Maintenance and Calibration of your Gas Detection System

GAS DETECTION

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CoGDEM, the Council of Gas Detection and Environmental Monitoring, is the trade association representing manufacturers and service providers operating in the areas of industrial, commercial and domestic gas detection and analysis. In a series of articles specially written for IET, CoGDEM members give guidance on issues that are relevant to users of equipment in common use. In this article, Kevin Stockwell of BW Europe Ltd gives advice on how to keep your gas detectors safe, accurate and reliable over their lifetime.

Are Maintenance and Calibration things of the past?

The short answer is No. Despite the ever increasing reliability and intelligence of modern gas detection systems, the importance of regular maintenance and calibration must not be overlooked. Whilst modern gas alarms may be capable of carrying out regular automated checks on circuits, connections and sensors, the only true test is to check the response to gas.

Under health and safety regulations (eg DSEAR and ATEX 137 in Europe), it is the responsibility of the employer to ensure that safety systems work and give their workers the necessary protection. The allowable workplace exposure limits are generally being revised downwards over time requiring more accurate monitoring. Now more than ever, regular maintenance, testing and calibration must be carried out and documented to meet these obligations.

The good news it that most gas detection manufacturers have incorporated features and functions in their instruments to make testing and calibration straight forward and relatively painless. The introduction of dedicated test/calibration stations by a number of manufacturers has further automated and controlled the process.

The maintenance and calibration of a gas detection system whether, fixed, transportable or portable will depend on a number of factors including type of sensors used within the instrument and the application. It is important for those responsible to take these into account.

Maintenance

Maintenance refers to service operations that are expected to be carried out over the working life of the instrument or system. These operations can be carried out by trained users referring to published information from the manufacturer. Repair is different and deals with non-routine operations such as replacing electronic components on circuit boards. Repairs and should only be carried out by the manufacturer or an approved repair centre.

Figure 1: Many gas detectors can be serviced by the user

Maintenance tasks and procedures are defined by the manufacturer and will be detailed in the product instruction manual (this an ATEX requirement) or dedicated service guides. The main tasks are generally replacement of sensors, batteries, pumps and filters etc.

Figure 2: Examples of maintenance components

It is imperative that any spare parts used are those listed by the manufacturer in their documentation. Using seemingly equivalent parts can affect performance, invalidate a product's safety approvals and could be a hazard. For example, replacing an inline filter with one with a different pore size can affect the speed of response of the system and can also lead to pump problems. Replacing a pellistor without PTFE dust filter for one with a filter will affect the response of the sensor to the longer-chain hydrocarbons. This may not be a problem if monitoring methane but will definitely reduce the readings if monitoring nonane. Battery types are thoroughly checked as part of the product approval process. Only batteries from manufacturers listed on the instrument label and approval certificate should be used. Batteries from different manufacturers will have different internal resistances, short-circuit currents and temperature characteristics. Whilst these characteristics may not affect the gas monitoring performance, they will affect the electrical safety under fault conditions.

Maintenance should also include regular inspection of the equipment. Cracked housings, damaged displays, broken sounders and lamps are obvious safety hazards. However, anything abnormal such as cracked encapsulant, missing labels, damaged cable glands and corroded terminals can also be safety issues.

The frequency and extent of maintenance will be dependent on a number of factors and so it is difficult for general guidelines to be given. Sensor filters in a non-dusty atmosphere may only need replacing annually, whilst in another application they may need to be replaced monthly. A pellistor used for measuring flammable gases will need replacing more frequently where it is exposed to substances such as silicones, chlorinated solvents and hydrogen sulphide. Electrochemical sensors used to detect toxic gases are not generally 'used-up' but will need more frequent replacement when used in atmospheres containing organic solvents and alcohols. Electrochemical sensors for detecting oxygen have a limited life (typically 2 years) as the chemicals within the sensor are gradually consumed in the detection process.

Sensor replacement will depend on the type of sensor fitted and the conditions it has exposed to. Common sensors and some maintenance considerations are given in the table below,

Sensor Technology	Hazard Detected	Maintenance Considerations
Pellistor (Catalytic Sensors)	Flammable	Sensitivity can be affected by exposure to silicone containing substances, chlorinated substances, sulphides (including H2S) and very high levels of flammable gas. Mechanical shock such as dropping can also affect sensitivity.
Electrochemical	Toxic	Sensitivity can be affected by exposure to organic solvents and alcohols.
	Oxygen	Oxygen sensors have limited life with a rapid drop in sensitivity at end of life.
Semiconductor	Flammable & Toxic	Sensitivity can be affected by exposure to silicone containing substances, high humidity, solvents and very high levels of gas.
Infra-red	Flammable & Toxic	Build up of dust, oil or condensation on optical surfaces can affect performance. This can be rectified by cleaning.
Photo-ionisation Detector (PID)	Flammable & Toxic	Lenses need periodic cleaning and lamps need periodic replacement.

