An Introduction to Sampling for Vapours

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Introduction

Manufacturing processes found across many industrial sectors have the potential to expose workers to harmful dusts, gases and vapours and as a consequence, UK employers must meet the requirements of the CoSHH Regulations[1] and in the US, the Code of Federal Regulations (CFR)[2]. Similar legislation exists worldwide, the common theme being an onus on hazard identification, risk assessment and the provision of appropriate control measures.

Volatile organic compounds (VOC) (some of which are hydrocarbons) are common hazards found in the oil & gas, chemical and pharmaceutical industries, typically released through process leaks but also routinely during plant maintenance. There are a raft of other hazardous chemicals found in diverse manufacturing subsectors ranging from fabricated metal to textiles and furniture but also painting and printing. VOCs in particular have a significant vapour pressure at normal ambient temperature which means they evaporate (volatilise) at low temperatures and can easily enter the body through normal breathing, so monitoring the workplace air is vitally important. Indeed, if exposure or failure of control measures could lead to exposure limits being breached then exposure monitoring is expressly required.

High chemical concentrations can pose an immediate (acute) risk to life but repeated exposure to relatively low concentrations can lead to long term (chronic) illnesses, cancers and even hearing loss in the case of ototoxic chemicals such as solvents, nitriles, metals and their compounds.

Measuring Exposure

A direct reading instrument is often used, for detecting single or multiple hazardous gasses where there is an acute risk but this doesn't account for low level exposures which may vary throughout the workspace and/or with time.

There are basically three ways of sampling gases or vapours for subsequent laboratory analysis: -

1. By collecting a small amount of the workplace atmosphere in a suitable airtight container
2. By drawing air through a solution in a bubbler or impinger where the contaminant reacts with the liquid
3. By allowing workplace air to pass through an adsorbent material

Static sampling will generally lead to an underestimate of personal exposure but may be useful when examining the effectiveness of control measures, to identify sources or monitor known 'hotspots' in process plant. Personal monitoring is a preferred solution whereby a long-term average concentration may be determined and the use of pumped sorbent tubes will be discussed here.

In general terms, a known volume of air is drawn using a sampling pump through a suitable sampling medium which adsorbs the chemical in question. Back in the laboratory, the chemical is desorbed (thermally or chemically) and analysed, typically using a gas chromatograph. A concentration can then be calculated, which may then be compared against the relevant exposure limit. These limits are specified in several ways: 8-hour Time-Weighted Averages (TWAs), Short-Term Exposure Limits (STELs) and Ceiling values. 8-hour TWA limits are specified for full-shift exposures; STELs are usually issued as 15-minute exposure limits and Ceiling values are issued as peak levels not to be exceeded at any time during the working day.

A typical sampling train for personal monitoring is shown with a sampler mounted in the breathing zone i.e. within a 30cm radius centred on the nose & mouth, and in this case a Casella APEX2 medium flow pump (which would also require a low flow adaptor) is connected by a tube, with the pump clipped onto a belt or worn in a pocket. Anecdotal evidence from the pharmaceutical industry

is that a medium flow pump at circa 0.5Kg is sometimes too bulky, particularly for women to wear for an entire shift, so in this case a dedicated low flow pump is a recommended option.

They tend to be less bulky than medium flow devices because the internal pump mechanism and battery required to maintain a constant (low) flow are smaller and consequently lighter in weight. For example, the recently introduced Casella VAPex, weighs in at only 219 g. They operate at much lower flow rates (20 mL/min – 500 mL/min) than medium flow devices (normally used for sampling particulates) i.e. 20-500 mL/min versus 1- 5.0 L/min respectively.

In any event, the pump should meet the latest version of the ISO13137 standard 5 currently under review because it is now over 5 years old.

