Monitoring is essential for VOC emissions reduction

In general, volatile organic compounds (VOCs) are harmful to both health and the environment, so management of the risks associated with VOCs necessitates accurate and reliable monitoring. However, it is first necessary to distinguish between the two main areas of concern – indoor and outdoor VOCs, not least because the definition of VOCs is different for these two applications.

Indoors, VOCs are organic chemical compounds which evaporate under normal indoor atmospheric conditions of temperature and pressure. Some organic chemicals are harmful to the skin and can be absorbed, but volatility makes it possible for VOCs to be breathed in and cause a wide variety of negative health effects ranging from minor irritation to death.

In the outdoor environment, the main concern with VOCs is their role in the formation of ozone, a constituent of photochemical smog. At ground level, ozone is generated when VOCs react with sources of oxygen molecules such as nitrogen oxides, and carbon monoxide in the atmosphere in the presence of sunlight. Ozone can be harmful to health, particularly in children, the elderly, and people of all ages who have cardiovascular problems such as asthma or COPD. Ground level ozone can also have harmful effects on sensitive vegetation and ecosystems.

In the outdoor environment, VOCs are commonly defined as any organic compounds which are emitted from non-natural processes and have photochemical ozone creation potential. This is generally interpreted as any organic compound released to the atmosphere from an operator's plant or process, excluding releases of naturally produced VOCs from within the plant boundary and methane.

In most countries, the emissions of regulated processes with the potential to release VOCs are issued with permits that include an emission limit for total organic carbon (TOC). The Standard Reference Method for the measurement of TOC is with a Flame Ionisation Detector (FID). In some cases, where there is a potential for the emission of particularly toxic VOCs, the site permit may include a requirement for the monitoring of individual organic compounds, which means that a monitoring technology capable of speciation would be necessary. Alternatively, it may be necessary for the monitoring activity to distinguish between methane and non-methane VOCs.

What are the advantages of monitoring VOCs?

In addition to regulatory compliance, there are a host of other reasons for monitoring VOC emissions. For example, monitoring is often employed to measure and check abatement plant efficiency. Monitoring can also help to optimise process flows and can help to identify solvent reduction opportunities, which lower costs, improve environmental performance and reduce risks to workers. As such, monitoring forms an essential component of a solvent management programme.

Some FIDs are able to measure methane and non-methane VOCs, which is a significant advantage because methane is a major greenhouse gas (GHG) and in recent years, despite international efforts to lower GHG emissions, methane emissions have been rising.

What is a FID? And how does it work?

As the name implies, a flame ionisation detector measures the concentration of ions produced when hydrocarbons in a sample are burned in a flame. Hydrogen or a hydrogen/helium mixture is used as the fuel for the flame which burns in hydrocarbon free combustion air. An electric field is generated by a polarisation voltage between two electrodes, and the ions generated by the combustion result in a charge which is directly proportional to the quantity of Carbon atoms derived from organic compounds in the sample.

Globally, there is a significant number of manufacturers developing portable VOC detectors for fugitive VOC emissions, most of which employ a photoionisation detector (PID). However, this technology is not suitable for TOC emissions monitoring because of the enormous variation in response factor between different VOCs. It is also interesting to note that very few companies are developing advanced FIDs, so Signal Group is leading the field in this area.

What are the latest developments in FIDs?

In contrast with many other manufacturers, Signal is constantly developing its analyzers to find new levels of performance and features that make the instruments more reliable and easier to use. For example, the latest FIDs from Signal, the Series IV, build on their predecessors' rugged reliability and repeatability with greater levels of sensitivity. Importantly, these new models now provide remote connectivity. With 3G, 4G, GPRS, Bluetooth, Wifi and satellite compatibility, each instrument is built with its own IP address and runs on Windows software. As a result, users are provided with simple and secure access to their analyzers at any time, from anywhere, making the analyzers ideal for remote sites and for the operators of multiple sites. This remote connectivity saves time and money for operators, but it also opens up new possibilities for enhanced reliability. Users (and if requested, Signal service engineers) can monitor the status of analyzers remotely, so that timely service interventions can be implemented according to need rather than a timed schedule. As a result, it will be possible to lower the cost of ownership and reduce potential downtime.

Some of Signal's latest FIDs employ dual detectors for real-time monitoring of methane and non-methane as well as TOC.

The repeatability of Signal's FIDs (both between measurements and between analyzers) is protected by the use of a ceramic detector and a unique precision-machined monobloc, which ensures that the geometry of the test cell remains exactly the same. In addition, sample and gas flow rates are adjusted automatically to optimise analyzer performance.

Signal's Series 4 platform has built-in relays which can be easily set by the user to operate calibration valves at the end of a heated line. This means that users can easily choose to calibrate either locally or remotely. These relays can also be used to operate external controls, which is important because it means that users can set the instrument to open

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and close sample line valves, so that one instrument can be used to monitor lines from both pre- and post-abatement, irrespective of range.

