

Other Gases

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PORTABLE GAS DETECTORS

by P Bradley

1. Why is this guidance required?

The use of flammable and/or toxic gases, and solvents is an essential part of manufacturing in a range of industries. It is common practice to use portable gas detectors to check for the presence/ leaks of gas or vapour. Recent reports have shown that users of portable gas detectors may not be fully aware of the complexities of gas detection e.g. calibration requirements and action to be taken if the alarm level is reached.

There may be a lack of communication or understanding between the supplier/ maintenance contractor and the instrument owner/ operator as to how to use the detector, why particular detectors have been specified/ purchased and who has responsibility for maintenance.

HSE guidance on flammable gas detectors was withdrawn in 1995. There is no easily available guidance on gas detectors aimed at SMEs. This DIN includes general information regarding portable gas detectors which may be useful in discussions with users. **Section 12** and **Appendix 1** lists further guidance documents.

2. When should portable gas detectors be used?

A risk assessment on a particular work activity may specify use of a portable flammable gas detector. Portable gas detectors should only be used by people who have been trained in the technique to be used and in the interpretation of results.

In some circumstances the user may need to wear breathing apparatus (BA). Selection, correct fitting and use of BA requires specialist expertise and training; it should only be used after consultation.

Examples of situations where portable gas detectors are used include:

- To provide early warning of the presence of a flammable atmosphere in potentially hazardous areas during work which may generate an ignition source, e.g. welding or tank cleaning.
- To routinely check levels of flammable and/or toxic gas/ vapour over a wider area from a known source, e.g. landfill gas from a landfill cell gas extraction vent.
- In emergency situations to locate a suspected flammable or toxic gas/ vapour leak from pipework and equipment, e.g. natural gas pipework. In such a situation, and in d. below, a risk assessment should be carried out to determine whether gas monitoring is the correct method of leak detection and any precautions that should be taken, e.g. the instrument user may need to wear breathing apparatus.
- In emergency situations to check levels of flammable or toxic gas/ vapour over a wider area from a known leak. An example would be to check concentrations in a plant area when a known leak has occurred on a pressurised flammable liquid or gas pipeline in order to determine exclusion zones.
- To check the atmosphere in confined spaces both prior to entry into the confined space and at intervals specified on the entry permit. Initial monitoring should be done, where possible, from outside the space with the sample tube inside (**see also section 5**).

3. How do I go about selecting a suitable gas detector?

The selection of a suitable portable gas detector will depend the following factors.

3.1 Transportable and portable detectors

BS EN 50073 (BSI 1999) defines transportable apparatus as apparatus which is not intended to be portable but which can be readily moved from one place to another. Transportable detectors are not designed to be hand carried for long periods of time and are intended to be in place for hours or days. They can be used to monitor an area whilst a fixed gas detector is undergoing maintenance.

Portable detectors can be either small handheld apparatus, larger portable apparatus or personal monitoring instruments. Hand held apparatus may be used for leak-seeking or spot checks. Larger portable apparatus may be used for multiple roles according to the needs of the user, these may include leak-seeking, spot checks and local area monitoring.

Personal monitoring instruments are normally used in occupational health to determine the dose of a toxic substance over a period of time, e.g. a working day. This DIN does not cover these types of instruments.

In this DIN I use the term portable gas detector to mean both a truly portable gas detector and a transportable gas detector.

3.2 Passive and Active monitoring

Passive use of a detector is where the instrument is positioned temporarily in one place to monitor the atmosphere. This temporary installation may be for a period of hours or days. For example, a detector would be used in this way to monitor a potentially hazardous area whilst hot work was being carried out in the vicinity. Both transportable or portable apparatus may be used for this application.

Active use of a detector is where an operator carries the instrument around whilst monitoring. This may be in order: to find leaks, carry out spot checks, conduct local area monitoring or to check the atmosphere for vessel entry. Active monitoring is normally carried out using portable apparatus.

