed in BS3405: 1983.

Total Particulate Matter was determined using pre-weighed SKC 47 mm dia. ceramic filters obtained from a specialist environmental test house.

Air was extracted from the main stack isokinetically over a series of 30 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 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 EPA Method 25 using a Signal Instruments 3030PM instrument with FID calibrated for 80 ppm and 800 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 Testo Combustion Gas Analyser (0089 -112).

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 03-141).

2.2.4 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.
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 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 √Pv (at 273 K, 1013 mb)

or

Velocity (metres per second) = 1.280 √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:

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

Where:

V = Velocity of Flow on metres per second (ms^{-1})
T = Temperature in Kelvin (Kelvin = ° 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.

Location of Measuring Site:

The measuring site was 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 - 6 diameters downstream of the last point creating turbulence, in a straight run of ductwork. BS 3405 allows 1 diameter for a bend, 2 for a junction and 3 for a fan or damper. It should also be at least two diameters upstream of the next point creating turbulence. BS 3405 allows 1 diameter. There will be places where even the rules of BS 3405 cannot be met, in which case, very considerable care is needed in obtaining readings.

Measurements and Extractive Sampling:

Measurements were 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. These points are calculated by the Log linear rule for circular ducts, and the Log Tchebycheff rule for rectangular ducts. BS 3405 says that measurements may be taken at a series of 10 points evenly spaced across the duct.

Extractive Sampling points are chosen on the same basis, and BS 3405 says that samples should be collected at 2 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 which 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° 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° 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:

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

Centimetres per minute (cm/min) x Square centimetres (cm^2) = Cubic Centimetres per minute (cm^3/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:

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

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).

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

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

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

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:

Corrected Pollutant Concentration (mg/m^3) = $\frac{(20.9 - \text{Standard } O_2\%)}{(20.9 - \text{Measured } O_2\%)}$ x 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 $\text{ppm} \times \frac{\text{molecular weight}}{22.4} = \text{mg/m}^3$ **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:

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

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°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.

Particulates:

The sampling of stack particulates was undertaken using an Italian (Aquaria) sampling line following the main procedural requirements of BS 3405 EPA Method 17.

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 four 15 -30 minute periods, to obtain optimum samples at the point specified by BS 3405.

Samples are collected onto pre-weighed 47mm glass fibre filters, with the whole sampling assembly located inside the stack, thereby producing a dry sample.

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:

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

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 = °C + 273.15) or Rankine (°R = °F + 459.67)

2.2.5 INITIAL STACK PROFILE STUDY

As per the provisions of BS 3405, 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 BS 3405:1983).

2.2.6 CLIMACTIC CONDITIONS

The following climactic conditions were noted during the study;-

AMBIENT TEMP C	2
ATMOSPHERIC PRESSURE mBas	1,012
RELATIVE HUMIDITY %	33
WIND SPEED k.p.h.	< 15
WIND DIRECTION	NE
VISIBILITY metres	> 1000
WEATHER	BRIGHT, CLEAR SKIES, VERY COLD WITH HIGH WIND CHILL FACTOR, NO PRECIPITATION

2.2.7 QA - QC PROCEDURES

Halcyon operates QA - QC procedures following the guidelines of; -

EPA 600/9-76-005 1976 Quality Assurance Handbook for Air Pollution Measurement Systems, Vol.1.

EPA 600/4-77-027b 1979 As above Vol.3.

Halcyon is a member of the Source Testing Association.

2.2.8 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 1998/99

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	****Direct reading EPA METHODS 3/3B**
2)	TOTAL PARTICULATE MATTER	**BS3405**
3)	VOC	**EPA METHOD 25**
4)	**VOC as Carbon**	***EPA METHOD 25 + MS/GC**
5)	NO_x	****Direct reading**
6)	SO_x	****Direct reading**
7)	**Water Content**	**EPA METHOD 4**
8)	**Oxygen**	****Direct reading**
9)	**Free Formaldehyde**	**Draeger tube Activated charcoal back up tube.**

* Specific analytical procedures for certain speciated VOC analytes was based on US EPA method 25 + Mass spec / GC methodologies.

