Ventilation, Monitoring, Detection and Alarms

(Control Measure)

When gases are stored or used in an enclosed workspace there is a potential for the composition of the air to change, creating a hazardous atmosphere. Therefore, a risk assessment must be carried out.

There is often the temptation to readily install gas monitors and detectors because gas detectors can be used to trigger alarms if a specified concentration of the gas or vapour is exceeded. This can provide an early warning of a potential hazardous atmosphere, allowing appropriate actions to be taken and reduce or prevent any adverse event occurring.

Before installing gas monitors and detectors other, more effective, control methods should be considered. Controls that eliminate or reduce the risk of a hazardous atmosphere being created should be considered before engineering controls as part of the hierarchy of control. Examples of controls include:

- Storing the gas source outside, instead of using cylinders in the laboratory.
- Carrying out operations in discrete areas, isolated from the general workplace, where there is adequate natural ventilation.
- Distributing gas into the work area through pipework of suitable integrity, at the lowest possible pressure and at a restricted flow-rate suitable for the work task and suitable for the ventilation capability.
- Exhausts. Ensure that the exhausts from machines and pressure relief valves, vents etc. are directed to a safe area.
- Providing good workplace ventilation, to disperse released gases and minimise the extent to which they accumulate:
    - By increasing natural ventilation (for example, using additional louvres located at a suitable height).
    - Using a whole workplace forced air ventilation system.
    - Providing local exhaust ventilation systems.
    - Installing gas cabinets, for flammable or corrosive gases.

To check the mechanical ventilation and air changes in your laboratory, workshop etc. you will need to contact the Estates Helpdesk.

For further information and gas calculations see BCGA Guidance Note 11, The Management of risk when using gases in enclosed spaces.

If these control measures are not practicable or an additional level of safety is required to supplement other controls, gas detection or monitoring equipment that incorporates warning alarms both audible and visual, if possible, should be considered.

1.0 Monitoring and Detection

There are no set rules for determining when detection should be installed as previously mentioned It is an additional control measure to supplement other controls. However, there are circumstances where detection would be considered appropriate, such as:

- Where flammable and/or toxic gases are in use, particularly in circumstances where broad flammable limits exist or where a low workplace exposure limit (WEL) is assigned. In both circumstances, relatively small releases could present significant problems.
- In bulk indoor storage facilities where large quantities of asphyxiants such as liquid nitrogen is present, particularly where the storage vessels are fed by a piped system from a large external vessel.
- In areas where it is difficult to achieve decent ventilation – although in these circumstances the priority should be to either improve the ventilation or relocate the gases.

Fixed equipment is preferable to personal equipment because this protects all people in the workplace. However, it should be noted that gas detection/ monitoring alone does not provide absolute protection because the equipment can malfunction and may be unexpectedly out of calibration or be incorrectly positioned.

If the decision is made to install detectors, or you move into a lab where detectors are already installed there are a number of points that must be addressed to ensure the detectors are suitable (see New Gas Installation process):

1. **Type of gas** - The type of detector must match the gas that is to be detected. Each type of gas requires a different sensor, so it is important to know which type of gas you need to detect before making a choice. There are three main types of gases that detectors can sense: combustible, toxic and oxygen. If you have more than one type of gas you may need more than one sensor.

   Where a gas is present that presents an additional hazard e.g., flammable or toxic at concentrations lower than that which causes oxygen depletion a detector for that gas AND an oxygen depletion monitor should be used. i.e., a low oxygen sensor will not detect a carbon dioxide release before the workplace exposure limit (WEL) is exceeded.

2. **Environment** – When selecting the type of detector, you should also consider the environment i.e., the presence of dust, temperature and humidity, high magnetic fields, multiple detectors, portable equipment etc.

3. **Sensitivity** – The senor should be selected with the correct sensitivity i.e. it is important to choose a detector that is sensitive enough to detect the gas at the levels before they become harmful but not too sensitive that it gives false alarms.

   Where a sensor is intended for use with more than one gas, the ‘worst case’ should be determined, and it should be calibrated accordingly. If more than one sensor is necessary to monitor multiple gases, each sensor needs to be individually calibrated with the intended gas to be detected. Cross-sensitivity needs to be considered and fully understood.

