A04 Oxygen enrichment/deficiency

Preliminary remarks

These IGS safety instructions are recommendations for safe working if oxygen enrichment or oxygen shortage is to be expected. They are intended to supplement mandatory safety regulations rather than replace them.

Properties of oxygen

Oxygen (O_2) is a colourless and odourless gas that makes up approximately 21% of air. It is involved in many combustion and corrosion processes. Almost all living creatures require oxygen to stay alive. They usually get oxygen by breathing the air or by absorbing it from water (dissolved oxygen). A change in the relative concentration of oxygen in the air will have an effect on life and combustion processes. The hazards which arise as a result of a change in concentration are described below.

Adiabatic pressure surges (compression) can cause materials or valves to ignite due to the compression heat generated. Valves must therefore always be opened slowly. In addition, valves in oxygen systems must be made from suitable materials and must not be contaminated.

Further information on oxygen can be found in the safety recommendations entitled "A01 The main industrial gases – application and properties".

Oxygen enrichment

Hazards associated with oxygen enrichment

Oxygen enrichment of the air, even if it only amounts to a few per cent, increases the **fire risk** considerably. Materials that do not burn in air, including materials impregnated with a fire retardant, can burn vigorously or even spontaneously in air enriched with oxygen. The resulting flames will be significantly hotter and spread more quickly.

After time spent in an oxygen-enriched atmosphere, **clothing** is to be aired very carefully as oxygen will stick to it. An ignition source such as a cigarette could cause a clothing fire. Inhaling pure oxygen or air heavily enriched with oxygen does not generally have any adverse effect on the human body.

Oil and grease are particularly dangerous in the presence of oxygen because they can burn explosively. They must never be used to lubricate equipment that uses oxygen or oxygen-enriched air. Devices and equipment contaminated with oil and grease are to be degreased immediately using suitable solvents.

Cause of and measures for preventing oxygen enrichment

In principle, the discharge of oxygen is to be avoided in enclosed, poorly ventilated rooms in particular.

The points below outline some of the main causes of and measures for preventing oxygen enrichment:

- Oxygen supply systems must be subjected to a **leak test** before startup and at regular intervals. All devices, e.g. welding and cutting nozzles and hose connections are to be fastened carefully.
- Maintenance and repairs must be carried out by experienced trained staff.
- The main prerequisites for preventing oxygen enrichment during **welding, cutting,** etc. are the right choice of nozzle and the right pressure setting. Excess oxygen also escapes into the air during many processes that use oxygen such as e.g. gouging, flame cutting, scarfing, oxygen lancing, etc., with the actual amount depending on the technology being used. Sufficient **ventilation** must therefore be provided in areas in which such work is carried out.
- On completion of the work, as well as the valves on the welding and cutting torches, it is also essential to **close the oxygen valve** on the cylinder or on the supply line in order to prevent any discharge of oxygen between two work periods.

Besides the potential oxygen enrichment in the air depending on the technology being used, the **misuse** of pure oxygen is particularly dangerous and therefore expressly **prohibited** for the following applications:

- Powering pneumatic tools
- Inflating vehicle tyres, dinghies, etc.
- Cooling or improving air
- Cooling people down
- Dusting off workbenches, machinery and clothing
- Starting combustion engines
- Spray-painting

Oxygen should only be used if it cannot be replaced by any other gas.

Oxygen in its liquid state

Liquid oxygen has a **very low temperature** (minus 183°C at atmospheric pressure). Further information can be found in the IGS safety recommendations entitled "A06 Handling cryogenic liquefied gases".

Even a small quantity of liquid oxygen can generate a large quantity of gaseous oxygen and consequently to oxygen enrichment. In its evaporated state, cryogenic oxygen is significantly heavier than air. It is prohibited for any drains without a liquid seal (e.g. a siphon), open basement windows or other open accesses to **rooms at lower levels**, ducts, ditches, recesses, etc. to be located where the release of cryogenic liquefied oxygen is to be expected.

Environmental pollution caused by oxygen

Oxygen is a natural component of air and makes up 21% of it. If oxygen escapes into the atmosphere, it will not cause any pollution. If cryogenic liquefied oxygen is accidentally spilled, it will not pollute the soil. Temporary local ground frost will not cause any permanent damage to the soil either.

Oxygen shortage

Hazards associated with oxygen shortage

If the natural composition of air (approximately 21% oxygen, 78% by volume nitrogen and 1% noble gases) changes, then it can result in disturbances or even **damage to the human body**. If gases other than oxygen are added to the air that we breathe, the oxygen content will be reduced and oxygen shortage will occur. If the oxygen content falls below 17% by volume, physical and mental capacity will be increasingly reduced as a result. With oxygen concentrations of less than 13% by volume, serious irreversible damage can occur – such conditions can also result in death!
Properties and hazards associated with gases which can cause a reduction in the oxygen content can be found in the corresponding safety data sheets (SDSs).

