

Other Gases			
DIN No	TD5/035	Issue Date	2 June 2001
Open Government Status	Fully Open	Review Date	30 January 2004

FIXED FLAMMABLE GAS DETECTORS

by P Bradley

1. Why is this guidance required?

The use of flammable gases, and solvents is an essential part of manufacturing in a range of industries. It is common practice to install fixed flammable gas detectors to detect leaks of flammable gas or vapour. Recent reports have shown that owners/ occupiers of premises in which detectors are present may not be fully aware of the gas detection alarm levels and actions to be taken on hearing an alarm.

This is because third parties often install the detectors and, in some cases, also maintain them. There may be a lack of communication or understanding between the supplier, installer or maintenance contractor and the premises owner/ occupier as to why the detectors have been installed in particular positions 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HSE guidance on flammable gas detectors was withdrawn in 1995.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 gas detectors which may be useful in discussions with premises owners or occupiers. **Section 12** and **Appendix 1** gives further guidance/ reference material that may be of use.

2. Why should fixed flammable gas detectors be present?

Fixed gas detectors may be required where it is reasonably foreseeable that:

- Flammable gas or vapour may leak from pipework and equipment, e.g. live fire compartment training facilities or inside flammable gas cylinder filling operations.
- Flammable gas or vapour may occur as part of the process, e.g. solvent evaporating dryers.
- Flammable gas may enter a confined space, e.g. landfill gas or mines gas from the surrounding ground could enter a building.

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

Gas detecting apparatus is made up of a sensor, a control unit, an alarm and connecting cables. There are three main types of fixed apparatus:

- Sensor & control unit both situated within the hazardous area, the two parts may be combined into one unit or supplied separately.
- Separate sensor and control unit, usually with the sensor within the hazardous area and the control unit outside the hazardous area.
- Sampling apparatus with one or more sample points in the hazardous area, each point is drawn to the sensor via a sample line.

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

4.1 Modes of measurement

There are two modes of measurement, point and open path.

Point detectors 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 the flammable gas and ppm or mg/m³ for low level concentrations and toxic gases.

Open path detectors, also called beam detectors, consist of a radiation source and a physically separate, remote detector. The detector measures the concentration of gas integrated along the path of the beam. As the path can vary from several metres to a few hundred metres large distances can be monitored. The unit of measurement is concentration multiplied by path length, e.g. %LEL x m or ppm x m.

There are a number of techniques used for flammable gas detection, the main types are outlined briefly in sections 4.2 - 4.9. More information is available in BS EN 50073 (BSI 1999) for point detectors although there is no equivalent BSI standard for use of open path detectors.

4.2 Catalytic (Pellistor)

This point detector is small in size and is used for flammable gases from 0 - 100% LEL. It needs more than 10% oxygen to work correctly and can give false ambiguous reading 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 point detector is large in size and 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 point detector can be 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 point 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.

Operating principle: Same as for the flame ionisation detector, but the source of ionisation is an ultraviolet lamp.

4.6 Thermal Conductivity

This point 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 point detector can be 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 a 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

These can be either point or open path detectors and 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. For open path detectors large spaces can easily be monitored but the alignment of source and detector requires great care and objects in the beam can give false readings. If the sun is low in the sky stray radiation can enter the detector causing interference with the beam, if the beam is uncompensated this can give high readings.

Operating principle: Absorption of infrared light by certain molecules is detected by dilution over a beam path. For point detectors the beam length is short. For open path sensors the source of infrared light is a powerful narrow beam that illuminates the space between source and detector. Gas can be detected anywhere in this line of sight.

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 placement and false alarms may occur due to other ultrasonic emissions. Operating principle: Escape of gas from a high pressure pipeline or other pressurised system generates ultrasound that can provide a measure of the leak rate.

5. Where should the fixed detectors be positioned?

5.1 Sensors

The effective operation of a gas detection system relies critically on the placement of sensors in order to detect gas accumulations before they create a serious hazard. Further guidance is available in Guidance Note PM 84 (HSE 2000) for positioning of sensors in gas turbine enclosures and BS EN 50073 (BSI 1999) for general uses.

The positioning of the sensors depends on:

- the process plant and equipment
- the detection equipment
- the properties and dispersion characteristics of the gas
- other safety issues, e.g. location of personnel or equipment protection.

The plant should be assessed to identify the most likely sources of flammable gas/ vapour. The sensor should be positioned near the potential source or in the path of the gas/ vapour.