4. **Positioning of the sensor(s)** – The sensors must be positioned so they will readily detect the release of gas. You will need to determine where the gases will originate from and accumulate to, taking into consideration the properties of the gas i.e., at high levels for gases lighted than air and at low levels for gases heavier than air. The sensors should be positioned where they are not obstructed by large items or equipment and in a position where they can be readily accessed for maintenance.

5. **Set points required** – The detectors should be suitably calibrated, and the set points programmed at the appropriate level for the gas(s) being detected. They should be set to alarm at a level low enough to ensure the health and safety of people but high enough to prevent false 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), sensitivity to other gases or vapours, or sensor drift.

   There are two options for alarms, both options will have an audible and/or visual alarm:
   i. One stage alarm to warn personnel to initiate an emergency response such as evacuation of the work area/ lab and automatic shutdown of process and/or equipment where installed.
   ii. Two stage alarm levels where:
      a. The first alarm or low-level alarm acts as a warning for personnel to take the appropriate corrective/ emergency action prior to dangerous concentrations of gas being reached.
      b. The second alarm or higher alarm to warn personnel to initiate an emergency response such as evacuation of the work area/ lab and automatic shutdown of process and/or equipment where installed.

   *Users must be able to distinguish between first and second alarm levels

   There should be clear instructions on how the panel is re-set. If it is only one alarm this should always be re-set manually by authorised personnel – normally Faculty Technical and Operations team. If it is a two-stage alarm, you will need to consider if the first alarm re-sets when conditions return to safe working levels. The second alarm should always be re-set manually as detailed above.

   Clear instructions should be provided to all workers/ students who work in the area of the type of alarm and the actions to take following an activation.

   The atmospheric monitoring equipment status must be checked for safe operation before entry to the relevant area and during occupancy.

6. **Alarm position** – Alarms should be audible and visual. They must be positioned so they can be heard and seen from both within the laboratory/ work area (occupants are aware alarm is sounding and follow procedures) and at all access points outside the laboratory/ work area so others know not to enter.

7. **Additional Alarm functionality** – Need to determine if the alarm system requires additional functionality e.g., whether an alarm activation is linked to a solenoid valve that will

automatically shut off the gas supply or linked to the building management system (BMS) to increase ventilation in the event of an activation.

8. **Alarm panel** – Best located outside the area using the gas, preferably in an area where it can be interrogated from a position of relative safety. There should be appropriate information to help identify which detector has been activated and the set point for the detector (see labelling section). There should be limited users who are trained to re-set the panel.

9. **Battery Backup –** All detectors and panels must have battery backup. This is to ensure in the event of a power outage the system is still functioning.

10. **Maintenance** – There should be a maintenance schedule in place, which should be in line with the manufacturer's guidelines. Records of inspection and maintenance must be maintained. Please contact your Faculty Technical and Operations Team and University HS&R team for more information.

11. **Training** - There should be documented written procedures, such as safe operating procedures (SOP) which incorporate your emergency procedures. Or a separate SOP and emergency procedure detailing what different alarm types and sounds mean and to take in the event of an alarm activation. All gas users and non-gas users working in the area should be trained with regular refresher training in these procedures. Procedures should also cover when and how to re-set the panel; this should be limited to authorised personnel only.

12. **Testing** – Carry out weekly tests on panel for visual and audible alarm to ensure working correctly.

In certain circumstances there may be a requirement to use portable gas monitors either because of the nature of the activity or it is not practicable for fixed installation. In this instance you should consider the following:

1. Any warning given is for the person wearing it and only provides a warning once the gas enters the vicinity of the monitor rather than a potential leak which may be some distance away.
2. The equipment should be either maintained or within manufacturers specified use within dates (some models have a fixed lifetime and do not require maintenance).
3. The equipment is checked before use to ensure there is no damage and there is adequate battery life to complete the task.

2.0 Oxygen Detection

The normal concentration of oxygen in the atmosphere is approximately 21%. Oxygen levels can be dangerous if they are too high (oxygen enrichment) or too low (oxygen depletion). Normally oxygen monitors will alert to both enrichment and depletion.

3.0 Oxygen Depletion

Oxygen depletion can quickly lead to oxygen starvation, which can in turn impair the mental and physical ability of an individual and therefore increase the likelihood of accident or injury. Additionally, significantly lower levels of oxygen 12.5% and lower can rapidly induce unconsciousness and can potentially be fatal.

