

## Safety Services Guidance



**Siting of oxygen depletion monitors for use with inert gases and siting of carbon dioxide monitors for use with carbon dioxide.**

Key word(s) : Oxygen depletion, carbon dioxide, oxygen depletion monitoring

Target audience : PIs, safety advisors, laboratory staff

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## Introduction

1. Oxygen depletion monitors are frequently installed in areas where inert gases are used. Although the gases are inert and non-toxic in themselves they act as asphyxiants by displacing the oxygen in the air causing oxygen depletion.
2. Carbon dioxide is a toxic gas and monitors are often installed where carbon dioxide gas cylinders are used or stored.
3. There is no specific guidance on the siting of gas detectors, but they should be sited in accordance with suppliers' instructions or advice, and close to the source of the hazard. The need and location for gas detectors should be made on the basis of a risk assessment, including the expansion calculation where applicable, and be formally recorded. For each and every situation however, the supplier/installer should be asked to confirm that the device is suitable for the circumstances and give a recommendation (in writing) about the mounting position.
4. **Gas detection systems are not safety devices. They provide a warning that a pre-selected concentration of gas has been reached. Contingency plans in the event of them sounding must be drawn up as part of the risk assessment.**
5. Having decided on the need for detectors, the appropriate mounting height and position needs to be decided. As a general rule, for gases lighter than air e.g. helium, the detectors should be sited above the area where the leak or spillage may occur and for those heavier than air e.g. carbon dioxide, the detectors should be nearer floor level or in ducts where heavy gas may accumulate. Gases do not separate out into discrete layers according to their densities. If they did, air would not exist as a homogenous mixture. The nearer in density to air a gas is, the more easily it will flow with air due to draughts and ventilation.

## Who is at risk?

6. All those in the vicinity in the event of an accidental release or leak.

## Oxygen Depletion Monitors

7. Oxygen depletion detectors for use in areas where liquid nitrogen storage vessels are stored and used should be sited approximately 1 metre above the floor. If they are sited lower, when the transfer from the top-up vessel to the storage vessel occurs, the alarms will sound frequently. When liquid nitrogen, which is only slightly lighter than air is released from a storage vessel the cold temperature increases the density so it initially falls to the floor. As the gas

warms, expands and displaces the oxygen, it rises. If detectors are sited higher than 1 metre above floor level, there is less time for any person in the vicinity to respond to an emergency before depleted air reaches the average person's breathing zone.

### Effects of Oxygen Depletion

8. The following table summarises the effects of oxygen depletion. Below 11% there is a risk of death if the person is not resuscitated immediately.

11-14%	Reduced physical and intellectual performance without person's knowledge. Decision-making is compromised.
8-11%	Possibility of fainting after a short period without prior warning
6-8%	Fainting within a few minutes, resuscitation possible if carried out immediately
0-6%	Fainting almost immediate, death ensues, brain damage even if rescued

9. Symptoms of the possible onset of asphyxia can include:

- Rapid and gasping breath
- Rapid fatigue
- Nausea
- Vomiting
- Collapse or inability to move
- Unusual behaviour

### Carbon Dioxide Monitors

10. Carbon dioxide is toxic and can also act as an asphyxiant by displacing oxygen from the air. The workplace exposure limits are 5000ppm long-term exposure limit (8 hour TWA reference period) and 15000ppm short-term limit <sup>1</sup> (15 minute reference period) which correspond to 0.5% and 1.5 % in air respectively. Normal air contains 0.033 % carbon dioxide and 20.9% oxygen.

11. There is not a convenient relationship between oxygen deficiency and carbon dioxide enrichment. When the carbon dioxide level is 0.5 %, the concentration of oxygen resulting from displacement of air by carbon dioxide alone will be 20.8% and when the carbon dioxide level is 1.5 % the oxygen level will be 20.5%. At a

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<sup>1</sup> <http://www.hse.gov.uk/pubns/priced/eh40.pdf>

concentration of 9.1% carbon dioxide, the oxygen level would fall to 19% which would activate the oxygen depletion alarm, typically set at 19.5%.

