It's a (dangerous) gas

Gas detection is critical on a wide range of plants, in a wide range of industries. Brian Tinham looks at the issues with installation and particularly maintenance

"Most flammable gas hazards occur when the concentration exceeds 10,000ppm [1%] volume in air. But for toxic gases, we need to detect in the sub-100ppm [below 0.01%] range, if we want to protect personnel." That chilling observation from Andy Avenell, product manager at specialist Crowcon, explains the sheer range of technologies for fixed and portable gas detectors – and the importance of ensuring that equipment is rigorously maintained.

Avenell also reminds us that, although gases have different densities, and so tend to stratify – with heavy gases, such as hydrogen sulphide (H_2S), sinking, while light gases, like methane (CH_4), rise – Brownian motion ensures constant mixing, even in still conditions. The point: if toxic or flammable gases or vapours are around, they may be at all levels. So, as well as the sensors, we must also consider sampling method and positioning.

Plant engineers in the oil and gas industry know this and are invariably trained in terms both of health and safety/risk management, and equipment selection and maintenance – specifically including calibration of gas detectors. The same, however, cannot always be said of colleagues at other, less obviously hazardous, installations – presupposing such sites even have operations engineers.

Poor practice

As Avenell says: "I spent many years as a service engineer and I saw many gas detectors that clearly hadn't been touched in years. I've even seen reset buttons taped down, so the equipment wouldn't keep going into alarm and annoying operators. In one building next to a car park, where the risk was perceived to be carbon monoxide poisoning, the CO sensing equipment hadn't been maintained in five years, according to the calibration label. The only reason I'd been called in was because one of sensors had gone open-circuit."

How can that be? It's not that there aren't guidance notes on gas detectors: comprehensive advice has been available free online from HSE for years. It's true the emphasis is on flammable gases – for example, TD5/035 (fixed flammable gas detectors) and TD5/036 (portable gas detectors) – but, nevertheless, HSE provides plenty of information about sensing technologies, sampling systems and points to consider prior to installing kit.

The organisation also tackles maintenance, calibration and functional checks. In particular, it refers readers to BS EN 50073 (BSI 1999) for point-type gas detectors, although it concedes that there is no equivalent standard for open-path beam type instrumentation (not a problem, since it's primarily used in the well regulated oil and gas sector).

However, searching the HSE web pages for more general guidance and/or legislation quickly demonstrates why some sites slip through the good engineering practice net. Because, although there is advice relating to flammable gas detectors (as described), as well as LEV (local exhaust ventilation), H_2S (particularly offshore), chlorine, domestic gas, CO and now – following the ICL Plastics explosion report (Plant Engineer, July/August 2009, page 9) – also LPG, it's hard to find information for toxic gases.

There are dark mentions of: the ATEX directive (for equipment in potentially explosive atmospheres); Offshore Installations (Safety Case) Regulations 2005 (SCR05), Regulation 14; and Offshore Installations (Prevention of Fire and Explosion, and Emergency Response) Regulations 1995 (PFEER), Regulations 5, 9, 10, 12 and 19. CoGDEM's (Council of Gas Detection & Environmental Monitoring Manufacturers) gas detection and calibration guide, and COSHH (Control of Substances Hazardous to Health 2002) also feature – the latter citing EH40/2005, which provides a list of legally binding exposure limits.

But there is nothing to suggest that users are bound by anything like the thorough examination regimes with which we are familiar in, for example, lifting, under LOLER (Lifting Operations and Lifting Equipment Regulations). That just leaves the Health & Safety at Work Act 1974 and the more recent Corporate Manslaughter Bill. Both are all-powerful, yes – and ultimately enough to send failing duty-holders to jail – but they do nothing explicitly to prescribe activities likely to ensure that gas detection equipment remains in good working order.

Limited guidance

What about publications that might throw useful light on what to do? HSE guides us to, among others, HS(G)22 Electrical apparatus for use in potentially explosive atmospheres, where paragraph 51 refers to maintenance schedules listed in the former BS 5345. Follow that link and you're looped back to COMAH-based maintenance procedures – hardly relevant to the vast majority of sites using toxic gas detectors. Think about Avenell's car park.

That said, HSE's general advice 'Contributory factors for an assessor to consider concerning leak/gas detection' provides useful cautionary notes. It refers, for example, to: 'the effectiveness of using the detectors in terms of their positioning relative to the possible leak sources'; 'the effectiveness of the detectors for the types of substances to be detected at the concentrations required'; and, most important, 'the reliability of each detector (range, response time, level of maintenance, calibration frequency, performance testing frequency, testing)'.

That commentary is somewhat buried, but it doesn't take an Einstein to conclude that, should an incident occur – and with gas detector failure, it could well be nasty – the duty holder and his or her plant engineering staff are going to be under scrutiny. That means not only having a safety case capable of standing up in court, but reports proving that regular validation of your gas detection equipment was being done.

All responsible suppliers' manuals include instructions on how to maintain equipment, with regimes for testing and monitoring, depending on the sensor. Beyond that, it's about training, familiarity and ensuring that test gas(es) are available for the 'bump' calibration test. The rest is common sense: checking for damage to sample probes; ensuring adequate battery life; and verifying zero reading in clean atmospheres.

As Avenell puts it: "It's about applying the test gas of known concentration and checking you get an appropriate reading. Or issuing a contract to a service provider."

Remember, some sensors have a defined life, after which there's no way even of knowing they're not sensing gas. Which means that you and your colleagues are doubly vulnerable to a leak: the leak itself and the false security of useless instrumentation. Given that many toxic gases are invisible and odourless (even H_2S quickly renders our sense of smell useless), you could be playing Russian roulette with people's lives. PE

Getting a grip on gas detection instruments – and the issues around maintenance and calibration – could be a life and death matter

Sensor technologies

Given the very wide range of hazardous gases, it's no great surprise that these are serviced by different sensor technologies. So which might you use for your application?

For flammables gases, catalytic beads (pellistors), which respond to the temperature rise of a catalysed reaction between the gas(es) and oxygen, are still the most widely used. They're low cost, equally suited to fixed and portable instrumentation and can detect a very wide range of gases – including hydrogen, which newer infrared techniques can't. Advantages include their wide gas coverage and the fact that response rates are fairly linear. Disadvantages include: they are not gas specific; they can give false readings in gas-rich atmospheres; the catalyst can be poisoned by, for example, H_2S; and the metal screen can become blocked. So they need regular, careful maintenance.

Infrared sensors, which detect the absorption of IR light by gases, are much more expensive, but can't be poisoned, don't require oxygen and require less maintenance – although they are pressure sensitive. They can function as point or open-path devices and cover all hydrocarbon gases and vapours (but not hydrogen) and CO_2, generally with LELs (lower explosive limits) in the 1–5% volume range.

Electrochemical cells (which use a gas permeable electrode to the electrolyte) are ideal for toxic gases, such as ammonia, chlorine, CO, H_2S and SO_2, each being dedicated to a particular gas – although there can be cross-sensitivity. Such sensors typically measure oxygen from 0–100% and toxic gases from 0–1,000ppm.

Other detector types include paramagnetic and zirconia sensors for oxygen concentration (both also used in flue gas analysers). Then, for flammables, the range extends to thermal conductivity (portable and fixed instruments), flame ionisation (mostly fixed), flame temperature (fixed), semiconductor (portable), ultrasonic and photo ionisation (fixed).