Atmospheric Hazards of Controlled Atmosphere Storage Rooms

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Oxygen Deficiency

We all know the importance of Oxygen (O_2) – it is the only gas that supports human life. Did you know that a person's body has no way to detect low levels or the absence of oxygen?

Normal atmospheres contain between 20.8% and 21% oxygen. An oxygen deficient atmosphere is an atmosphere that contains less than 19.5% oxygen. The minimum requirement of 19.5% oxygen at sea level provides an adequate amount of oxygen for most work assignments and includes a safety factor.

Table 1 shows an individual's symptoms when exposed to varied levels of atmospheric oxygen.

TABLE 1. Signs and Symptoms of Oxygen-Deficient Exposure*

Oxygen Content of Air	Signs and Symptoms of Persons At Rest
21%	Breathing, all functions normal
15%-19%	Decreased ability to work strenuously. May impair coordination. Decreased ability to perform tasks. May induce symptoms in persons with coronary, pulmonary, or circulatory problems.
17%	Night vision reduced. Increased breathing volume. Accelerated heartbeat.
16%	Candle extinguished. Dizziness. Reaction time for novel tasks doubled.
15%	Impaired attention. Impaired judgment. Impaired coordination. Intermittent breathing. Rapid fatigue. Loss of muscle control.
12%-15%	Respiration deeper. Increased pulse rate. Impaired perception. Muscular coordination for finer skilled movement is somewhat disturbed.
10%-12%	Further increase in rate and depth of respiration. Further increase in pulse rate, performance failure. Giddiness. Poor judgment. Lips blue.
8%-10%	Mental failure. Nausea. Vomiting. Fainting. Legs give way. Unconsciousness. Ashen face. Blue lips.
6%-8%	8 minute exposure: may be fatal in 50-100% of exposures. 6 minute exposure: may be fatal in 25-50% of exposures. 4-5 minute exposure: Recovery with treatment.
4%-6%	Coma in 40 seconds. Respiration ceases. Death

* Data obtained from: Safetygram-17: *Dangers of Oxygen-Deficient Atmospheres*, Air Products and Chemicals. www.airproducts.com and *CA Storage Safety,* Agricultural Engineering Facts, Department of Agricultural Engineering, New York State College of Agriculture and Live Sciences, written by J.A. Bartsch.

An oxygen deficient atmosphere is a hallmark of CA storage. The low level oxygen (1%-2%) atmosphere inside an in-use, sealed CA room can and will kill a person who enters without the appropriate respiratory protection. Remember that product respiration may also lower the oxygen content to a level below 19.5% in the room if the internal panel door has been sealed and pose an increased risk to those working within the space. Test the air for oxygen prior to entry!

Carbon Monoxide

Carbon monoxide is odorless and colorless and can quickly build up in a room if a propane-powered forklift is used. Because CO is less dense than air, CO tends to stay where it is generated unless it is removed via ventilation. Table 1 shows the Physiological Effects of Carbon Monoxide (in parts per million (ppm) in air) at various concentrations.

Table 1. CO concentration In Air (in ppm) and Physiological effects

CO Concentration in Air	Symptoms
PPM	
35	MIOSHA TLV
50	OSHA Permissible Exposure Level
200	Possible mild frontal headache in 2-3 hours
400	Frontal headache and nausea after 1-2 hours, occipital headache (back of head after 2-3 hours
800	Headache, dizziness and nausea in 45 minutes; Collapse and possible death in 2 hours
1,600	Headache, dizziness and nausea in 20 minutes; Collapse and possible death in 1 hour
3,200	Headache and dizziness in 5-10 minutes; Unconsciousness and danger of death in 30 minutes
6,400	Headache and dizziness in 1-2 minutes; Unconsciousness and danger of death in 10-15 minutes
12,800	Immediate effects: unconsciousness; Danger of death in 1-3 minutes

Propane fueled forklifts <u>should not</u> be used to load or unload fruit in CA fruit storage unless they are equipped with effective catalytic converters on the engine. If electric forklifts cannot be utilized, employers should ensure that a propane-powered forklift has regular and proper maintenance, a properly sized and tuned carburetor, and a functional and properly tuned catalytic converter to reduce CO emissions. The system should have an air to fuel (A/F) ratio of 15.2:1 to get the best fuel economy and low CO emissions at approximately 0.5%. To ensure engines are properly tuned, an exhaust gas CO analyzer designed for tailpipe exhaust sampling should be used when adjusting the fuel system.

