



HAZARDS OF OXYGEN- DEFICIENT ATMOSPHERES

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As part of a programme of harmonization of industry standards, the European Industrial Gases Association (EIGA) has issued EIGA Doc 44, *Hazards of oxygen-deficient atmospheres*, jointly produced by members of the International Harmonization Council.

This publication is intended as an international harmonized publication for the worldwide use and application by all members of Asia Industrial Gases Association (AIGA), Compressed Gas Association (CGA), European Industrial Gases Association, and the Japan Industrial and Medical Gases Association (JIMGA). Regional editions have the same technical content as the EIGA edition, however, there are editorial changes primarily in formatting, units used and spelling. Regional regulatory requirements are those that apply to Europe.

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1 Introduction

The industrial gas industry is very concerned about the incidents that industrial gas companies and users of inert gases continue to report each year, where the direct cause has been lack of oxygen resulting in asphyxiation.

There are two essential points to remember related to oxygen-deficiency incidents involving inert gases:

- Incidents resulting from oxygen deficiency due to inert gases happen unexpectedly and the reactions of personnel can be incorrect; and
- Incidents involving asphyxiating atmospheres are always serious, if not fatal.

2 Scope and purpose

This publication sets out the essential information necessary to prevent asphyxiation incidents involving inert gases.

It is not a detailed procedure for confined space entry but focuses on the considerations that are important when there is an actual or potential hazard from inert gases or oxygen deficiency.

The minimum safe oxygen concentration for entry into a space is 19.5% oxygen. There are applications with oxygen concentrations less than 19,5% where entry is permitted provided that further precautions are taken in accordance with proper risk assessment and national regulations.

This publication is intended for supervisors, line managers, direct workers and users wherever inert gases are produced, stored, used, or where oxygen depletion could otherwise occur.

Appendix A is a simplified summary of the main publication.

Appendix B lists some actual incidents that have taken place in recent years and may be used as examples to underline the potentially fatal hazards of inert gases.

Other hazards exist with oxygen-enriched atmospheres greater than 23.5% oxygen. When presented with an oxygen-enriched atmosphere, see EIGA Doc 04, *Fire Hazards of Oxygen and Oxygen Enriched Atmospheres*, for more information [1].

Although carbon dioxide is not an inert gas, most of the information in this publication is applicable as it too will cause oxygen depletion. This publication does not cover the specific hazards and physiological effects of carbon dioxide, see EIGA [Safety Information 24, Carbon Dioxide Physiological Hazards – "Not just an Asphyxiant!"](#) or CGA G-6, *Carbon Dioxide*, for more details about the additional hazards of carbon dioxide [2, 3].

3 Definitions

For the purpose of this publication, the following definitions apply.

3.1 Publication terminology

3.1.1 Shall

Indicates that the procedure is mandatory. It is used wherever the criterion for conformance to specific recommendations allows no deviation.

3.1.2 Should

Indicates that a procedure is recommended.

3.1.3 May

Indicates that the procedure is optional.

3.1.4 Will

Is used only to indicate the future, not a degree of requirement.

3.1.5 Can

Indicates a possibility or ability.

3.2 Technical definitions

3.2.1 Anoxia

Abnormally low amount of oxygen in body tissues.

3.2.2 Asphyxiant

Material that reduces the amount of available oxygen either by simple dilution or by reaction.

3.2.3 Asphyxiation

Effect on the body of inadequate oxygen, usually resulting in loss of consciousness and/or death.

3.2.4 Confined space

Area not necessarily designed for people, that has limited or restricted means for entry or exit, and is not designed for continuous occupancy but which is large enough for workers to enter and perform certain jobs [4].

NOTE—Confined spaces include, but are not limited to, tanks, vessels, silos, storage bins, hoppers, vaults, pits, manholes, tunnels, equipment housings, ductwork, pipelines, etc.

3.2.5 Enclosure

Any type of architecture (for example, building, shed, bungalow) composed of five walls (one roof and four walls) allows workers to enter and perform certain jobs occasionally or permanently.

NOTE—An enclosure is also known as an enclosed space.

3.2.6 Flammable gas

Gas having a flammable range in air at 20 °C and a standard pressure of 101.3 kPa.

3.2.7 Inert gas

Gas that is not toxic, doesn't support human breathing, and reacts scarcely or not at all with other substances.

3.2.8 Partially enclosed

Any type of architecture composed of three or four walls (including a roof) that allows workers to enter and perform certain jobs occasionally or permanently.

3.2.9 User

Individuals, companies, or other organisations that make use of the products sold by industrial gas companies.

NOTE—Users can be, but are not necessarily, customers.