Good product design can minimise some of the above effects but cannot eliminate them.

Maintenance-free Detectors

In recent years, an increasing number of "maintenance-free" portable gas detectors have become available. Sensors, calibration and batteries last the life of the product which can be 2 or even 3 years. Such products have been well received in the marketplace and can reduce the cost of ownership dramatically. Although requiring no calibration or maintenance, it is still important that these instruments are regularly checked.

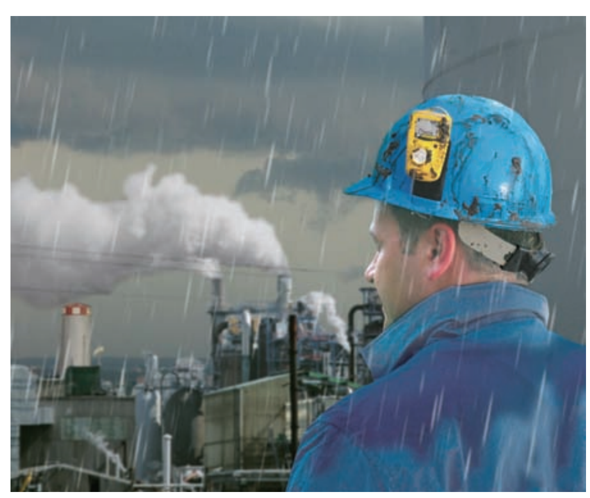

Figure 3: Typical maintenance-free gas detector in use

Calibration

All sensors suffer from some drift with time or exposure to contaminants. It is therefore important to periodically 'realign' the response of the instrument to a known reference concentration to ensure accurate readings. This process of calibration is usually a two-stage process. After the detector has been allowed to warm-up (check user manual), it is "zeroed" by applying clean air to give a baseline reference. The second stage is to apply a calibration gas that contains an accurate and known concentration of the gas (or gases) that the detector is designed to measure. The detector readings are then adjusted to match these values either by physically adjusting a component such as a potentiometer or more commonly, by allowing the instrument software to store new reference levels.

Before calibration there are a number of things to consider.

Where to carry out the calibration – calibration should be carried out in a 'clean' atmosphere. This means free from background gas and contaminants. Recalibrating a detector in a background of gas will result in a negative offset and have the effect of reducing the sensitivity after calibration. When the detector is taken into clean air the zero reading will go negative and may trigger a fault alarm.

Calibration should also be carried out in 'normal' operating conditions. This usually means at normal ambient temperature, humidity and pressure. As sensors are often affected by these conditions calibration around the middle of the range will minimise measurement errors at the extremes of the range.

Delivery of gas – the method and rate of delivery of gas during calibration can affect the accuracy of calibration. Follow the flow rates recommended by the manufacturer which should mimic the way the instrument sees gas in the field. Too high a flow rate can force gas into the sensor at an increased pressure and result in an artificially high reading during calibration. This again leads to an instrument with reduced sensitivity.

The length and type of tubing used to deliver the gas can also be important. Reactive gases such as hydrogen sulphide and chlorine are absorbed on the surface of some types of tubing affecting the concentration received by the instrument. Some gases such as isobutylene (a common calibration gas for PID sensors) need to be used with PTFE or PTFE lined tubing to eliminate absorption. The usual advice applies, if in doubt check with the detector manufacturer.

Shelf-life – cylinders of calibration gas have a limited shelf-life and should be marked with an expiry date. The shelf-life is often a year or more depending on the type of gas. Beyond this date the accuracy of the concentration within the cylinder and hence the accuracy of any calibrations carried out cannot be ensured.

Figure 4: Typical delivery systems for calibration gas

Cross Calibration – for some gases, calibration can be done using a different gas to which the sensor is cross-sensitive. This often makes calibration easier and means only a limited number of calibration gases need to be stored. Examples of this are methane for pentane (see below) or chlorine for nitrogen dioxide. However, users should be aware of the limitations. The method relies on the cross-sensitivity characteristics of the sensor determined by the sensor manufacturer. This will be an average over many sensors and so an individual sensor may vary from this average leading to measurement errors. Also, cross-sensitivities can change during the lifetime of the sensor.