Examples of likely sources of flammable gas/ vapour are:

- a. Leaks may occur from pipework flanges, valves or gas cylinder filling equipment.
- b. Flammable vapour will occur as part of the process in some equipment such as solvent evaporating dryers. Positioning of sensors in this case needs to be carefully considered, taking into account likely concentration gradients throughout the equipment.
- c. Where gas detectors are used to warn of gas entering a confined space the sensors should be located close to likely ingress points such as drains or underground cable conduits. An example is landfill gas entering a building.

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. A knowledge of gas dispersion (which may include modelling), the ventilation pattern of the area and possibly practical tests (such as a smoke test) will be necessary in order to determine the best place for sensors.

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. If there are no alternative locations some suitable precautions may be taken such as vibration isolation mountings, in other cases reduced sensor life is likely.

The failure, or removal for maintenance, of an individual sensor should not compromise the safety of the premises being monitored. BS EN 50073 (BSI 1999) recommends duplication (or triplication) of remote sensors and control apparatus where continuous monitoring is required.

5.2 Control panels & instrument readouts

The position of the instrument read out and control panel should be carefully considered. It should not be necessary to enter a hazardous situation in order to read the instrument. For example, if a control panel with local readout is inside a normally unmanned location, such as a turbine hall, then there should be a second instrument readout outside the turbine hall, possibly in a manned control room.

The control panel should be sited such that local readouts may be taken and access gained for calibration and maintenance. A suitable position would be on the wall of the building (possibly near an exit), at an easy working height (approx. 1.5 m), with reasonable room for access and working.

5.3 Alarms

An alarm may be audible and/or visual, e.g. a flashing red light. It should be possible to hear or see the alarm both inside the building and also before entering the building to warn people that a hazardous situation may exist inside.

An audible gas alarm should be distinguishable from a fire alarm because different emergency actions are likely to be required (**see section 7**).

For safety critical applications an alarm for 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.

6. At what gas concentration should the detector alarm?

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 levels 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. whether the area is usually occupied), and any industry standards. Although it is not covered in this DIN the toxicity of the gas should also be considered.

Alarm levels should be set with a sufficient safety margin included to account for poor mixing of gases and to ensure that a flammable mixture does not exist anywhere in the area being monitored by the sensor.

It may be necessary to set two alarm levels in some cases. The lower alarm would act as a warning and the higher alarm as an evacuation and/or shutdown (**see also section 7**). If gas detectors are installed as part of the process where a flammable atmosphere is expected the alarms levels should take into account normal operating conditions and the maximum safe operating concentration of the equipment. For general area monitoring (i.e. not as part of the process) the first alarm level should be set as low as possible without causing spurious alarms, this is normally at or under 10% of the Lower Explosive Limit (LEL). For area monitoring the

second alarm level should be no more than 20 - 25% LEL but the above factors and the manufacturer's recommendations should also be taken into account.

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. Most flammable gas detectors will not measure carbon dioxide although gas detectors are available that will measure methane, carbon dioxide and oxygen levels without being poisoned or sensitive to trace gases and water.

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

An alarm may trigger an automatic (executive) action or warn personnel and set into motion manual emergency procedures. In either case, there must be clear instructions 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 may be necessary to set two alarm levels in some cases. The lower alarm would act as a warning, that is where personnel follow procedures to determine if there is a problem and try to rectify it. The higher alarm would initiate an evacuation and plant shut down. It should be remembered that even if the plant causing the leak is shut down the ventilation system should be kept running in order to disperse the build up of flammable gas. It should be remembered that any alarm means there is a potential problem.

If a gas detector is alarming in an area that is not normally occupied the risk should be assessed before a person enters the area. It may be necessary to locate the detector panel in a separate occupied area, e.g. control room, where a gas concentration reading can be obtained. Gas detector control panels with attendant alarms can be co-located with fire detection systems but it should be noted that the actions on alarm may be very different depending on whether there is a release of gas or fire detected (e.g. in the event of a fire in a room the ventilation may be switched off to prevent fresh air supply to the fire).

8. What about 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. The initial accuracy upon commissioning will be degraded depending on the type of detector and operating conditions (e.g. dusty environment). These factors will affect the frequency of inspection, maintenance and calibration. Refer to BS EN 50073 (BSI 1999) clauses 6.4, 7 & 8 and COGDEM (1999) for more detailed information.

