THE LINDE GROUP

Safety Advice.
3 – Oxygen deficiency.

1. Introduction

This Safety Advice provides recommendations based on practical experience of conditions that can lead to an in the event of oxygen deficient atmosphere. It does not replace mandatory regulations but is meant to complement them.

2. What is oxygen deficiency?

Typically air is composed of 21% by volume of oxygen and 78% by volume nitrogen and the other 1% is other gases. Oxygen is required to support all living organisms including humans. If the percentage of oxygen is changed then humans can be severely affected and in extreme cases death can result. If the percentage of oxygen is reduced either by removing oxygen or adding other gases then the resultant oxygen concentration can be below 21% which is called oxygen deficiency.

As an example, if the oxygen concentration falls below 15% by volume a persons physical and intellectual efficiency is significant reduced. If this reduction of oxygen is caused by the addition inert gases e.g. nitrogen, argon, helium etc the reduction in intellectual efficiency occurs without the person's knowledge.
If the oxygen percentage is further reduced to 10% a loss of consciousness occurs without prior warning. Below about 8% death by suffocation occurs within a few minutes, unless resuscitation is carried out immediately.

In the event of oxygen deficiency caused by toxic or flammable gases the risk of the toxic or flammable effects of the gas may be greater than that caused by oxygen deficiency:
Even low concentrations of toxic gases in air can severely affect health or even cause death. Low concentrations of flammable gases (some of which can also be toxic) can lead to an increased risk of fire or explosion.
No matter what the operation if the percentage of oxygen can be reduced below the norm of 21% then a risk assessment shall be carried out. The reduction in the levels of oxygen have different affects on different people e.g. the young, elderly or pregnant women so any variation from 21% shall be investigated.

3. Causes of oxygen deficiency

3.1. When liquefied gases e.g. liquid nitrogen, liquid argon or liquid carbon dioxide evaporate, one litre of liquid creates approximately 850 litres of gas. This enormous volume of gas can very quickly lead to oxygen deficiency unless there is adequate ventilation. If a flammable liquefied gas is evaporated e.g. propane or LNG then an explosive atmosphere will form within even a shorter period of time.

3.2. Prior to any entry into a confined space or where it is suspected that the level of oxygen could be reduced, then atmospheric analysis shall be carried out to ensure the atmosphere is safe to breath. The entry or associated work shall also be controlled and monitored by a permit to work to ensure the atmosphere remains safe at all times. Depending of the conditions of the permit to ensure a safe system of work, prior to entry any points where gases etc could enter the area may have to be blanked off or personal oxygen monitors worn.

3.3. If work has to be carried out in the vicinity of ventilation openings, vent pipes or the discharges from relief devices, personnel must be prepared to encounter an atmosphere where the oxygen concentration may be altered.

3.4. Oxygen deficiency will always occur when making vessels, or equipment safe for maintenance or repair by purging with nitrogen or other inert gases.

3.5. Practically all welding, cutting and any heating processes working with a naked flame will involve taking oxygen from the air and can thus lead to oxygen deficiency unless there is adequate ventilation of the workspace.

3.6. If a gas that is heavier than air either due to its nature or temperature has to be removed from a vessel or pit it is better to suck out the gases from the bottom, rather than trying to displace them by blowing air in. As most of the air blown into such spaces from the bottom rises through the heavier gas without displacing it.

Leak test

4. Detection of oxygen deficiency

Human senses cannot detect oxygen deficiency.
Measuring instruments giving an audible or visual alarm in case of oxygen deficiency (or enrichment) will only indicate the oxygen content. As a rule, these instruments

do not indicate if the gases which can lead to oxygen deficiency have other properties e.g. are harmful, toxic or flammable. Therefore if the presence of these gases is suspected then gas specific measuring instruments shall also be used.

Caution: Danger of asphyxiation

5. Breathing equipment

Breathing equipment must be used in situations where oxygen deficiency is expected and which cannot be remedied by adequate ventilation. Gas masks are without exception useless for this purpose, as they only filter out gases. Recommended types of breathing equipment are:

- Self-contained breathing apparatus using air cylinders. It should be borne in mind that when wearing this apparatus it may be difficult to enter manholes, etc.
- Fresh air masks where the mask is connected via a hose of adequate length and diameter to a fresh air supply.

Periodic inspection of the equipment shall be carried out and the user of this type of equipment should be adequately trained.

6. Confined spaces, vessels, etc.

Any entry into a confined space where oxygen deficiency may occur shall be controlled by a permit to work. This permit shall stipulate the activities required to ensure that a safe system of work is initiated and maintained. This may require amongst other things physical isolation to stop gases entering the confined space. This may be achieved by block and bleed, by the removal of a section of pipe, by the use of a spectacle plates or by inserting blanking spades. Reliance on the closure of valves alone might prove fatal and should not be used. Any confined space should be thoroughly ventilated, oxygen content (and the concentration of harmful or flammable gases, if need be) shall be measured periodically before entry and during work. If the atmosphere is not breathable then breathing equipment shall be used.
Permission to enter such a space shall be given only after the issue of the permit certificate signed by a responsible person.

In the event of an incident occurring in a confined space there should be adequate measures to ensure that the person is rescued quickly and safely. This will require a system to be put in place where people involved know their roles and responsibilities and have been trained to act correctly. This as a minimum will require a person stationed permanently outside the confined space, with communication to the person inside, whose sole duty is to raise the alarm in the event of an incident so a rescue team can affect a rescue. Any person entering a confined space should be certified medically fit to do so.

7. Emergency measures

In the event of a person having fainted due to oxygen deficiency rescue can only be affected if the rescue personnel are equipped with breathing apparatus, or the same fate will befall them.
The patient should be removed to open air, medical help summoned and the necessary first aid administered.

8. Final remarks

Safe handling of gases is only possible if the specific properties of the gases are known and they are used correctly. Gases used for the wrong application or inappropriately may lead to suffocation or death.

Any person using a gas must have sufficient knowledge of it properties.
Gases have neither good nor bad properties, what matters is the knowledge of how to use them in the right way.

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