# Controlling the risks of inert gases

BOC GASES

# Foreword

The European Industrial Gases Association publishes many documents on the safe use of industrial gases and this leaflet is based on upon its publication IGC Document No. 8/76 entitled “Prevention of Accidents Arising from the Enrichment or Deficiency of the Oxygen in the Atmosphere”. This EIGA publication has subsequently been withdrawn, but the information contained in this extract is still a very useful summary for practising managers and engineers controlling operations involving inert gases.

Those people who have a special responsibility for safety or who are engaged in teaching or training others in the use of inert gases should study the more comprehensive treatment of this subject contained in IGC Document No. 44/90/E “The Hazards of Inert Gases”. A listing of IGC documents and where to purchase them are given in Appendix 3 of the BOC Gases publication “Safe Under Pressure”.

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# 1. Introduction

Oxygen deficiency can arise when using gases like nitrogen, carbon dioxide and argon unless good practice is observed.

This booklet specifies the dangers and the simple precautions to be taken to ensure that every user employs these gases with confidence and without danger.

### 1.1 Composition and behaviour of air

The approximate volumetric composition of air is:

| | | |
|---|---|---|
| Oxygen | $0_2$ | 21% |
| Nitrogen | $N_2$ | 78% |
| Argon | Ar | 1% |

The atmospheric gases are non-toxic, but alterations in their concentrations - especially that of oxygen - have an effect upon life and combustion processes. It is essential to have sufficient oxygen in atmospheres being breathed.

Although not itself flammable oxygen does support combustion whereas nitrogen and argon inhibit combustion.

If good practice is not observed accidents may happen because changes in concentration cannot be detected in good time by the human senses.

When these gases are in the liquid state, it is necessary to bear in mind the very low temperature involved (less than -180°C at atmospheric pressure). They can rapidly cause cold burns and make certain materials sufficiently brittle to lead to structural failure.

# 2. Hazards from oxygen deficiency

Oxygen is essential to life, and it is therefore vital to ensure that adequate oxygen is present in any atmosphere being breathed.

While a healthy person may survive a short exposure to an oxygen content as low as about 16%, no one should ever be asked to endanger his life by breathing such an atmosphere.

An insidious feature of oxygen deficiency is that it cannot readily be detected by the senses, and victims are usually unaware of the danger they are in and may even have a feeling of well-being.

### 2.1 Symptoms

Human beings vary considerably in their reactions to oxygen deficiency, and it is therefore not possible to lay down hard and fast rules. A general indication of what is liable to happen is given in the table below, but it should be appreciated that the reactions of some individuals may be very different from those shown, and may be increased by the presence of other gases, especially carbon dioxide.

| **Oxygen content (vol %)** | **Effects and symptoms (at atmospheric pressure)** |
|---|---|
| 11-16 | Diminution of physical and intellectual performance without the person being aware |
| 8-11 | Possibility of fainting without prior warning |
| 6-8 | Fainting within a few minutes, resuscitation possible if carried out immediately |
| 0-6 | Fainting almost immediate |

Below 11% oxygen there is a risk of death due to asphyxia unless the person is resuscitated immediately

**In general, oxygen deficiency can lead to:**

— loss of mental alertness
— distortion of judgement
— brain damage (after a relatively short time)

# 3. Causes and avoidance of oxygen deficiency

Oxygen deficiency of the atmosphere is best guarded against by careful attention to the following points:

### 3.1 Leakage of gases other than oxygen

This leads automatically to oxygen deficiency. Newly assembled equipment which uses inert or any other gas should be thoroughly leak checked by a timed gas pressure drop test, supplemented by soap and water tests or other equivalent methods as necessary. Periodic retests are recommended.

All equipment, for instance piping and hose connections, should be properly fitted. Hoses and other equipment should be kept leak-tight and be protected from damage. All maintenance and repair work should be carried out by experienced and fully skilled personnel.

When the work period is over, the cylinder valve or piped supply stop valve must be turned off, in order to avoid possible leakage in the time between the end of one working period and the beginning of the next. The valves on welding equipment should not be relied upon for turning off the gas supply. Gas cylinders in use should be protected against knocks or pulling over.

### 3.2 Spillage of liquid gases

A small amount of liquid can lead to the formation of a large amount of gas. Consequently, liquid spillage can rapidly cause oxygen deficiency in confined spaces, pits etc.

Tanks and equipment for the storage and handling of liquid gases should be inspected carefully and maintained in accordance with the relevant regulations or recommendations.

### 3. 3 Vent outlets

Vented gases are often deficient in oxygen, and work should not be carried out in such atmospheres.

### 3.4 Purging and cryogenic processes

Oxygen deficiency will arise when preparing plant items such as vessels for repair by purging with nitrogen or other inert gases.

Processes such as food cooling, ground freezing, cryogenic surgery and blood plasma preservation, in which the vaporisation of liquid nitrogen is involved, lead automatically to oxygen deficient atmospheres. People should not enter such areas, even if the atmosphere is only slightly deficient in oxygen, unless adequate breathing equipment is used.

### 3.5 Welding and heating processes

All gas welding and heating processes involve taking oxygen from the air and can lead to a deficiency unless the volume of workspaces and their ventilation is sufficient.