3.3 Sampling mode

The main types of portable/ transportable gas detecting apparatus are:

- a. Portable gas detector used in diffusion mode for general area monitoring
- b. Portable gas detector used with a static probe or a hand/ mechanically aspirated sample probe for leak seeking or testing inside confined spaces beyond the normal reach of the user. Probes are normally rigid and about 1 metre in length although they may be telescopic and may be connected to the apparatus by a flexible tube.
- c. Transportable gas detectors used with a sample line. Condensation in the sample line (and apparatus) should be avoided as this may cause a blockage, lower the concentration and reading, and may contaminate following samples.

3.4 Gases and vapours to be monitored

Portable gas detectors could either monitor:

- a single specific gas, e.g. hydrogen, methane, etc.
- all volatile organic carbon (VOC) gases, or total hydrocarbons
- all flammable gases as a total
- oxygen
- a combination of flammable gas(es), oxygen, carbon dioxide and other gases such as hydrogen sulphide or nitrous oxide. Separate sensors being used for each gas/ group of gases and the values being reported separately.

4. What types of sensors are there and when should they be used?

4.1 Modes of measurement

Portable gas detectors are point source detectors. These measure the concentration of the gas at the sampling point of the instrument. The unit of measurement is % volume ratio, % lower explosive limit (LEL) for flammable gas, ppm for low level concentrations (& toxic gases) or

mg/m³. It is important that the user understands the significance of the units of measurement when setting alarm levels, etc.

There are a number of techniques used for gas detection, the main types are outlined briefly in sections 4.2 - 4.12. More information is available in BS 50073 for point source detectors.

4.2 Catalytic (Pellistor)

This detector is small in size and can be hand held. It is used for flammable gases from 0 - 100% LEL. It needs more than 10% oxygen to work correctly and can give false ambiguous readings above the upper explosive limit (UEL), that is in gas rich atmospheres. The catalyst can be poisoned by various trace gases such as hydrogen sulphide.

Operating principle: Heat is generated during the catalysed reaction between the gas and oxygen in air. The resulting rise in temperature of the catalyst bead (pellistor) causes a change in electrical resistance which is a measure of gas concentration.

4.3 Flame Temperature

This detector is large in size. It is used for flammable gases from 0 - 100% LEL. The flame temperature detector has a fast response but needs hydrogen to generate the flame and a clean air supply. Halon may cause a false reading.

Operating principle: The temperature of a controlled hydrogen flame is monitored using a pyrometer. Flammable gas in the air supply to the flame causes the temperature of the flame to change. This change is a measure of gas concentration.

4.4 Flame Ionisation

This detector is used for most hydrocarbon gases and vapours from ppm to %v/v levels. It needs hydrogen to generate the flame and a clean air supply. The detector is fast and sensitive. Operating principle: An ionised gas will conduct an electrical current in proportion to the number of ions present. Hydrocarbon gases and vapours are easily ionised and the current flow in the ionised gas is easily measured. The source of ionisation is a hydrogen flame.

4.5 Photo ionisation

The usage and range of this detector are dependant on the energy of the UV lamp. Its range is from ppm to %v/v levels. It needs hydrogen and a clean air supply. The detector is fast and sensitive but humidity may affect the readings. These detectors are small and can be hand held. Operating principle: Same as for the flame ionisation detector, but the source of ionisation is an ultraviolet lamp.

4.6 Thermal Conductivity

This detector is used in the range 0.1 - 100 %v/v. It can be used to compensate catalytic detectors when they are used above the UEL. It only works well when differences in thermal conductivity between the target gas and reference gas (air) are large, e.g. hydrogen or methane.

Operating principle: Gases conduct heat at different rates. If a gas is in a mixture with a reference gas then the concentration can be determined by comparing the thermal conductivity of the mixture and the reference gas by measuring the heat dissipated by heated elements. The out of balance voltage from a resistance bridge is a measure of the gas concentration. The bridge compensates for ambient temperature changes.

