SELECTION AND SPECIFICATION OF FIXED GAS DETECTORS

Invisible, and often odourless, relatively low concentrations of certain gases can prove fatal to personnel or cause extensive damage to plant. Safety managers are required to carry out a formal safety assessment of all potential hazards, to identify risks to personnel and to ensure that suitable safety equipment and working procedures are in place to minimise those risks. Under the new ATEX directive, documentation of the risk assessment is mandatory. From June 2003 it will be mandatory for all equipment mounted in a Hazardous Zone to comply with this new EC directive. In broad terms, equipment which is already certificated to comply with the latest CENELEC standards on explosion protection will be able to be made compliant with the ATEX directive. There is a secondary part to the directive which places a requirement on users and installers to complete a risk assessment on their plant in which they identify the nature of the flammable materials present, the scale of any possible explosion, the probability of ignition and the training and marking requirements so that all personnel are aware of the hazard. All of these points need to be recorded in an explosion protection document and the use of the standard BS EN 50073, discussed later in this article, will be helpful in declaring that an appropriate approach has been taken with this risk assessment.

Industrial installations must continually review and update their risk assessment in the light of experience and new practice. An important aspect of this re-assessment must be an evaluation of the existing gas detection systems, as these form the first line of defence against gas hazards. As equipment is continually updated and new technologies become available, steady improvements in the safety of plant and personnel are possible. A careful evaluation of the various technologies available should be the first step in choosing a dependable gas detection system. It is crucial that a knowledge of current safety regulations is maintained, as gas safety thresholds often change, exemplified by the UK Health & Safety Executive's (HSE) current investigation of the toxic effects of hydrogen sulphide, which is covered later in this article.

A fixed gas detection system, linked to remote detectors in hazardous areas of the plant, allows safety officers to monitor gas concentrations from a single control point. Programmable alarm levels and emergency safety procedures, such as plant evacuation or shutdown, and sprinkler systems, can be triggered automatically by microprocessor controlled command and control centres.

SPECIFICATION OF FLAMMABLE GAS DETECTION EQUIPMENT

Certain gases readily combust if a suitable mixture of the gas and air comes into contact with a source of ignition. This ignition source could be a spark or a heated surface. It is therefore crucial to have advanced warning of the presence of explosive gas mixtures.

In the oil and gas industries, and anywhere where petroleum fuels are used or stored, there is a high risk of flammable hydrocarbons being present in the atmosphere. The Lower Explosive Limit (LEL) is the lowest concentration of flammable gas in air that will burn. For most flammable gases, this level is less than 5% by volume. Flammable gas detectors measure the concentration of a flammable gas from 0-100% of its LEL.

There are two key technologies, which should be considered when specifying equipment for monitoring flammable gas.

Infrared detectors

Gases that contain more than one type of atom absorb infrared radiation. Hydrocarbon gases such as methane, propane and butane are gases of this type. An infrared gas detector consists of an infrared source and an infrared detector. When flammable gas passes between the source and detector, the gas absorbs infrared radiation and a lower intensity is registered at the detector. Specific gases are detected by measuring the amount of absorbed infrared radiation at specific wavelengths, the difference being related to the concentration of gas present.

Pellistor detectors

A pellistor detector consists of a matched pair of elements, one of which is an active catalytic detector and the other a non-active compensating element. Each element consists of a coil of very fine platinum wire embedded in a bead of alumina. In the case of the detecting element, a catalytic coating is applied.

Flammable gas contacting the catalytic surface of the detecting element is oxidised, causing a rise in temperature of the bead. This rising temperature increases the resistance of the platinum coil. There is no such change in the compensating element. The output signal of the detector is based on the imbalance between the two resistances.

The choice is yours

Pellistor sensors are able to give accurate readings under adverse environmental conditions as any change in ambient temperature, humidity or pressure will impact equally on both elements. However, pellistors can be poisoned or inhibited by silicones, sulphides, chlorine, lead and halogenated hydrocarbons. The detectors therefore require regular cleaning and calibration, increasing the costs of maintenance. Pellistor sensors also require the presence of oxygen in order to operate.

Infrared detectors are immune to poisoning effects and operate in inert atmospheres. They are therefore suitable for use in confined spaces where oxygen depletion might limit the effectiveness of a pellistor detector. Infrared detectors have a fail-safe design. If the detector becomes obscured or fails, no infrared radiation is recorded and alarm signals are activated. Infrared detectors are available in either a fixed-point format, in which gas diffuses into the detector, or open-path format, in which the source and detector are separated by distances of tens or even hundreds of metres. In this way, a line-of-sight beam is formed and a gas cloud passing through the beam will be detected.

SPECIFICATION OF TOXIC GAS DETECTION EQUIPMENT

Many gases have detrimental physiological effects even at low levels. Depending on the nature of the gas and the level and time of exposure, effects vary from a mild headache, to dizziness, unconsciousness and in extreme cases death. Toxic gases are usually measured in parts per million (ppm). In industrial environments, the most common toxic gas is hydrogen sulphide, characterised by its ‘rotten eggs’ smell at low concentrations. The Health and Safety Executive (HSE) publishes guidance note EH40 each year to help employers adequately control their processes so that workers are not exposed to levels of toxic materials above recognised safe levels.