**Testo Combustion Gas Analyser instrument.

SECTION 4

MEAN EFFLUX VELOCITY DATA

4 FLOW DYNAMICS RESULTS

The following results were determined using the calculations and correction coefficients detailed in BS3405:1983

The following results were determined at the portal locations; -

TABLE 4.1 MEAN EFFLUX VELOCITY RESULTS.		
SAMPLING LOCATION.	**MEAN VELOCITY (m/s)**	**DISCHARGE TEMP(C)**
TEST 1	19.0	137
TEST 2	19.2	131

10 point trans-axial temp traverse ratio Tmax:Tmin = 1.0989:1

10 point trans-axial velocity traverse ratio Vmax:Vmin = 1.778:1

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

The implicit BS 3405 error factor of +/- 25.5 % was considered as satisfactory, as was the +4 % isokinetic correction factor applied to the calculation.

SECTION 5

ANALYTICAL RESULTS

5 ANALYTICAL SEQUENCE AND RESULTS

The monitoring strategy was undertaken over one standard working half 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 black smoke.

Periodic monitoring of O_2, water vapour, CO, SOx, NOx and V.O.C. were undertaken.

T.P.M. measurement was undertaken on 30-minute sampling schedules with the filters located outside of the stack.

5.1. ANALYTICAL RESULTS

Analytical mean result data is detailed below: -

ANALYTE	TEST 1	TEST 2	MEAN	PG 1/12 MAX LIMIT
1. CO (mg/m3)	22 TEST SAMPLES		2176	250
2. T.P.M. (mg/m3)	412.6	363	387.8	200
3. VOC as C (mg/m3)	15 TEST SAMPLES		45.9	20
4. OXYGEN (%)	22 TEST SAMPLES		10.09	-
5. WATER VAPOUR (%)	3.6	4.2	3.9	-
6. SOx (mg/m3)	22 TEST SAMPLES		2.09	-
7. NOx (mg/m3)	22 TEST SAMPLES		41.3	-
8. FORMALDEHYDE (mg/m3)	< 1	< 1	< 1	-

*** N.B.

These results are reported in accordance with the protocol defined by EPA 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 AND OLFACTORY ASSESSMENTS

6 VISUAL AND OLFACTORY ASSESSMENTS

6.1 VISUAL ASSESSMENT

In accordance with the provisions of LA-APC 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 in excess of Ringlemann shade 1.

6.2 OLFACTORY ASSESSMENT

In accordance with the provisions of LA-APC an assessment of Weiss unit's releases was undertaken at the point of discharge.

Perceptive odour evaluations were non quantitative and dependant upon the assessors, however an *evaluation by subjective procedures was carried out by specialist personnel familiar with odour* assessment techniques.

The unit's emissions were assessed as a low impact perceived odour, characterised by a typical *neutral notes at close proximity.*

6.3 NOISE ASSESSMENT

With reference to noise, the operation of the plant facilities detailed within this report was not perceived to be exceptional nor excessive as to be considered a nuisance with regard to noise and its effect on site operators and the local Community.

DAVID SMITHS
WATERBASED COATING.

SAFETY DATA SHEET

1 Identification of the substance/preparation and of the company/undertaking

Product Name: VACSOL AQUA 6108
Datasheet Number: 6108 1. 1. 0

Harmful

HSE No.: 6083
Intended Use: Concentrate wood preservative for dilution in water.Application in industrial vacuum/low pressure plant.

Name of Supplier: ARCH TIMBER PROTECTION
Address of Supplier: A1 Business Park,
Knottingley,
West Yorkshire,WF11 0BU.
England
Responsible Person: Contact the company

Telephone: 01977 671771 (Office hours)
Fax: 01977 671701 (Office hours)

Emergency Telephone: +44 (0)1865 407333 (24 hours)

2 Composition/information on ingredients

Chemical Name	Concentration	R Phrases	Symbols
ebuconazole	0.688 %w/w	not classified	
Propiconazole	0.688 %w/w	R22	Xn
Permethrin	0.500 %w/w	R22 36/38	Xn
Sodium nitrite	< 5 %w/w	R8 25	O, T