4.7 Semiconductor

This detector is used for most hydrocarbon gases and vapours from ppm to %v/v levels. It has a non-linear response and needs oxygen. It is sensitive to water vapour and many other gases/ vapours which may produce a false reading.

Operating principle: A surface interaction between gas and a gas sensitive semiconductor alters the conductivity of the semiconductor. Generally, reducing gases (e.g. hydrocarbons) drive the conductivity in one direction and oxidising gases (e.g. oxygen) drive it in the opposite direction. The change in electrical conductivity of the semiconductor is a measure of the concentration of hydrocarbons in air.

4.8 Infrared

Infrared detectors can be either point or open path (beam) but for portable use they will almost certainly be point detectors. They are used mainly for hydrocarbon vapours from 0 - 100 %v/v. The detectors do not require oxygen, cannot be poisoned and are not ambiguous above the LEL, but they cannot detect hydrogen and are pressure sensitive.

Operating principle: Absorption of infrared light by certain molecules is detected by dilution over a beam path. For point source detectors the beam length is short.

4.9 Ultrasonic

This is a non-concentration based detector used to detect leaks from high pressure systems. Theoretically it provides 360° coverage and does not require transport of the gas to the sensor. Care is needed in positioning the sensor and false alarms may occur due to other ultrasonic emissions.

Operating principle: Escape of gas from a pipeline or equipment under pressure generates ultrasound that can provide a measure of the leak rate.

4.10 Electrochemical

This sensor measures oxygen from 0 - 100% (and toxic gases from 0 - 1000 ppm). It has a slow response.

Operating principle: The gas diffuses through a permeable electrode to its interface with the cell's electrolyte. Here electrochemical reactions take place which alter the electrical characteristics of this electrode. Measurement of these electrical parameters with respect to other electrodes within the cell give a signal proportional to the gas concentration.

4.11 Paramagnetic

This sensor measures oxygen in the range 0 - 100%. It has a fast response. If the instrument is calibrated in one direction (e.g. North - South) and is used in another direction (e.g. South - North or East - West) there will be some offset. Paramagnetic sensors are not often used in portable instruments because of this orientation dependency.

Operating principle: Oxygen atoms are strongly attracted to a magnetic field, i.e. they are paramagnetic. Measuring the differential interaction between the magnetic field and the target gas and a reference gas generates a response proportional to the oxygen concentration.

4.12 Zirconia-type

This sensor measures oxygen concentration in the range ppb - % (by volume). They are suitable for high temperature environments and are very sensitive. The sensor produces a non-linear response which is also temperature dependant.

Operating principle: Zirconium oxide (zirconia) or similar substances are ceramics that conduct electricity by the movement of oxygen ions when heated above 300°C. If the oxygen concentration on each side of a thin plate of zirconia is different a flow will occur and a voltage will be generated between the two surfaces. Electrodes on the two surfaces will detect the voltage, this is a measure of the difference in oxygen concentration.

5. How should the portable detectors be positioned and used?

5.1 Passive use

The effective operation of a gas detector relies on the correct placement of the sensor in order to detect gas accumulations before they create a serious hazard. Further guidance is available in BS EN 50073 (BSI 1999).

The positioning of the sensors depends on:

- nearby process plant and equipment
- the detection equipment
- the properties and dispersion characteristics of the gas
- the location of personnel or equipment protection.

The area should be assessed to identify the most likely sources of flammable gas/ vapour. The sensor should be positioned near the potential gas, in the path of the gas/ vapour or near the ignition source. Examples of positions for gas detectors in different scenarios are:

- a. Near to flanges, valves or gas cylinder filling equipment to check for leaks.
- b. Near to equipment such as solvent evaporating dryers where flammable vapour occurs as part of the process.