Cause of oxygen shortage

When liquefied gases (e.g. cryogenic liquefied nitrogen, cryogenic liquefied argon and liquid carbon dioxide) evaporate, a litre of liquid will turn into approximately 600 to 850 litres of gas. This significant volume of gas will cause oxygen shortage particularly quickly if there is **insufficient ventilation**. When liquefied combustible gases (e.g. propane and liquid natural gas) evaporate, an explosive atmosphere will be created within a very short space of time.

If gases other than oxygen can be discharged from gas-carrying lines, containers, etc., then oxygen shortage is always to be expected. Therefore the possible **discharge points** are to be checked for **leakage tightness** at regular intervals.

If work needs to be carried out in the vicinity of **vents** or blow-off pipes, then the discharge of gases with a low or no oxygen content from these openings must always be expected.

Oxygen shortage will always occur if plant or containers are **purged** with nitrogen or other **inert gases** during the performance of repairs or maintenance.

Practically all welding or heating procedures involving an **open flame** consume oxygen from the air and can therefore lead to oxygen shortage if work areas are not large enough and there is insufficient ventilation. In addition, some welding procedures can enrich the breathable atmosphere with gases that are harmful to health or toxic.

If gases that are **heavier than air** (e.g. argon, CO_2, refrigerants, cold gases, propane, butane, etc.) need to be extracted from containers and deep ditches, it is more favourable for these gases to be **extracted from below** than to have them displaced by air blown in. A lot of the air that is introduced into such rooms rises through the heavier gas without displacing it.

Determining oxygen shortage

The human sensory organs cannot detect oxygen shortage directly (possible indirect symptoms: nausea, headaches and dizziness). **Oxygen meters** that display oxygen shortage (or excess oxygen) visually or acoustically can only be used to determine the oxygen content. As a rule, these devices do not provide any information regarding the composition of the air or whether it is harmful to health, toxic or combustible. If the latter kind of hazard is suspected, measurements must be carried out using appropriate devices.

Respiratory protective devices

If oxygen shortage must be expected that cannot be rectified by taking corresponding ventilation measures, suitable respiratory protective devices are to be used. These must only be used by suitably trained staff. **All filter devices (gas masks) without exception are ineffective if there is an oxygen shortage**.

Working in confined spaces, containers, etc.

If it is necessary to enter a container or a confined space in which oxygen shortage is suspected or could occur, then every line leading into the container is to be isolated from its gas supply by dismantling a section of the pipeline and fitting a **blank flange** or a **blanking disk** before work starts in the container. Just counting on the leakage tightness of valves can have fatal consequences. Before entering any such container or space, it must be carefully aerated and the **oxygen content** (and if necessary the content of other gases that are harmful to health or combustible) is to be **analysed** at regular intervals. If a breathable atmosphere cannot be produced in any such container or space, then respiratory protective devices must be used. Such spaces must not be entered until a signed written access permit has been obtained from a responsible person.

While a person remains in a confined space or container, a safety monitor must stand directly at the entrance at all times.

The safety monitor must hold the rope from the safety harness being worn by the person working in the confined space. The safety monitor must not be distracted by other activities as the life of the person working in the confined space or container is in his hands.

Emergency measures in the event of oxygen shortage

If an employee has lost consciousness due to oxygen shortage, then he can only be rescued if the **rescue staff** can enter the dangerous area equipped **with respiratory protective devices**. Where possible, the victim is to be given oxygen from an automatic resuscitator or artificial respiration is to be provided. Artificial respiration is to be continued until the victim is able to breathe independently or a doctor gives the instruction for resuscitation to stop.

The victim is to be brought into the fresh air immediately and kept warm.

Final remarks

If is only possible to handle gases safely if the specific properties of the gases are known and intentionally utilised. Improper use of gases can cause asphyxiation, for instance, while the proper application of oxygen shortage (inertisation) can help to reduce the explosion hazard, for example.

Scope/Definition

This document replaces the existing IGS safety recommendations entitled "Oxygen enrichment IGS-TS-002/03" and "Oxygen shortage IGS-TS-003/02".

Handling cryogenic liquid gases is described in the IGS safety recommendations entitled "A06 Handling cryogenic liquefied gases".

Further information on oxygen can be found in the safety recommendations entitled "A01 The main industrial gases – application and properties".

Information on the safety-relevant properties of the gases can be found in the safety data sheets (SDSs).

Do you have any questions?
We hold further documents ready for you.

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