

Dangers of oxygen-deficient atmospheres

Workers can become asphyxiated by exposure to atmospheres deficient of oxygen, that can lead to serious injury or loss of life. Oxygen is the only component of the air we breathe capable of supporting life. Air is composed of approximately 21% oxygen, 78% nitrogen and other trace components. Asphyxiation is the greatest hazard associated with nitrogen and other inert gases, such as argon and helium. However, the addition of any gas, except oxygen, to air can reduce the oxygen concentration through displacement and dilution. Breathing as little as one or two breaths of air containing too little oxygen can have serious and immediate effects, including unconsciousness. Because there are no warning signs of reduced oxygen concentrations, these environments are extremely dangerous.

Effects of oxygen-deficient atmospheres

Effects of exposure to low oxygen concentrations can include giddiness, mental confusion, loss of judgment, loss of coordination, weakness, nausea, fainting, loss of consciousness and death.

The immediate effects of low oxygen environments are due to our body's oxygen transport system. Blood absorbs oxygen from the air in our lungs to fuel the cells in our bodies. The brain is the body organ most sensitive to the lack of oxygen. Within five seconds after inhaling only a few breaths of oxygen-free gas, there is a rapid drop in the oxygen concentration of the blood. Mental failure and coma follow a few seconds later. Symptoms or warnings are generally absent, but even if present, the loss of mental competence, weakness, loss of coordination, or fainting prevents victims from helping themselves or even summoning help. Death follows in just two to four minutes.

Warning: Exposure to atmospheres containing less than 10% oxygen can rapidly overcome a person and bring about unconsciousness without warning so they are incapable of helping themselves. Lack of sufficient oxygen can cause serious injury or death.

Table 1 describes the health effects of inhaling oxygen concentrations at less than normal levels. However, it is not unusual for the exposed person to be unaware of the symptoms. They may even experience a false sense of security and well-being. Poor physical health and high degrees of physical exertion aggravate the symptoms of oxygen-deficient exposure. Some symptoms of oxygen deprivation are noticed at high altitudes where the density of air, and therefore the mass of oxygen, is much lower per unit volume.

Precautions

Workers handling gases should review the Safety Data Sheet (SDS) for information on gas properties and safe handling. For example, the SDS shows the specific gravity or relative vapor density of the gas. Gases with a relative vapor density less than one, such as helium, are lighter than air and can collect near the ceiling. Conversely, cold vapors and gases with a relative vapor density greater than one, like argon, are heavier than air and will tend to settle at or near the floor, or in low spots or depressions, such as culverts, ditches and manholes. These areas may contain little or no oxygen, while surrounding areas have normal air composition.

Workers handling gas cylinders or other containers must read the label to identify the product. The container color or outlet connections are not reliable methods for product identification. In industrial incidents, inert gases have been inadvertently used as breathing air because of interchangeable couplings and poor or non-existent labeling, which have resulted in severe injury or death.

Table 1: Effects of Oxygen-Deficient Exposure

Oxygen concentration (% vol)	Health effects of persons at rest
19	Some adverse physiological effects occur, but they may not be noticeable.
15–19	Impaired thinking and attention. Increased pulse and breathing rate. Reduced coordination. Decreased ability to work strenuously. Reduced physical and intellectual performance without awareness.
12–15	Poor judgment. Faulty coordination. Abnormal fatigue upon exertion. Emotional upset.
10–12	Very poor judgment and coordination. Impaired respiration that may cause permanent heart damage. Possibility of fainting within a few minutes without warning. Nausea and vomiting.
<10	Inability to move. Fainting almost immediate. Loss of consciousness. Convulsions. Death.

A formal risk assessment is required to identify all hazards and evaluate the controls needed to ensure the safety of workers. Typical controls would include training, atmospheric monitoring, implementing safety procedures for work and energy isolation, providing an attendant and posting of warning signs.

When using inert gas systems, always provide adequate air movement and ventilation, such as exhaust or floor fans. Be aware that increases in gas consumption rates may require additional ventilation. Fresh air should be supplied into the area so that any spilt gas is diluted and the atmosphere maintains an oxygen concentration of 20.9%. It is recommended that all vents be piped to the exterior of the building.

Oxygen-deficient atmospheres may exist in poorly ventilated areas, confined spaces, areas immediately outside confined spaces, enclosures and low-grade areas. When working in confined spaces, all the requirements of confined space regulations must be strictly followed. Effective emergency procedures for entry and rescue can avoid serious injuries or fatalities.

Low oxygen levels can also exist in “open areas,” including areas with ventilation, laboratories, buildings and outside near equipment.

Visual or odor indicators cannot detect an oxygen-deficient atmosphere. The only way to detect low oxygen concentrations is with real-time oxygen monitoring. Use of a continuous oxygen monitor is strongly recommended in work areas where high concentrations of gas can accumulate.

A release of a cold vapor, such as from cryogenic liquid nitrogen, can form a visible vapor cloud or plume created by the condensation of atmospheric moisture. As the released gas warms up to ambient temperature, the visible vapor cloud may disappear before the oxygen concentration returns to a sufficient level. Do not rely on the absence of a visible cloud as evidence of normal air concentrations. Even outside, asphyxiation can occur in an oxygen-deficient vapor cloud.

Workplace safety regulations commonly regulate work in atmospheres containing less than 19% to 19.5% oxygen. When it is necessary to work in an oxygen-deficient atmosphere, supplied air must be provided. Air can be supplied with either an air-supplied respirator or self-contained breathing apparatus (SCBA).

Emergency response

Workers involved in emergency activities must not allow emotions to override safe work procedures and training. Only trained, qualified personnel equipped with supplied air and necessary safety equipment should attempt a rescue in accordance with safe rescue procedures. You cannot hold your breath and safely enter areas with low oxygen levels. Tragically, without supplied air equipment, attempts to save someone in an oxygen-deficient atmosphere most often result in additional victims.

First aid

Persons exposed to oxygen-deficient atmospheres should be quickly moved to fresh air. If the victim is not breathing, artificial respiration should be administered immediately. If the victim is breathing, give supplemental oxygen.

Emergency Response System

T 800-523-9374 (Continental U.S. and Puerto Rico)

T +1-610-481-7711 (other locations)

For regional ER telephone numbers, please refer to the local SDS 24 hours a day, 7 days a week for assistance involving Air Products and Chemicals, Inc. products

Technical Information Center

T 800-752-1597 (U.S.)

T +1-610-481-8565 (other locations)

Monday–Friday, 8:00 a.m.–5:00 p.m. EST

F 610-481-8690

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