- c. Near to ingress points such as drains or underground cable conduits, where gas detectors are used to warn of gas entering a confined space, e.g. landfill gas entering a building.
- d. Near to work which generates an ignition source in a potentially hazardous area.

The path of the gas or its dispersion characteristics will depend on the density of the gas and the ventilation patterns. The density can be used to determine at what height sensors should be positioned relative to the potential source. For example:

- Methane (natural gas) is less dense than air so it will rise.
- Vaporised liquefied petroleum gas (LPG) is heavier than air so it will fall and/or hug the ground.
- Landfill gas (a mixture of methane, carbon dioxide, hydrogen and trace gases) will have a density depending on its composition. For example, mature landfill sites generate gas with a density slightly less than air.

The ventilation patterns for indoor locations will depend on the position, and size of louvres, doors and other openings and on the operation of ventilation fans. The ventilation patterns for outdoor locations will also depend on wind speed/ direction, plant layout and topography. It may be necessary to have some knowledge of gas dispersion and the ventilation pattern of the area (possibly from a wind sock, if outdoors) in order to determine the best position for sensors and/ or the best place to stand whilst taking measurements.

The sensors/ sample points should not be positioned where they may be susceptible to excess vibration or heat; contamination; mechanical damage; or water damage due to normal operations.

5.2 Active use

An operator may carry the instrument around in order to: take 'walk through' measurements to determine gas concentrations in the general area; monitor the atmosphere within a confined space or take measurements near likely sources of gas e.g. drains or flanges.

For all situations the gas concentration should be measured and noted before the operator enters a hazardous area. This can be achieved for 'walk throughs' by ensuring the open end of the sample probe precedes the operator who should continually monitor the readout to determine if it safe to continue in that direction. For example if the gas concentration increases dramatically it may not be safe to proceed, even if an alarm concentration has not been reached. Note: the readout should not be monitored continually to the detriment of general health & safety e.g. the operator falling because they were not looking where they were walking. It should be remembered that the instrument has a finite response time, **see Section 10**.

For leak seeking or monitoring known sources, e.g. known leaks or ingress points the probe should be placed as close to the source as possible with the operator upwind of the source and as far away as the probe will allow whilst still being able to monitor the readout.

For testing atmospheres of confined spaces the sample probe should be positioned inside the space with the operator remaining outside. Where this is not possible breathing apparatus (**see section 2**) should be worn until the instrument operator can prove that a safe, breathable atmosphere exists in the confined space. The operator should monitor a number of points inside the tank, using extended probes where necessary, to take into account vapour pockets and stratification. It may be necessary to continuously monitor during the work, if so the gas detector sample tube should be positioned in the confined space. The space should be monitored for flammable gases, oxygen concentration and toxic gases that are likely to have been present in the space. The oxygen concentration may be particularly important because, as previously discussed, reduced oxygen concentration may affect the sensor reading. More details on safe work in confined spaces can be found in the HSE publication L101 (HSE 1997). For information on cleaning and gas freeing of tanks refer to the HSE publication CS15 (HSE 1997a). It should be noted that HS(G)5 'Hot work' (HSE 1986), is in the process of being rewritten and may eventually lead to the withdrawal of CS15.

Some hand held gas detectors can be used as personal monitors to alarm if toxic gas is present or if the oxygen concentration is too low. This DIN does not cover such detectors.

5.3 Control panels & instrument readouts

The portable instrument readout and control panel should be easy to read whilst the instrument is being carried and used. For newer instruments the readout tends to be a digital display on the instrument body itself. For some older instruments the readout may be a handheld dial situated at the end of the fixed probe, the main body of the instrument is connected by means of a flexible tube.

5.4 Alarms

An alarm may be audible and/or visual, e.g. a flashing red light. In the case of a portable gas detector the alarm is often located on the main body of the instrument itself. For passive use it is important to locate the instrument such that the operator can see or hear the alarm from the work position.