### 3.6 Removal of argon, carbon dioxide and cold gas

Removal of argon, carbon dioxide or cold gas from large vessels and deep pits can be difficult due to the relatively high density of the gas compared with air. The fact that air introduced into the bottom of such spaces tends to float up through the dense gas without displacing it presents a special problem in that purging is liable to take much longer than expected.

## 4. Detection of oxygen enrichment or deficiency

### 4.1 Measuring instruments

The equipment must be easy to handle and offer a high degree of reliability of operation. BOC can advise on the suitability of actual instruments.

These indicate increases and decreases in the oxygen concentration of the ambient atmosphere and have a measuring range from 0 to 40% by volume of oxygen.

Various measuring techniques giving visible and/or audible warnings are in use, the important difference being whether they are suitable for continuous or discontinuous measurement.

When working in rooms where the oxygen content can change to a dangerous extent during the working time, continuous measuring methods must be used.

Discontinuous measuring methods may be used only if the time between two measurements is such that the tendency for dangerous change of oxygen can be detected quickly enough.

#### 4.1.1 Accuracy

The accuracy of the measuring method should be such that, when indicated 21%, the real value is between 19.5% and 22.5%.

#### 4.1.2 Using the measuring instruments

The directions of the manufacturers for the use and maintenance of the measuring instruments should be carefully observed.

The measuring instrument should be located as near as possible to the worker, in confined spaces. In confined spaces, it is recommended that the worker has a portable measuring instrument attached to his working clothes, giving an audible and/or visual alarm if the oxygen content of the atmosphere deviates more than 2% from that of normal air.

### 4.2 Other gases

The safety of a space does not depend on oxygen content alone, but can be affected by other gases such as fuel gases. These should be analysed as necessary.

# 5. Preventive measures

## 5.1 General considerations

Apparatus used for the manufacture, distribution and utilisation of inert gases must be installed and identified in accordance with the recommendations of the industrial gas industry, and must comply with whatever regulations are applicable.

Any leak must be dealt with by people who have been adequately trained and who have the proper equipment.

Information should be provided on actions to be taken by personnel and first aiders in the event of an incident.

Operating personnel must at all times obey works rules and regulations and, where called for, protective equipment must be worn.

## 5.2 Breathing equipment

### 5.2.1 Application

Appropriate breathing equipment is essential in situations where oxygen deficiency can arise and on no account should rescue be attempted without proper equipment and adequate training in its use.

Breathing equipment is not required for oxygen rich situations.

### 5.2.2 Types of equipment

Absorbent types of respirator give no assistance whatsoever in an oxygen deficient atmosphere.

**Recommended types of breathing equipment are:**

— Self-contained breathing apparatus using air cylinders. When wearing this apparatus, it may be difficult to enter manholes.
— Fresh air masks where the respirator is connected via a tube of adequate length and diameter to clean compressed air supply or to a region where the atmosphere is of satisfactory composition to support life.

## 5.3 Double manning

Where personnel have to work in confined spaces such as vessels which may become subject to atmospheric oxygen enrichment or deficiency, a watcher must be stationed immediately outside the confined space entrance. The watcher should hold the rope of a rescue harness attached to the person working in the confined space and should, if necessary, have a winch available.

## 5.4 Analysis

Before people enter a space which may be subject to oxygen enrichment or deficiency, the atmosphere should be analysed for oxygen. Free entrance is permissible only if the oxygen concentration is between 20 and 22%. However, if there is any possibility of a change in concentration, anyone entering such a space shall be issued with a personal continuous oxygen measuring device giving an audible alarm when the oxygen concentration in the atmosphere varies outside the safe limits.

## 5.5 Information and training

All people who work in spaces where oxygen deficiency or enrichment can occur should be given adequate instructions as to the risks involved, special attention being drawn to the insidious nature of the risks due to the rapidity of their effects coupled with the fact that an operator may be completely unaware of the potential danger he is exposed to.

Practical training should be given in the means by which such risks can be minimised.

## 5.6 Blanking and ventilation

Any vessel which is connected to a gas source other than air containing 21% oxygen must be disconnected from such a source by the removal of a section of pipe, by the use of a spectacle plate or by inserting blanking spades and the space should be thoroughly ventilated so as to maintain a normal atmosphere before and during entry. Reliance on the closure of valves to prevent oxygen enrichment or deficiency is not sufficient. Permission to enter such a space may be given only after the issue of a permit certificate signed by a responsible person.

# 6. Steps to be taken in case of accidents due to oxygen deficiency

Remove the patient to the open air without delay and keep him warm. Administer oxygen from an automatic resuscitator, if available, or supply artificial respiration by an approved method. Summon medical assistance and continue treatment until the patient revives or a doctor advises stopping.

Ensure that all rescue personnel have adequate supplies of oxygen or air from self-contained breathing apparatus or a fresh air line.

## 7. Entry into confined spaces

Guidance is given in the HSE Approved Code of Practice called 'Safe work in confined spaces' L101(ISBN 0-7176-1405-0) available from HSE Books, cost £7.50. It also contains the Confined Space Regulations 1997.

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