12. However, as can be seen from the table below the effects of carbon dioxide would be evident before there was significant oxygen depletion. It is therefore recommended that carbon dioxide monitors are fitted in areas where carbon dioxide is stored and used. Oxygen monitors are **not necessary** in these areas **unless** other asphyxiant gases are also stored in the area.

### Effects of Carbon Dioxide Enrichment

1%	Slight, possible increase in breathing rate
2%	Breathing becomes deeper-50% above normal
3%	Breathing becomes laboured-100% above normal Hearing ability reduces Headaches Increase blood pressure and pulse rate
4-5%	As for 3% but after 30 minutes exposure signs of poisoning will be evident with a choking sensation
5-10%	Characteristic pungent smell noticeable Breathing heavily laboured, leading to physical exhaustion Headaches Visual disturbances Ringing in the ears Loss of consciousness within minutes
Over 10%	Loss of consciousness more rapid with risk of death from respiratory arrest. Concentrations > 20% are immediately hazardous to life

### Selection, Installation and Maintenance

13. Monitors may be mains or battery powered. Battery powered ones are easier to move should the area for storage need to change, but batteries will need checking and replacing on a regular basis. The requirements and preferences should be discussed with the provider and the project manager (if appropriate).
14. The gas sensor in a monitor will have a limited lifespan and will need replacing/calibrating at regular intervals. Depending on model, this might be as short as 6 months. Therefore sensors must also be sited in a location accessible for testing and maintenance.
15. Consideration should be given to whether the monitor signal should also be seen/heard from a location remote from the sensor, e.g. a repeater panel on a corridor away from the area being monitored.

16. When selecting a sensor thought should be given to whether there is any cross-sensitivity to other gases present.
17. Once installed the systems should be maintained according to the manufacturer's recommendations, and it is essential that the user manual is obtained from the suppliers or installers. Sensor replacement and equipment maintenance and monitoring will normally be the responsibility of the user group or school.

## Management

18. It is essential to document the reasons for the decision on which gas detectors are fitted and the system(s) must be periodically inspected to ensure that they remain appropriate in the light of any changes to the position and size of storage vessels used.
19. If additional storage vessels are introduced to an area, the risk assessment and the need for sensors must be reviewed. This is particularly important if a decision not to install sensors was based on a worst case scenario of release from the largest, original storage vessel.

### Example:

A lab of dimensions 12x12x3 (m) has a volume 432 m<sup>3</sup> and contains a liquid nitrogen storage dewar of 25L. In the event of a total accidental release the oxygen level would fall to 20.0 % on average and an oxygen depletion alarm would not be required. If someone then replaced the 25l dewar with a 160L dewar a further calculation would be needed. The 160L dewar would reduce the oxygen level to 15.5 % in the event of a total release and oxygen depletion monitors would be required.

Please note: The calculations make critical assumptions about mixing, i.e. that it is perfect and instantaneous, and that there are no removal mechanisms through natural or forced ventilation. Whilst the first two conditions may be approached over time, they will not be true immediately following a release, and risk assessments must ensure that staff and others are informed about the risk and what to do if they are present and observe containment loss. Pockets of high concentrations of gas or low concentrations of oxygen may well exist

## Legal requirements

20. Use of asphyxiant gases involves substances that are potentially hazardous to health therefore a COSHH assessment is required. A risk assessment is also needed for the hazardous properties not included under COSHH, e.g. low temperature and high pressure, flammability or explosivity. This should identify

measures to ensure that exposure is prevented or where this is not reasonably practicable, adequately controlled.

## Bibliography

[Inert Gas risks – Oxygen deficiency](#) BOC website (2014)

Reduced Oxygen Atmospheres: The management of risk associated with reduced oxygen atmospheres resulting from the use of gases in the workplace. BCGA Guidance Note 11, Rev3: 2012 available free from the University Library OHSIS database, or via <http://www.bcgga.co.uk/pages/index.cfm>

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