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 the hazard is still potentially present, e.g. the plant is not shutdown, then it will be necessary to use a replacement fixed or transportable gas detector in the area until the original detector is reinstated. 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.

Calibration of fixed gas detectors is normally done using a gas mixture from a cylinder; it is convenient and accurate. In many cases, for example petrol, 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.

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 of the other gases 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 location, 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 detector location and 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 and detector position, etc.

11. What else should be considered when installing gas detectors?

Discussions with manufacturers and users suggests that gas detectors are not perceived as reliable enough to depend upon as the sole means of explosion protection. Whether this will continue to be the case is not certain. Usually the main protection system adopted is explosion prevention through intrinsic safety and/or explosion mitigation through explosion relief.

Flammable gas detectors may form part of a complex safety related system, in such a case IEC 61508 'Functional safety of electrical/ electronic/ programmable electronic safety-related systems' may be applicable. This standard sets out a generic approach for all safety lifecycle activities for systems comprised of electrical and/or electronic and/or programmable electronic systems (E/E/PESs) that are used to perform safety functions. Low complexity E/E/PE safety related systems may be exempt from compliance with certain requirements. Expert advice is required to decide whether a gas detection system could be exempt from these requirements.

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). A list of guidance is available in **Appendix 1**. The following guidance is particularly useful and has been referenced in the text:

- 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 (2000)
Guidance note PM 84: Control of safety risks at gas turbines used for power generation. HSE, 2000.
- HSE (1987)
Industrial use of flammable gas detectors. Guidance Note CS1 (withdrawn). HSE.

Appendix 1

A1.1 List of internal HSE guidance

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.

OC 278/34 (rev) The filling and storage of aerosols with flammable propellants. para 48, paras 49-51. Safety critical interlock with machine.

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.

Offshore detector siting criterion investigation of detector spacing by Lloyds Register. Offshore Technology Report OTO 93002. HSE, 1993.

Kelsey, A., Hemingway, M. and Walsh, P. T., Evaluation of the effectiveness and optimisation of gas detector location from dispersion trial data. HSL Internal Report FM/99/10, 2000.

A1.2 List of external HSE guidance

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

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.

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 1539: 2000 Dryers and ovens in which flammable substances are released. Safety requirements.

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

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.

BS EN 50104: 1999 Electrical apparatus for the detection and measurement of oxygen. Performance requirements and test methods.

BS EN 50270: 1999 Electromagnetic compatibility. Electrical apparatus for the detection and measurement of combustible gases, toxic gases or oxygen.

BS EN 50241-1:1999 (Parts 1 & 2) Specification for open path apparatus for the detection of combustible or toxic gases and vapours.

97/200736 DC Electrical apparatus for the detection and measurement of combustible gases, toxic gases or oxygen. Requirements and tests for detectors using software and digital technologies (prEN 50271). (Current, Draft for Public Comment).

Kelsey, A., Hemingway, M. A., Walsh, P. T. and Connolly, S., Evaluation of the effectiveness of the location of flammable gas detectors from dispersion trial data. Major Hazards Offshore Conference, London 2000, p5.4.1-5.4.12. ERA, Leatherhead, 2000.

Guidelines for fire and explosion hazard management. UKOOA, May 1995. Issue 1.

Institute of Petroleum Model Code of Practice: Part 19: Fire precautions at petroleum refineries and bulk storage installations. IoP, 1993.

COP on managing fire safety in vehicle test facilities. MPI/98/145/P. British Technical Council of Motor and Petroleum Industries, Nov. 1998.

IGE/UP/5 Part 1 Commun 1558. Natural gas vehicles. Design and installation of filling stations. Institution of Gas Engineers.

LPGA Code of Practice 12. Recommendations for the safe filling of LPG cylinders at depots. Liquefied Petroleum gas Association, 1989.

LPGA Code of Practice 3. Recommendations for prevention or control of fire involving LPG. Liquefied Petroleum gas Association, 1995.

Guidelines for the application of gas detection. Energy Industries Council.

Guidelines on the monitoring of hazards in the microelectronics industry. Semiconductor Safety Association (Europe).

BCGA/CIF CP 18 The safe storage, handling and use of special gases in the microelectronics industry. British Compressed Gases Association (BCGA) and Electronics Components Industry Federation.

A guide to safety in aerosol manufacture. British Aerosol Manufacturers Association (BAMA).