

Cryogenic Safety

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Cryogenic liquids commonly handled in our industry include oxygen, nitrogen, argon, hydrogen and helium. Other less common cryogenic liquids include neon, krypton, xenon, ethylene, methane and carbon monoxide.

Potential Hazards

Each of these cryogenic liquids has their own inherent hazards which can be gleaned from their MSDS, but collectively the potential hazards can be grouped into the following five categories.

- Ultra cold temperatures that can cause serious cold burns and frostbite injuries.
- Fire and explosion hazards from escaping flammable gases.
- Fire or explosion from escaping oxygen, which is not flammable, but increases the flammability of ordinary combustibles.
- Container or piping failure because of overpressure due to large expansion ratio from liquid to gas.
- Asphyxiation due to displacement of oxygen by escaping liquid

You may want to spend some time discussing the hazards and control measures associated with cold temperatures, fire and explosion potential, and over pressurization of containers and piping, but the balance of this topic will focus on the less obvious and less understood hazard of asphyxiation.

Asphyxiation

Oxygen is the only gas that will support life. Nitrogen, carbon dioxide, argon and the other inert gases like neon, krypton and helium are noncombustible, not toxic, inert and will not support life. These gases present a significant hazard if released into the atmosphere by reducing and displacing the breathable oxygen in the air. Reduce it below a safe level and it will cause significant health effects up to and including death.

The reason these gases are so hazardous, especially when in their liquid form, is because they have an extremely high expansion ratio (averaging about 800:1) when their physical state changes from liquid to vapor gas when warmed up. Therefore, even a small leak or discharge from a cryogenic container or system can rapidly fill a small space and cause a very dangerous situation. If that release occurs in a confined space, limited or restricted area with low or poorly ventilated space, basement, or in an elevator, the oxygen level could be reduced and asphyxiation could occur. If the oxygen content is reduced by only a few percent from the normal oxygen content in air (approximately 21 percent) there can be a substantial risk of life. OSHA defines an oxygen-deficient atmosphere as an atmosphere with less than 19.5 percent by volume. Therefore any atmosphere below 19.5 percent by volume is considered unsafe and corrective action must be taken to increase the oxygen level to ensure safe entry into the area. The table below shows the effect on humans as the oxygen level in air decreases.

Effect Thresholds for Exposure to Reduced Oxygen

(Healthy Individuals at Sea Level)

Volume % Oxygen	Effect
17	Night Vision
	Increased breathing volume
	Accelerated heartbeat
16	Dizziness
	Reaction time for novel tasks doubled
15	Impaired attention
	Impaired judgment
	Impaired coordination
	Intermittent breathing
	Rapid fatigue
	Loss of muscle control
12	Very faulty judgment

	very poor muscular coordination
	Loss of consciousness
	Permanent brain damage
10	Inability to move
	Nausea
	Vomiting
6	Spasmodic breathing
	Convulsive movements
	Death in 5-8 minutes

In sudden and acute asphyxia (e.g. from the inhalation of pure nitrogen) the victim loses consciousness immediately and without warning. If exposure continues death will rapidly follow. Even when asphyxia develops slowly due to the gradual reduction in the oxygen level there is little warning and the victim may easily miss the few signs as the reduced oxygen level impairs the ability to think clearly.

Control Measures

- Make sure all employees are properly trained and fully understand the inherent hazards associated with these inert gases if released into the atmosphere.
- Ensure an oxygen alarm is present in the work area when appropriate. These are available in personal handheld or fixed models
- Periodically test and calibrate the oxygen alarm.
- Use natural ventilation and or mechanical ventilation systems where appropriate.
- Avoid transporting containers in enclosed spaces such as elevators.
- Avoid placing stationary systems in areas of poor or no ventilation.