Safety advice.

Oxygen deficiency.

Properties

Oxygen is essential for life, without sufficient oxygen we cannot live. Air normally contains approximately 21% oxygen.

Asphyxiation is the effect on the body of inadequate oxygen, usually resulting in loss of consciousness and/or death. This is also known as suffocation or anoxia. Any material which reduces the amount of available oxygen either by simple dilution or by reaction is called asphyxiant. This includes the so-called inert gases; an inert gas is not toxic, does not support human breathing and reacts little or not at all with other substances. The common inert gases are nitrogen and rare gases like helium, argon, neon, xenon and krypton.

When the natural composition of air is changed, human beings will be affected or even severely impaired and death may result.

If gases other than oxygen are added or mixed with air, the oxygen concentration is reduced (diluted) and oxygen deficiency occurs.

No human sense will give an indication of oxygen-reduced atmosphere.

The minimum safe oxygen concentration for entry into a space that is being controlled or measured because of the risk is 19.5% total O₂.
Hazards

The normal concentration of oxygen in air is approximately 21%. It only takes a relatively small depletion to create an oxygen deficient atmosphere that will affect people. In any oxygen deficient atmosphere there is the risk of asphyxiation.

<table>
<thead>
<tr>
<th>Oxygen (Vol %)*</th>
<th>Effects and Symptoms</th>
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<tbody>
<tr>
<td>18–21 %</td>
<td>No discernible symptoms can be detected by the individual</td>
</tr>
<tr>
<td>11–18 %</td>
<td>Reduction of physical and intellectual performance without the sufferer being aware</td>
</tr>
<tr>
<td>8–11 %</td>
<td>Possibility of fainting within a few minutes without prior warning. <strong>Risk of death below 11 %</strong>.</td>
</tr>
<tr>
<td>6–8 %</td>
<td>Fainting occurs after a short time. Resuscitation possible if carried out immediately</td>
</tr>
<tr>
<td>0–6 %</td>
<td>Fainting almost immediate. Brain damage, even if rescued. With no oxygen present, inhalation of only 1–2 breaths of nitrogen or other inert gas will cause sudden loss of consciousness and can lead to death.</td>
</tr>
</tbody>
</table>

The values in the table are valid for healthy persons, not those with respiratory diseases.

Exposure to air containing 11% or less oxygen will bring about unconsciousness without warning and so quickly that a person cannot help or protect themselves. Lack of sufficient oxygen may cause serious injury or death.

**Causes of oxygen deficiency.**

a) When liquefied gases (such as liquid nitrogen, liquid argon, or liquid helium) evaporate, one litre of liquid produces approximately 600 to 850 litres of gas. These large volumes of gas can very quickly lead to oxygen deficiency unless there is adequate ventilation.

b) In the event of gases other than oxygen leaking out of pipe work, cylinders, vessels, etc., oxygen deficiency must always be expected. Checks should be made periodically for possible leaks. Spaces with limited or inadequate ventilation (e.g. vessels) must not be entered unless air analysis has been made, safe working conditions are confirmed and a work permit has been issued.

c) If work has to be carried out in the vicinity of ventilation openings, vent pipes or a vessel man way for example, personnel must be prepared to encounter gases with a low oxygen concentration or without oxygen at all, being discharged from these openings.

d) Oxygen deficiency will always arise when plant and vessels are purged with nitrogen or any other inert gases.

e) When the consumption of oxygen occurs in confined spaces e.g. due to hot works using naked flames.

f) In cutting and welding applications such as laser cutting, nitrogen may be released in large amounts.
Precautions

Detection of oxygen deficiency
Human senses cannot detect oxygen deficiency until it is too late i.e. death.
Monitoring or measuring instruments must be used if an oxygen-deficient atmosphere is suspected. They give an audible or visual alarm of the oxygen concentration and can indicate the oxygen content. Portable or personnel instruments should always be tested in the open air before use; instruments should always be within calibration. Typically, the instruments will alarm at 19% oxygen in air. If the presence of carbon dioxide, toxic or flammable gases is possible, specific instruments must be used.

A reduction of the oxygen content in the atmosphere is not an effective indication of the presence of other gases or vice versa. As an example, it is possible to have a low oxygen content of 18% and a high carbon dioxide content of 14% which is very dangerous due to the toxic effect of CO₂ rather than the lack of oxygen. See the Safety Advice about Carbon dioxide.

Breathing equipment
Breathing equipment must be used in situations where oxygen deficiency is expected and which cannot be remedied by adequate ventilation. Cartridge gas masks necessary for use in the presence of toxic gases (such as ammonia, chlorine, etc.) are useless for this purpose, as they filter out chemicals in the atmosphere, and do not add oxygen.

Recommended types of breathing equipment are:
• Self-contained breathing apparatus using compressed air cylinders;
• Full-face masks with the respirator connected through a hose to a fresh air supply;
• Chemical oxygen generators.

Note:
• When wearing these types of equipment particularly with air filled cylinders, it might sometimes be difficult to enter manholes
• Periodic inspection of the correct functioning of the equipment must be carried out in accordance with local regulations
• Users must be trained and must practice handling the equipment regularly

Confined spaces
For any entry or work in a confined space, a particular risk assessment must be carried out and a permit to work used to ensure a safe working environment. As a guide, the following details are some of the precautions that may be taken to ensure a safe entry to a confined space; the actual details required to provide a safe system of work will depend on the particular risk assessment.

Any vessel or confined space where oxygen deficiency is expected and which is connected to a gas source must be disconnected from such a source:
• by the removal of a section of pipe; or
• by inserting a blanking plate before and during the entry period.

Reliance on the closure of valves alone might be fatal.

A space or vessel should be thoroughly ventilated, and the oxygen content should be measured periodically before and during the entry period. If the atmosphere in such a vessel or space is not breathable, a qualified person must use breathing equipment. Permission to enter such a space must be given only after the issue of an entry permit signed by a responsible person. As long as a person is in a vessel or confined space, a watcher must be present and stationed immediately outside of the confined entrance. He must have a self-contained breathing apparatus readily available. The person inside the confined space to facilitate rescue must wear a harness and rope. A hoist may be necessary to lift an incapacitated person. The duties of the watcher should be clearly defined.

Emergency
Never try to enter a confined space to rescue an unconscious person.
The risk is that the rescuer will become the second victim, which obviously must be avoided by all means. Ideally, he should raise an alarm and call for assistance so that a prepared rescue can be carried out.
Awareness training in the hazards of inert gases and oxygen-deficient atmosphere is of vital importance for everyone who might enter a space or who might discover and affected person in a space with potentially asphyxiant atmosphere, in order to prevent subsequent fatalities as result of “unplanned rescue” attempts.
In the event of a person having fainted due to oxygen deficiency, he can only be rescued if the rescue personnel are equipped with breathing apparatus, enabling them to enter the oxygen-deficient space without risk.

Remove the patient to the open air and administer oxygen without delay from an automatic resuscitator if available or apply artificial respiration. Call for medical assistance. Continue until the patient revives or until being advised to stop by qualified medical personnel. Guidelines and instructions for resuscitation can be obtained from the European Resuscitation Council (Internet Homepage: www.erc.edu).

Refer to the relevant Safety Data Sheet for further information/
Contact your local Linde supplier for specific questions
More information available from the EIGA campaign “Against Asphyxiation”, available on the EIGA website www.eiga.eu

The safety data sheet informs users about chemical and physical properties of a material and its generic use, provides advice on the safe handling, storage, transport, use and disposal of the material, provides information about the health effects, exposure control, environmental effects and emergency procedures.