An alarm to warn of a fault condition is vitally important. There are some situations where a failure of a part of the gas detector system could continue to show a zero reading, falsely indicating a safe position. Ideally there should be no non-detectable fault conditions in the detector. It is common for portable gas detectors to have a low battery alarm. Some, where appropriate, have a low fuel (hydrogen) alarm.

6. At what gas concentration should the detector alarm?

Most modern gas detectors have the facility to set an alarm level. The gas detector should be set to alarm at a level low enough to ensure the health and safety of personnel but high enough to prevent spurious alarms. False alarms are most likely to be caused by fluctuations in sensor output due to environmental changes (e.g. ambient temperature, pressure or humidity) and cross-sensitivity to other gases or vapours.

In determining the required alarm level for a flammable gas the following should be taken into account: lower flammability limits, size of likely leak (time to reach a hazardous situation), time and method of response to the alarm (e.g. time taken to make the area safe and/or evacuate), and any industry standards. Often the level is set at 10% of the Lower Explosive Limit (LEL) but the above factors and the manufacturer's recommendations should also be taken into account. In determining the required alarm level for oxygen concentration the following should be taken into account:

- a. For oxygen deficient atmospheres: health effects of reduced oxygen concentration, possible cause of reduced concentration (e.g. leak of another gas), time and method of response to the alarm (e.g. time taken to make the area safe and/or evacuate), and any industry standards.
- b. For oxygen enriched atmospheres: size of likely leak (time to reach a hazardous situation), time and method of response to the alarm (e.g. time taken to make the area safe and/or evacuate), and any industry standards.

Although it is not covered in this DIN the toxicity of the gas should also be considered.

In all cases alarm levels should be set with sufficient safety factors included to account for poor mixing of gases. This should ensure that a hazardous atmosphere does not exist anywhere in the area being monitored.

Some portable gas instruments can be used to monitor for flammable gas, oxygen, carbon dioxide and other gases such as hydrogen sulphide or nitrous oxide using separate sensors within the instrument.

Note: Where the detector is used to monitor for landfill gas or mines gas the toxic (asphyxiant) properties of the carbon dioxide contained in the mixture should be considered to be at least an equal hazard to the mixtures' flammable properties. Instruments that measure flammable gases alone will not measure carbon dioxide.

7. What actions should be taken on the gas detector alarming?

A gas (set-point) alarm will warn personnel who should then set into motion emergency procedures. There must be clear instructions for appropriate personnel on what to do when an alarm sounds. The instructions should be linked to safety procedures, the company safety management system and be backed up by training and refresher courses. It should be remembered that any alarm means there is a potential problem.

A low battery indicator, distinguishable from the 'set-point' alarm, is normally present on portable instruments. This may not shut down the instrument immediately but the manufacturer's instructions will give further details. If the low battery indicator annunciates the

instrument should be recharged in a safe area, away from the area being monitored, as soon as is reasonable.

8. What about maintenance, calibration and function checks?

8.1 Frequency of maintenance, calibration and function checks

It is extremely important to have an inspection (function check), calibration and maintenance routine. Detector performance is affected by operational life and the initial accuracy upon commissioning will be degraded depending on the type of detector and operating conditions (e.g. poisoning of catalytic sensor), these factors will affect the frequency of inspection, maintenance and calibration. Refer to BS EN 50073 (BSI 1999) clauses 7 & 8 and COGDEM (1999) for more detailed information. It is important to consult the manufacturer when setting these frequencies.

The user should consider the sensor type, operating conditions, required use/ accuracy of the detector and manufacturers' guidance to assess the frequency of inspection and/ or calibration. For example:

- Portable catalytic gas detectors used as a general purpose detector ('walk through' situations) would require calibration before and after each use to guard against catalyst poisoning.
- Portable flame ionisation flammable gas detectors used as a general purpose detector ('walk through' situations) to look for potential problems where actual concentrations were not important would require a function check before and after each use and calibration on a less frequent basis, e.g. weekly.
- Any portable gas detector used to check the atmosphere inside a confined space would require calibration before and after each use.
- Any portable gas detector used to check for toxic chemicals would require calibration before and after each use.