4 General information about inert gases and oxygen depletion

In spite of the wealth of information available such as booklets, films, and audio-visual aids, there are still serious incidents resulting in asphyxiation caused by the improper use of inert gases or by oxygen depletion. It is therefore essential to draw attention to the hazards of inert gases and oxygen depletion.

4.1 Oxygen is essential for life

Oxygen is the only gas that supports life. The normal concentration of oxygen in the atmosphere is approximately 21%. The ability to concentrate, think, and make decisions is impaired when the oxygen concentration falls only slightly below atmospheric levels. These effects are not noticeable to the affected individual.

If the oxygen concentration in air decreases or if the concentration of any other gases increase, a situation is rapidly reached where the risks of asphyxiation are significant. For this reason, any depletion of oxygen below 19,5% shall be treated with concern.

An oxygen-deficient atmosphere can bring about unconsciousness without warning. In as little as one or two breaths, an individual's life can be endangered by low oxygen intake. Table 1 describes a quantitative evaluation of the health effects and symptoms that can be expected in humans who inhale air containing less than normal levels of oxygen.

4.2 Inert gases give no warning

It is essential to understand that with inert gases, asphyxia can occur with no warning.

Inert gases are odourless, colourless, and tasteless. They are undetectable and can therefore be a great deal more dangerous than toxic gases such as chlorine, ammonia, or hydrogen sulfide, which can be detected by their odour at very low concentrations.

The asphyxiating effect of inert gases occurs without any preliminary physiological sign that could alert the victim. Lack of oxygen can cause vertigo, headache or speech difficulties, but the victim is not capable of recognising these symptoms as asphyxiation. Asphyxiation leads rapidly to loss of consciousness—for very low oxygen concentrations this can occur within seconds.

Table 1—Effects at various oxygen breathing levels

Oxygen percent at sea level (atmospheric pressure = 760 mmHg)	Effects
20.9	Normal (below 19.5% is considered oxygen deficient)
19.5 – 10	Increased breathing rates; accelerated heartbeat; and impaired attention, thinking, and coordination
10 – 6	Nausea, vomiting, lethargic movements, and perhaps unconsciousness
<6	Convulsions, then cessation of breathing, followed by cardiac standstill (death). These symptoms can occur immediately.
NOTES - Adapted from Title 29 of the U.S. <i>Code of Federal Regulations</i>, Parts 1910 and 1926 [4]. - These indications are for a healthy average person at rest. Factors such as individual health (being a smoker), degree of physical exertion, and high altitudes can affect these symptoms and the oxygen levels at which they occur. - A hazardous atmosphere oxygen concentration range as defined by OSHA is outside the range of 19,5% and 23,5% [4]. - While the percentage of oxygen does not change with altitude, the partial pressure of the atmosphere decreases, which creates physiological effects similar to oxygen deficiency. These effects increase at higher altitudes. Working at altitudes above 2 438 m (8 000 ft) can have similar effects to working in a 15% oxygen atmosphere and working at altitudes of 4 267 m (14 000 ft) can have effects similar to a 12% oxygen atmosphere. Precautions such as supplemental oxygen and acclimatisation shall be taken when working at altitudes to protect the employees against the effects of altitude sickness and other physiological effects similar to those experienced with decreasing oxygen concentrations. Consult knowledgeable medical and safety professionals regarding the specific precautions to take when working at high altitudes.	

WARNING: Exposure to atmospheres containing less than 10% oxygen can rapidly overcome an individual and bring about unconsciousness without warning so the individual cannot help or protect themselves. Lack of sufficient oxygen can cause serious injury or death.

4.3 Inert gases act quickly

In any incident when the supply of oxygen to the brain is affected, prompt emergency treatment is critical. Medical treatment such as resuscitation if given promptly can prevent irreversible brain damage or even death in some circumstances.

An emergency rescue procedure shall be planned in advance to avoid the possibility of the rescue team becoming victims also. Unplanned interventions resulting in the fatalities of would-be rescuers have occurred on multiple occasions.

Workers suddenly involved in emergency activities shall not allow emotions to override safe work procedures and training. Only qualified and trained personnel equipped with the necessary personal protective equipment (PPE) should attempt a rescue in accordance with the company's rescue procedures.

4.4 The ambiguity of inert gases

An inert gas is often thought to be a harmless gas. Individuals shall be aware of the ambiguity of the expression "inert gas," sometimes called "safety gas," when it is used to prevent fire or explosion. An inert gas can be applied as a safety gas, but it is not without its own risks (such as asphyxiation).

4.5 Awareness with regard to inert gases and oxygen depletion

Considering the hazards of inert gases, it is essential to provide all those who handle or use inert gases with the information and training necessary regarding safety instructions. This includes the means of prevention and procedures to be followed to avoid incidents, as well as planned rescue procedures to be implemented in the event of an incident.