CASELLA VAPEX

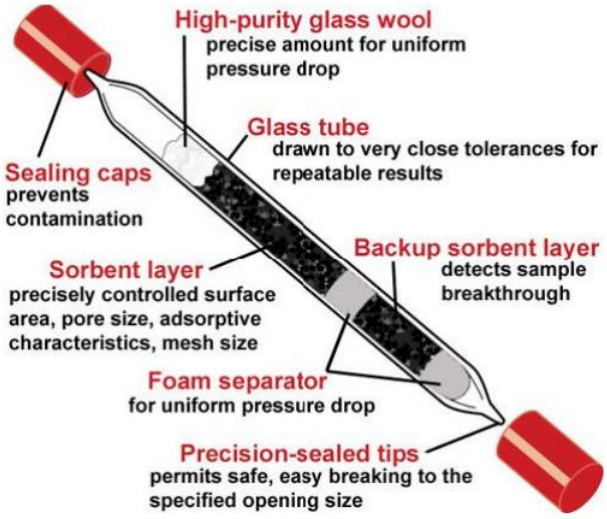
Sampling Media

The type of “suitable sampling medium” mentioned above largely depends on the sampling and analytical method selected for the chemical under investigation but are usually a form of sorbent tube (glass or re-usable metal). The Health and Safety Executive (HSE) in the UK and NIOSH in the US publish guidance known as Methods for the Determination of Hazardous Substances (MDHS)[3] and NIOSH Manual of Analytical Methods (NMAM)[4] respectively.

Sorbent tubes developed in the 1970s for NIOSH have been established as a reliable sampling method for many of these sampling requirements.

A sorbent tube contains a chemically inert material which adsorbs the vapour or gas onto its surface during sampling.

Charcoal is the most common sorbent material but Silica Gel, Chromopak, Tenax and other specialist materials are also used dependent on the method. Most tubes have two layers of material where the smaller layer is the ‘back up’ and should be closest to the sampling pump inlet; there is normally an arrow on the tube which also indicates the correct direction of the airflow.
The diagram shows the complexity of the tube which requires material of a specified mesh size and weight in each of the two layers.



Courtesy SKC

Prior to use check that the tubes are ‘in date’ before breaking the ends of the sorbent tube off and inserting them into a tube holder which is then connected to the personal sampling pump using chemically inert plastic tubing such as Tygon. Handle glass tubes with care whilst setting up the sample train and check carefully for leaks. Samples should also be taken with the tube in a near vertical position on the body to prevent ‘channelling’ which could otherwise lead to an underestimate.

After sampling, the tubes are removed and the ends sealed (with the caps provided) and sent off to a laboratory for further analysis along with unused control tubes from the same batch. The sorbent tubes are then desorbed chemically (or thermally in the case of metal tubes) and analysed, generally by gas chromatography (GC). The two layers are analysed separately and if the ‘back up’ layer is more than 10% of the main layer, the tube is deemed to be saturated and another sample must be taken perhaps varying the parameters (time, flow rate, size of tube etc.) to improve the chance of an acceptable sample.

Calibration

The standard method chosen will recommend a flow rate for sampling and this needs to be set using a suitable flow calibrator pre-sampling and then checked again post sampling. Maintaining a steady flow within +/-5% is vital to ensure that the sampled volume can be calculated from the set flow rate and sample time. A simple rotameter may be used in the field but a digital flowmeter such as the Casella Flow Detective is preferable for its precision and inherent accuracy. Additionally, the recent generation of Casella pumps and calibrator are now equipped with Bluetooth™ connectivity, which means that the whole calibration process can be fully automated thus minimising the risk of set up errors as well as saving the occupational hygienist valuable time. Another benefit of this connectivity is that progress of the sample can be checked remotely using a dedicated phone app (subject to intrinsic safety requirements) without having to disturb the worker thus improving the productivity of the worker and hygienist alike.

In conclusion, like many seemingly routine measurements they still require care and the devil is always in the detail. It is important to check for changes in methods and exposure limits and that the measuring equipment is up to date and regularly serviced. Developments in both pump and flow technology will help to ensure accurate results and improve productivity and will justify overhauling your fleet of pumps. For further information visit www.casellasolutions.com

References

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3. http://www.hse.gov.uk/pubns/mdhs/index.htm
4. https://www.cdc.gov/niosh/nmam/default.html
5. ISO 13137:2013 Workplace atmospheres -- Pumps for personal sampling of chemical and biological agents -- Requirements and test methods