8.2 Function checks & inspection

Function checks should include: check that a zero reading is obtained in a clean atmosphere away from known sources of gas or vapour; check for a response to a flammable vapour (acetone vapour is normally drawn into the probe and the reading watched to see if a concentration is registered, the value is not important); check the battery charge level is adequate for the job and check the level of any other reservoirs (e.g. hydrogen in a flame ionisation detector) is adequate.

Prior to each use the instrument should be inspected for any damage. Dents, kinks and bends in the sample probe may restrict the sample and give a false reading. A damaged battery, damaged fuel reservoir or cracks in the casing would make the instrument unsafe and/or unreliable. Contamination, e.g. water or dust, could give false readings and may damage the instrument. A damaged display would make the instrument difficult/ impossible to read and a broken alarm may not register a hazardous situation. Any air inlet filters should be clean in order to allow an unrestricted air flow into the instrument. It is also important to check the integrity of other parts such as the carrying handle or case and shoulder strap.

BS EN 50073 clause 7.2.1 contains information on inspection and field checks.

8.3 Calibration

If a gas detector is to be used to measure a different gas than its original duty dictated then the manufacturer should always be consulted. It may not be possible to measure the required gas with the same detector. If it is possible to measure the new duty gas the instrument would need to be recalibrated with that gas, or if this is not possible a calibration factor supplied by the manufacturer should be used.

Calibration of portable gas detectors is normally done using a gas mixture from a cylinder; it is convenient and accurate. In many cases obtaining a calibration gas in a cylinder is a physical impossibility so calibration must be done with another gas mixture and calibration factors used (**see section 9**).

Many gas sensors are sensitive to pressure and care must be taken when calibrating instruments that true readings are produced. When using a gas mixture cylinder to calibrate a diffusion instrument the gas should be passed through a calibration mask and out to atmosphere; excessive flow through the mask will lead to over pressuring the sensor and false

high readings whilst too little flow will lead to air ingress and a false low reading (this is only a problem for low gas concentrations). For pumped (aspirated) systems it is normal to flow the gas to waste and allow the instrument to draw the mixture from a tee-piece or reservoir in the line. Again care must be taken not to set the flow too high or low as similar problems will occur as for diffusion instruments. On aspirated systems care must be taken to ensure that all joints in the sampling system are secure as leakage into the system will cause low readings. In all cases care must be exercised over the waste calibration mixture if it is released into an enclosed space; it is unlikely to build up to flammable concentrations but with some calibration mixtures the occupational levels set under COSHH in EH40 could be quickly exceeded.

8.4 Maintenance

Before being repaired or maintained the gas detector should be removed to a safe place outside the area being protected, e.g. a workshop. If hazards are still potentially present then it will be necessary to use a replacement portable gas detector until the original is repaired. Suitably qualified and trained personnel should perform maintenance in accordance with the gas detector manufacturer's procedures. If qualified personnel or suitable facilities are not available then the detector may need to be sent to the manufacturer or a qualified repair company.

9. What gas should be used to calibrate the detector?

Ideally the gas to be measured should be used to calibrate the gas detector. It is normal for gas detectors to be calibrated for methane, which is fine if methane based gas is being measured, e.g. natural (mains) gas or mines gas.

If the detector is monitoring for another gas, e.g. hydrogen in a cylinder storage area, ideally that gas should be used for calibration of the instrument.

In some cases it is not possible to calibrate for the exact gas or vapour because it contains many different chemical compounds, petrol vapour is an example. When petrol vapour is being measured the detector can be calibrated using hexane, one of the many constituents of petrol which gives a good approximation.