Calibration Factors – these are often used for 'non-specific' sensors such as pellistors for flammable gases and PID sensors for VOCs (volatile organic compounds). A pellistor calibrated to methane for example, can be used to detect pentane, but only if the difference in response is accounted for. After calibration in methane, a gas concentration of 50% LEL pentane would only be displayed as 25% LEL because of the reduced sensitivity to this gas. The correction factor is therefore 2. Many instruments now have correction factors built into the software to allow the display to be corrected for different target gases. When calibrating these instruments ensure the correct calibration and target gases have been selected.

Safety – don't overlook the safety hazards involved with calibration. High pressure gases, heavy cylinders, toxic, corrosive and flammable gases are all potential hazards. Ensure measures are in place for handling, storage, first aid, fire fighting, accidental release monitoring and safe disposal. Ensure calibration is carried out in an adequately ventilated area since calibration gases may exceed short-term exposure limits (STEL). Hydrogen sulphide for example has a 15 minute STEL of 10ppm (EH40/2005) but gas detectors are often calibrated using 25ppm hydrogen sulphide.

For those interested in more details on calibration techniques and methods the publications 'Gas Detection Selection and Calibration Guide (Sira, 2005)' and 'Gas Detection and Calibration guide (CoGDEM/Bedfont, 1999)' are recommended.

'Bump' Testing

'Bump' testing refers to the functional check of an instrument by applying gas and verifying that the response is within acceptable limits and that the warning functions operate. No adjustments are made to the calibration or sensitivity of an instrument as it is purely a check. It therefore does not replace the periodic calibration of instruments but acts as a safe-guard between calibrations.

The Canadian Standards Association "Combustible Gas Detection" standard C22.2 No.152 has a requirements for users to test the sensitivity of combustible gas detectors before each day's usage. A known concentration of the gas equivalent to 25 - 50% of full scale concentration must be applied and the accuracy of the detector verified to be with –0 to +20% of the concentration applied. Whilst there are no specific requirements for bump testing in Europe, the CSA approach is very sensible and would also be recommended for all toxic and oxygen detectors.

Automated Test/Calibration Stations

Figure 5: Automated calibration equipment

A number of manufacturers have introduced automated test and/or calibration stations for their instruments. These are generally automated systems which apply test gas to instruments to bump check or carry out full calibration. The advantage of these systems is that they apply gas consistently, reduce operator error and can speed up the process by checking a number of units in parallel.

The more advanced systems can also log the serial numbers of units and maintain a record of which units were tested, when they were tested and the results. These will often interface to PC run software which can be used to manage a company's 'fleet' of gas detectors.

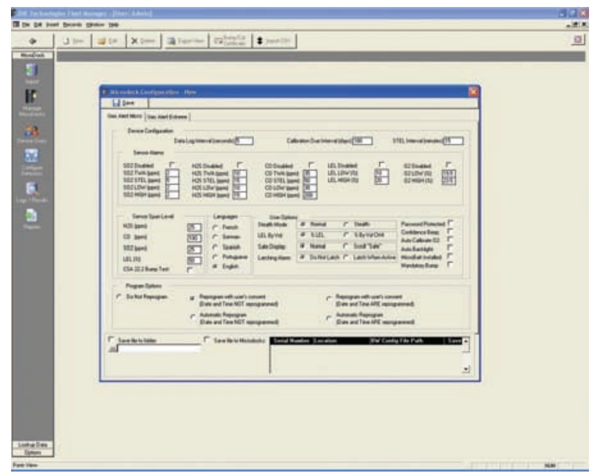

Figure 6: Software designed to manage and log bump testing and calibration

5 Quick tips on the Maintenance and Calibration of your Gas Detection System

1) The only true test is to apply gas and check response

2) Best practise is to combine regular calibration with a daily "bump" test

3) Use auto-test/calibration stations where available for reliable and consistent checking

4) Consider using software to manage your fleet of gas alarms

5) If in doubt speak to the equipment manufacturer

References:

Gas Detection Selection and Calibration Guide, Sira, 2005

Gas Detection and Calibration Guide, CoGDEM/Bedfont, 1999

About the Author:

Kevin Stockwell BSc is the European Approvals Co-ordinator for BW Europe Ltd, a manufacturer of gas detection instrumentation for use in industrial safety applications, particularly in hazardous areas. BW is an active member of CoGDEM, with representation on its Industrial Sub Group.

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