EH40 sets out occupational exposure levels in two categories. Maximum Exposure Levels (MELs) are for the more dangerous substances. Exposure in these cases should be as low as possible and certainly never above the MEL. Occupational Exposure Standards (OESs) are for less dangerous materials where a safe exposure level can be set in which workers can work day after day.

Currently, HSE are investigating the OES for hydrogen sulphide, whose long-term exposure limit (LTEL) over an eight hour time-weighted average reference period, is set at 10 ppm. It is likely that future editions of EH 40 will reduce this limit to 5 ppm, so it will be imperative that existing or new gas detection systems can cope with this change.

There are two main methods of detecting hydrogen sulphide in industrial safety applications and both of these are capable of being used with the proposed limit values.

Electrochemical sensors

Any gas that can be oxidised or reduced electrochemically can be detected by means of a fuel cell-based electrochemical sensor. Fuel cells are electric batteries that consume gas from outside rather than solid or liquid materials within. Electrochemical sensors are miniaturised fuel cells that react to low concentrations of gas to produce a current that is linearly proportional to the gas concentration.

Other gases may be detected by galvanic electrochemical sensors. In these sensors, electrodes or electrolyte within the fuel cell are used up in the electrochemical reaction. The life span of these sensors is therefore governed by the amount of gas that they absorb.

Semiconductor Gas Sensors

Solid-state sensors which use heated and semiconductor materials are also available. An example of this is the Sulphistor, which is a hybrid device, that is most useful for hot environments in which the temperature exceeds 45°C or where there is a continuous high background of hydrogen sulphide. Under such conditions electrochemical sensors may be unsuitable.

SPECIFICATION OF OXYGEN DEPLETION MONITORS

As well as the obvious hazards of flammable gas concentrations leading to explosions and toxic gas build-ups leading to poisoning, there is an equal or greater hazard in industry from the depletion of oxygen within confined spaces. Although personnel entering such a confined space would normally be equipped with a portable oxygen depletion monitor, it is sensible to install fixed apparatus in areas where such hazards may occur. An example of such a location could be a laboratory or storage area containing liquid nitrogen cryogenic vessels or carbon dioxide tanks. Leakage's of either of these two gases could lead to the displacement of normal atmospheric oxygen. With carbon dioxide being heavier than air and liquid nitrogen falling due to its low temperature, it is appropriate to mount oxygen detectors at low levels and it is interesting that the National Blood Service, a major user of cryogenic vessels, have generated their own standards, stating that oxygen depletion detectors should be mounted only 1 metre above floor level.

Oxygen detectors used in industrial safety applications typically utilise an electrochemical sensor, which contains a lead wool material in contact with electrodes and electrolyte. When oxygen is allowed to diffuse into this material the electrochemical reaction causes a current to flow. Such sensors are very reliable, but once all of the lead has been consumed the sensor needs to be replaced.

GAS DETECTOR SELECTION CRITERIA

One of the most useful reference documents is the British/European Standard BS EN 50073: 1999, which is titled "Guide for Selection, Installation, Use and Maintenance of Apparatus for the Detection and Measurement of Combustible Gases or Oxygen". The guidance that it contains can also be applied to toxic gas detection apparatus. It lists the criteria which should be considered when selecting appropriate gas detection apparatus, including knowledge of the gases and concentration ranges which the apparatus may encounter, together with the possibility of interfering gases being present. It is important to consider the intended application of the apparatus (e.g. area monitoring, personal safety or leak seeking) and any required explosion protection for the area of use. The materials used in the construction of the sensors and housings must be compatible with the local environmental conditions. The required time-to-alarm for the whole system may determine whether remote detectors are appropriate rather than a sampling system with either diffused or aspirated operation.

SPECIFICATION CRITERIA

In setting the specification for the system to be installed, one of the key influencing criteria is the number and location of detectors or remote sampling points. Many factors need to be considered and these include a full knowledge and survey of the site to identify the location and nature of the potential sources of gas. Air movements due to natural or forced ventilation will be dependent on whether the site is indoors or outdoors. A typical indoor example would be a chlorine storage room at a water treatment works. A knowledge of the topography of the site may show whether gas can build up to hazardous concentrations or will immediately disperse should a leak occur. The nature or concentration of the gas release will affect the location of gas detectors, as high-pressure jets, slow leaks or the spillage of volatile liquids can all give different scenarios.

For flammable gas or vapours it is important to identify potential sources of ignition and for all gas hazards it is crucial to know the location and number of personnel who may be working in the vicinity before the full gas detection system can be specified. In certain cases it may be necessary to model the air movement and behaviour of gases following a release and it is quite common to use smoke trails to identify likely patterns of movement. This should only be done by experts as gas density and temperature can change the movement patterns.

Finally, it is obviously sensible to locate detectors or sampling points where the chances of damage are low but in positions where maintenance engineers can gain easy access.

FURTHER READING

For further reference, CoGDEM have produced a “Gas Detection and Calibration Guide” which contains very detailed information on techniques used by commonly available equipment and the gases which they are designed to detect along with recommendations on calibration procedures and training. Guidance can also be obtained from the Health and Safety executives publications, such as the Control of Substances Hazardous to Health Regulations (COSHH), the Confined Space Working Regulations, Occupational Exposure Standards (EH40) and general guidance from the Health and Safety at Work Regulations.