If obtaining a calibration gas in a cylinder is a physical impossibility, i.e. an organic solvent produces a flammable mixture in air at ambient temperature and pressure but becomes liquid when pressurised in a gas cylinder, then another gas mixture can be used which would give a similar detector response to the target gas. The difference in detector output is then corrected by use of a response or calibration factor. Most detector manufacturers have tables that show the calibration gas mixture and correction factor for every target gas that the sensor will respond to. It must be noted that these tables are model specific as different types of sensor (e.g. infrared, catalytic) will have different correction factors.

If more than one gas may be detected and there is no obvious good correlation then it is best to err on the safe side and calibrate for the least sensitive gas, this approach will lead to artificially high readings but will ensure that a flammable concentration is not reached. Specialist knowledge will be required to determine which gas should be used to calibrate the detector in individual circumstances as sensitivity may vary depending on the sensor.

10. What is a reasonable response time?

In gas detector specifications the response time is usually defined as the time it takes the output of the sensor to reach 90% of its final value when subject to a step change in gas concentration at its sample point, it is written as T_{90} . The overall response time of a gas sensing system is governed by two factors:

- The intrinsic time it takes the gas sensing mechanism to respond. These are determined, for example, by chemical reaction rates for catalytic sensors or physical changes, e.g. spectroscopic transitions for infrared sensors.
- The time taken to transport the sample to the sensor. For pumped (aspirated) systems the transport time is determined by the sample tube length, tube diameter, aspiration rate and diffusion rate from the flow system to the sensor. For diffusive systems as only diffusion to the sensor occurs the time is based on the diffusion rate alone and as such are slower.

An acceptable response time will depend on the purpose of the system and speed of the expected problem. Protection of personnel and large/ catastrophic leaks require a fast response time whereas small leaks that build up gas concentration slowly and non-toxic environmental monitoring can accept a slower response.

The response time should be considered in conjunction with the alarm level. For example a longer response time may be allowable if the system alarms to evacuate at 10% LEL rather than 25% LEL, for the same gas leakage rate, etc.

11. What else should be considered when specifying/ using gas detectors?

The ATEX directive, EC Directive 94/9/EC: Equipment and protective systems intended for use in potentially explosive atmospheres, requires a type test for gas detection apparatus intended for use in zones 0 and 1. Equipment supplied for use in potentially explosive atmospheres must therefore have the 'CE' and 'Ex' markings to show conformity with the regulations. The directive describes the essential safety requirements in general terms and regulates the technical requirements for all such equipment and protective systems.

There is also a new, additional ATEX directive (EC Directive COM (95) 310 (Draft) concerned with the implementation of the 'minimum requirements for improving the safety and health protection of workers potentially at risk from explosive atmospheres.' This may also require testing of gas detection systems to conform with its essential safety requirements.

12. What guidance is available on gas detectors?

This DIN has been based on information in Walsh et al. (2001) and Walsh et al. (1999).

Appendix 1 contains internal and external HSE guidance, British Standards and known industry specific guidance (available publicly). A list of some single company guidance is provided in Walsh et al. (1999) but is not reproduced here. The following guidance has been referenced in the DIN and is particularly useful:

- Walsh et al. (2001)
Walsh, P T, Hedley, D. and Pritchard, D. K., Framework for HSE guidance on gas detectors (On-line checking of flammability monitoring equipment - Final report). HSL Internal Report EC/01/10, FM/01/01.
- Walsh et al. (1999)
Walsh, P T, Hedley, D. and Pritchard, D. K., On-line checking of flammability monitoring equipment (Phase 1). HSL Internal Report EC/99/75, FM/99/9.
- BSI (1999)
BS EN 50073:1999 Guide for the selection, installation, use and maintenance of apparatus for the detection and measurement of combustible gases or oxygen.
BSI, London.
- COGDEM (1999)
Gas detection and calibration guide. COGDEM, Hitchin.
- HSE (1997)
Safe work in confined spaces. Confined spaces regulations 1997, approved code of practice, regulations and guidance. L101, HSE
- HSE (1987)
Industrial use of flammable gas detectors. Guidance Note CS1 (withdrawn). HSE.