Applications for VOC emissions monitoring

Broadly speaking, VOC emissions monitoring can be split into five categories:

1. Permit compliance

In addition to regulations limiting the use of solvents in products such as paints, coatings, adhesives, aerosols, cleaning chemicals and inks, there are also regulations that set emissions limits from industrial processes. These include those that involve solvents such as coating, printing, cleaning and degreasing as well as a wide variety of combustion processes.

The type of monitoring will depend on a number of factors. For example, different countries apply different regulations, and there may be variation between States or regions. In addition, local regulators may impose specific conditions on individual processes. However, a process operator may choose a more rigorous monitoring system to lower risks and improve environmental performance, or if the process is part of a larger group with environmental standards that apply at all group sites irrespective of location.

In some cases, continuous monitoring will be required, but in others, especially smaller processes, occasional monitoring is permitted, so a portable, heated FID such as Signal's PURE 3010 Minifid will be employed. This facilitates the discontinuous monitoring of multiple sites and of multiple stacks at one facility.

In many countries, some type of third party instrument approval is necessary to underpin the reliability of monitoring data. For example, in the EU, TÜV or MCERTS certification is required for monitoring equipment at larger processes. Process operators should therefore check that instruments have appropriate approvals before purchase.

2. Abatement

As described above, VOC monitoring checks that abatement is working correctly and provides timely warning when potential problems occur. A variety of abatement techniques are available including solvent recovery methods such as adsorption, cryogenic condensation or absorption with oils. Solvent destruction methods include thermal or catalytic oxidation, bio-filtration, activated carbon or a sacrificial liquid, or concentration systems followed by oxidation. All of these systems require monitoring to ensure the ongoing success of emissions reduction, and in some cases, monitoring provides a feedback mechanism to optimise the performance of the abatement system.

3. Process monitoring and control

For many different processes, the monitoring of in-process VOC levels provides insight into the process itself, especially now that most processes involving solvents are designed to minimise their use to ensure that levels in the final product are minimised and to lower solvent costs and to ensure that emissions are minimised.

Monitoring also provides useful data for the operators of combustion processes. TOC measurement is important in emissions monitoring as an increase in TOC can indicate poor combustion efficiency, resulting in the release to air of partially combusted materials containing organic carbon, which may increase the emissions of particulates. In this situation, elevated levels of TOC are accompanied by increased concentrations of carbon monoxide, which is another indicator of poor combustion efficiency.

4. Fugitive emissions

In addition to VOC emissions from chimneys, stacks and vents, there are also unintended emissions that result from spills and leaks in equipment, tanks, pipes, seals, valves, etc. Fugitive emissions are therefore more difficult to monitor, but a wide range of methods are available. For example, site surveys can be conducted with a portable PID, or fixed monitors employing optical techniques are able to continuously monitor large areas of a plant.

5. Research and development

A significant proportion of Signal's customers employ the company's reference gas analyzers in their research and development activities. In addition to FIDs, this also includes chemiluminescence detectors (CLD), and a variety of non-dispersive infra-red (NDIR) technologies. The choice of technology depends on the parameters to be measured, and Signal's particular strength in this market sector is a result of two main factors. Firstly, R&D work requires a high level of accuracy and repeatability, and secondly, the required instrumentation is often bespoke; built to meet the precise needs of the customer; often including a heated sample line, autocalibration, a sample switch-over unit, pumps, a controller – and anything else necessary to ensure a fully working monitoring system.

As concern grows about climate change and the mortality rates and health effects of air pollution, global regulations on emissions to air have become increasingly rigorous; affecting everything from domestic heaters to automotive vehicles and power stations. As a result, development engineers are working furiously to create products that minimise the emissions of harmful pollutants. The automotive sector is a prime example of this, with diesel vehicles being targeted for their effects on urban air quality. Previously governments have promoted diesel engines because they emit less GHGs per kilometre, but the need to improve urban air quality has led to a dramatic change in the industry. Automotive engineers are therefore responding rapidly to the latest requirements; developing electric and hybrid engines. This work necessitates detailed and comprehensive analysis of development engines.

Summary

In recent decades, awareness of the VOC emissions potential for combustion and solvent using processes has increased considerably and significant initiatives have been undertaken to reduce solvent use and control emissions. Emissions reduction relies on monitoring to develop better engines and combustion plant, to check compliance, and ensure that abatement equipment and processes are operating correctly. Looking forward, if further reductions are to be achieved, it seems likely that emission limits will continue to be lowered and the requirement for continuous monitoring will increase.according to need rather than a timed schedule. As a result, it will be possible to lower the cost of ownership and reduce potential downtime.

3010 MINIFID
Portable heated FID VOC analyser

Customers with non-continuous or multi-site applications may also consider a portable analyser.

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