3 Hazards identification

- Classification under Control of Pesticides Regulations 1986 (COPR).
- Ingestion: Harmful if swallowed (R22)

4 First aid measures

Contact with skin

- Remove contaminated clothing immediately and drench affected skin with plenty of water. Then wash with soap and water

4 First aid measures (....)

Contact with eyes

- If substance has got into eyes, immediately wash out with plenty of water for at least 15 minutes
- Seek medical advice if necessary

Ingestion

- Do not induce vomiting, give 250 ml milk to drink followed by water, both sipped slowly. Seek medical advice immediately.

Inhalation

- Inhalation is unlikely to occur
- In case of accident or if you feel unwell, seek medical advice immediately (show this safety data sheet or the label where possible).

General

- In case of accident or if you feel unwell, seek medical advice immediately (show this safety data sheet or the label where possible).

Fire-fighting measures

- Non-flammable
- In case of fire use water spray or fog, dry chemical or carbon dioxide (S43)
- Do not use water jets
- Use appropriate containment to avoid environmental contamination (S57)
- Smoke from fires is toxic. Take precautions to protect personnel from exposure
- Wear Positive-Pressure Breathing Apparatus

6 Accidental release measures

Immediate Actions

- Shut off source of leak if safe to do so
- Use appropriate containment to avoid environmental contamination (S57)

Clean Up Actions

- Recover the product where possible
- Absorb spillage in earth,sand, sawdust or other inert material.
- Place in appropriate metal or plastic container.
- Seal containers and label them
- Remove contaminated material to safe location for subsequent disposal

Special Precautions

- If contamination of drainage systems or water courses is unavoidable, immediately inform appropriate authorities

7 Handling and storage

Handling

- WEAR SUITABLE PROTECTIVE CLOTHING (COVERALLS),GAUNTLETS, CHEMICAL RESISTANT FOOTWEAR AND EYE PROTECTION when using the product and during maintenance of treatment plant equipment.
- WEAR IMPERVIOUS GAUNTLETS,IMPERVIOUS FOOTWEAR AND AN IMPERVIOUS APRON when handling freshly treated timber.

7 Handling and storage (....)

Storage

- Keep locked up and out of reach of children (S1/2)
- Keep away from food, drink and animal feedingstuffs (S13)
- Keep in a cool place away from frost (S3/14)

8 *Exposure controls/personal protection*

Personal protection

- WEAR SUITABLE PROTECTIVE CLOTHING (COVERALLS),GAUNTLETS, CHEMICAL RESISTANT FOOTWEAR AND EYE PROTECTION when using the product and during maintenance of treatment plant equipment.
- WEAR IMPERVIOUS GAUNTLETS,IMPERVIOUS FOOTWEAR AND AN IMPERVIOUS APRON when handling freshly treated timber.

Exposure Limits

- There are no recommended or established controls for this product

9 Physical and chemical properties

- Odour: Slight sweet odour.
- Appearance: clear, pale, orange, Liquid
- Boiling point 100 °C
- Completely soluble in water
- Density (water=1) 1.06
- Non-flammable
- Viscosity 39 centipoise at 20 deg C

10 Stability and reactivity

- Keep away from frost, Keep away from heat (S15)
- Do not use empty containers for any other use.

11 Toxicological information

Toxicological information

- LD50 (oral,rat) estimated 1750 mg/kg
- LD50 (skin,rat) estimated >5000 mg/kg

12 Ecological information

Ecotoxicology

- EXTREMELY DANGEROUS TO FISH AND OTHER AQUATIC LIFE, DO NOT CONTAMINATE water courses or ground.

Environmental Fate

- Completely soluble in water
- Permethrin degradation in soil has a half life of 28 days or less.
- For further information contact the company.

12 Ecological information (....)

Environmental Hazard Values

- LC50 (fish) estimated < 5 mg/l (96 hr)
- EC50 (daphnia) estimated < 0.25 mg/l (48 hr)

13 Disposal considerations

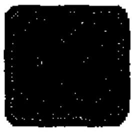
Disposal considerations

- *Do not discharge into drains or the environment, dispose to an authorised waste collection point*
- Disposal should be in accordance with local, state or national legislation
- Do not use empty containers for any other use.