HSE (1986)

Hot work. HS(G)5. HSE.

Appendix 1

A1.1 List of internal HSE guidance/ reports

Walsh, P T, Hedley, D. and Pritchard, D. K., Framework for HSE guidance on gas detectors (On-line checking of flammability monitoring equipment - Final report). HSL Internal Report EC/01/10, FM/01/01, 2001.

Walsh, P T, Hedley, D. and Pritchard, D. K., On-line checking of flammability monitoring equipment (Phase 1). HSL Internal Report EC/99/75, FM/99/9, 1999.

Walsh, P. T., Review of guidance on gas and fire detectors. HSL Internal Report CAM/98/01, 1998.

Bagley, M. J. & Hardwick, K., Flammable Gas Response Factors for Portable Explosimeters II: Further Fuels. HSL Internal Report FMS/00/07, 2000.

Wake, D. & Bagley, M. J., Flammable Gas Response Factors for Portable Explosimeters. HSL Internal Report FMS/99/06, 1999.

OC 201/7 (1992) Portable gas detection instruments and the effect of electromagnetic interference.

NIGM 3/C/1997/12(rev) Health and Safety at CCGT and CHP Plant HSE Interim Advice Note. Ventilation and gas detectors for turbine halls and enclosures. (Intranet)

NIGM 3/C/1998/9 Local odourisation of gas sites affected and implications for CCGT and CHP plant. Appendix 2 Section 3.2.

Level 3 Guidance for the Assessment of the Technical Aspects of COMAH Safety Reports Leak/ Gas Detection. (Intranet)

Safety Case Assessment Manual Level 2 Guidance Fire and gas protection systems for offshore installations (1992).

Lewis, M. J., Explosion hazards in gas turbine power plant: Ventilation and detection in the absence of an enclosure. HSL Internal Report CM/9912, 2000.

A1.2 List of external HSE guidance

Industrial use of flammable gas detectors. Guidance Note CS1 (withdrawn). HSE, 1987.

The cleaning and gas freeing of tanks containing flammable residues. Guidance Notes CS15. HSE. 1985 (reprinted 1997)

Safe work in confined spaces. Confined spaces regulations 1997, approved code of practice, regulations and guidance. L101, HSE, 1997.

Hot work. HS(G)5. HSE, 1986.

The safe use and handling of flammable liquids. HS(G)140, HSE, 1996.

Protection of workers and the general public during the development of contaminated land. HS(G)66, HSE, 1991.

Lift trucks in potentially flammable atmospheres. HS(G)113, HSE, 1996.

Guidance note PM 84: Control of safety risks at gas turbines used for power generation. HSE, 2000.

Safe management of ammonia refrigeration systems. PM81, HSE, 1995.

Health and safety in demolition work Part 4: health hazards. GS29/4, HSE.

Carbon monoxide: health and safety precautions. EH43, HSE, 1998.

A1.3 List of other external guidance

Gas detection and calibration guide. COGDEM, Hitchin. 1999.

BS EN 50073:1999 Guide for the selection, installation, use and maintenance of apparatus for the detection and measurement of combustible gases or oxygen. BSI, London.

BS EN 1775:1998 Gas supply. Gas pipework in buildings. Maximum operating pressure \leq 5 bar. Functional recommendations.

BS 6164:1990 Code of practice for safety in tunnelling in the construction industry.

BS EN 1127-1:1998 Explosive atmospheres. Explosion prevention and protection. Basic concepts and methodology. (No mention of gas detectors but refers to EN 50054-58).

BS EN 50054:1999 Electrical apparatus for the detection and measurement of combustible gases. General requirements and test methods. (This standard is current but has been superseded).

BS EN 61779: 2000 (Parts 1 - 5) Electrical apparatus for the detection and measurement of flammable gases.

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