Oxygen depletion monitors are commonly used in research and teaching laboratories where inert or other asphyxiating gases are present such as nitrogen, helium, and argon or in confined spaces or where significant amounts of carbon dioxide are in use. They are recommended for use where the risk assessment has determined there is a risk that the volume of oxygen may fall below 19.5% volume. However, as previously mentioned where there is a risk carbon dioxide can displace oxygen, the work exposure limit (WEL) for carbon dioxide would be exceeded before the oxygen depletion monitor would detect the drop and therefore in this instance a carbon dioxide monitor should be installed alongside an oxygen depletion monitor.

4.0 Oxygen Enrichment

Increased levels of oxygen can dramatically increase the flammability of combustible materials. If oxygen levels exceed 24% volume, even the materials such as clothing which may normally smoulder may burst into flames.

Oxygen enrichment exists where pure oxygen is stored. Oxygen sensors should always be used where oxygen is stored/ used.

24%	• Increased Fire risk
19.5% - 23.5%	• Normal / Safe Oxygen levels
19% - 16%	• Inceased breathing, heart rate, imparied co-ordination and thinking
16% - 12%	• Increased breathing, accelerated heartrate, impaired attention, thinking and co-ordination
14% -10%	• Faulty judgement, intermittent respiration, exhaustion.
10% - 6%	• nausea, vomiting, lethargic movement, unconscious.
<6%	• Death

5.0 Combustible

If you are using gases in an area where an explosive atmosphere may occur, a Dangerous Substance and Explosive Regulations (DSEAR) assessment should be carried out. Please contact the HS&R Team.

The flammable range of a gas or gas mixture is defined as the range of concentrations of the gas in air which will propagate flame. The severity of an explosion caused by the ignition of flammable gas, air or other oxidant mixture depends on several factors including the quantity and extent of enclosure or confinement of the gas(s).

There is an upper and lower limit defined for each gas or homogenous gas mixture. The lower flammability limit (LFL) or lower explosion limit (LEL) and upper flammability limit (UFL) or upper explosion Limit (UEL) can be found in the supplier safety data sheet. The limits may vary considerably with pressure and the nature and content of other gases in the mixture.

In general, for a first alarm or low-level alarm to detect leaks it should be set as low as practicable, but preferably no higher than 10% of the LEL. The second alarm or high-level alarm should be no more than 25% of the LEL.

For further information please see

- HSE selection and uses of flammable gas detectors
- Dangerous Substances and Explosive Atmospheres Regulations 2002. Approved Code of Practice and guidance L 138
- BS EN ISO 101456, Gases, and gas mixtures – Determination of fire potential and oxidising ability for the selection of cylinder valve outlets.

6.0 Toxic/ Corrosive

The presence of toxic gases at high levels can present several health and safety risks such as fire, explosions and if users are exposed can lead to illness and can sometimes be fatal. Some toxic gases have a distinct smell such as ammonia, whereas other have no smell such as carbon monoxide.

As previously mentioned, there are specific toxic gas detectors available to help monitoring potential leakage areas for harmful gas levels.

7.0 Labelling

The labelling at the gas panel should include:

- A plan of where the detectors are located.
- A record of the detector number, type and set point.

One Alarm System

Detector Number	Detector Type	Set point %

Two Alarm system

Detector Number	Detector Type	Set point %	
		Lower Alarm	Higher Action

8.0 Detectors

The detector in the lab should also be labelled with the type of sensor, e.g.

Oxygen Depletion Detector

Oxygen Enrichment Detector

Carbon Dioxide Detector

9.0 Door Signs

Example door sign shown below:

Do not enter if the alarm is sounding.
Oxygen depletion/ gas alarm

10.0 Additional Information

References (available to download from https://bcga.co.uk/publications/):

- BCGA GN11 - The management of risk when using gases in enclosed workspaces.
- BCGA CP18 - The safe storage, handling, and use of special gases (e.g. toxic, corrosive, flammable and pyrophoric gases).
- BGCA CP44 - The storage of gas cylinders.
- BCGA CP47 - The safe use of individual portable or mobile cylinder gas supply equipment.

Other

- Dangerous Substances and Explosive Atmospheres Regulations 2002 Approved Code of Practice and guidance L138 https://www.hse.gov.uk/pubns/books/l138.htm