14 Transport information

- Not classified as hazardous for transport

15 Regulatory information



Harmful

Applicable Laws

- *This product is approved under the* Control of Pesticides Regulations (COPR) *1986, for use as directed.*
- The COSHH Control of Substances Hazardous to Health Regulations 1999 apply to the use of this product.
- The Dangerous Substances (Notification of Marking of Sites) Regulations 1990 may apply to users of this product.
- The Health and Safety at Work Act 1974, The Manual Handling Regulations 1992 and The Environmental Protection (Duty of Care) Regulations 1992 may apply to users of this product.

Risk Phrases

- Harmful if swallowed (R22)
- FOR USE ONLY BY INDUSTRIAL OPERATORS.

Safety Phrases

- *Engineering control of operator exposure must be used where reasonably practicable in addition to the following items* of personal protective equipment.
- WEAR SUITABLE PROTECTIVE CLOTHING (COVERALLS),GAUNTLETS, CHEMICAL RESISTANT FOOTWEAR AND EYE PROTECTION when using the product and during maintenance of treatment plant equipment.
- WEAR IMPERVIOUS GAUNTLETS,IMPERVIOUS FOOTWEAR AND AN IMPERVIOUS APRON when handling freshly treated timber.
- AVOID EXCESSIVE CONTAMINATION OF COVERALLS AND LAUNDER REGULARLY.
- DO NOT BREATHE FUMES OR VAPOUR.
- However, engineering controls may replace *personal protective* equipment *if a* COSHH *assessment shows they provide* an equal or higher standard of protection.
- WHEN USING DO NOT EAT, DRINK OR SMOKE.
- WASH HANDS AND EXPOSED SKIN before eating, drinking, smoking and after use.
- WASH SPLASHES from skin or eyes immediately.
- EXTREMELY DANGEROUS TO FISH AND OTHER AQUATIC LIFE, DO NOT CONTAMINATE water courses or ground.

Note - Area is bunded.

15 Regulatory information (....)

- KEEP IN A SAFE PLACE
- KEEP AWAY FROM FOOD, DRINK AND ANIMAL FEEDING STUFFS.
- KEEP OUT OF REACH OF CHILDREN.
- DISPOSE OF SURPLUS PRESERVATIVE, CONTAMINATED MATERIAL (INCLUDING SAWDUST) AND THE EMPTY CONTAINER safely using a method approved by the WASTE DISPOSAL AUTHORITY.
- IF YOU FEEL UNWELL SEEK MEDICAL ADVICE (show label where possible).
- TREATED WOOD SHOULD BE HELD UNDER COVER UNTIL DRY BEFORE DESPATCH.
- READ ALL PRECAUTIONS BEFORE USE.

16 Other information

It is the duty of every employer to ensure that his employees using this product have received such necessary instructions and guidance as required under COPR.

No person shall use this product unless he has been adequately trained in the safe, efficient and humane use of this product and is competent for his duties.

Hickson Timber Products Ltd offer their clients regular structured training and competency courses.Further information is available from
Customer Services, Sowgate Lane, Knottingley, West Yorkshire. WF11 0BS.
Telephone 01977 671771 Fax 01977 671701

Since the users working conditions are not known by us, the information supplied on this Safety Data Sheet is based on our current level of knowledge and on national and community regulations.

It is at all times the responsibility of the user to take all necessary measures to comply with legal requirements and local regulations.The information given on this data sheet must be regarded as a description of the safety requirements relating to the product and not a guarantee of its properties.

Hickson accepts no responsibility for any loss or damage which arises directly or indirectly from following the above interpretation of legislation or guidance.

This information has been lodged with Poisons Information Units throughout the United Kingdom and Ireland.

The product must not be used for any purpose other than wood preservation in an industrial vacuum pressure impregnation plant.

For advice on VACSOL AQUA treated timber refer to the Code of Practice No 30 and the treated timber Safety Data Sheet SD 601, both available from the above address.

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