NOTE: Catalytic converters require well maintained engines tuned to the right A/F ratio. Catalytic converters may substantially reduce the risk of CO poisoning, but do not eliminate the risk, because catalytic converters do not eliminate all CO in exhaust gas; reductions are usually in the range of 70% to 90%. Since neither good maintenance nor a catalytic converter eliminate all carbon monoxide, this approach is not as effective as switching to an electric forklift.

The National Institute of Occupational Safety and Health (NIOSH) engineers modeled the time required for a gasoline-powered, 5-horsepower, 4-cycle engine to reach the 200-ppm (ceiling) and 1,200-ppm

IDLH CO concentration for room sizes of 1,000 to 100,000 cubic feet and general ventilation rates of 1 to 20 air changes per hour (ACH). The results were summarized in the NIOSH Publication No. 96-118, *Preventing Carbon Monoxide Poisoning from Small Gasoline Powered Engines and Tools.* Figure 1 shows the CO modeling results for a 100,000 cubic foot room.

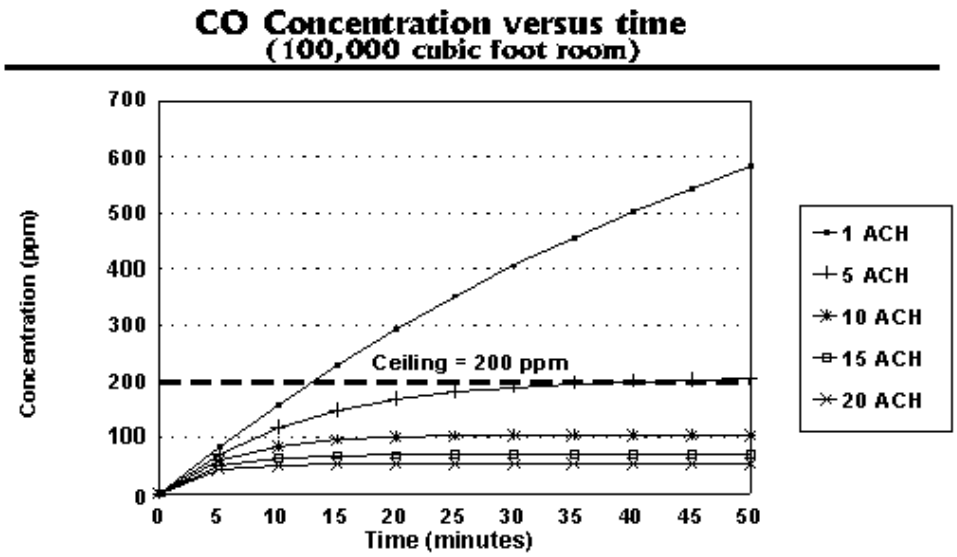

Figure 1. CO Modeling Results for a 100,000 cubic foot room

The State of Washington found, from 1994 to 1999, approximately 41% of the state's CO poisonings specific to fruit packing and storage occurred in cold rooms or open CA rooms. The Environmental Protection Agency adopted regulations that governed the emissions of new forklifts (those with large spark-ignition engines rated at 19kW or more). Forklifts manufactured in 2007 meet a CO emission standard of 4.4 g/kW-hr and *if properly maintained,* should generate much lower concentrations of CO than previously manufactured forklifts.

Although CA rooms have limited ventilation, the ventilation should be operational when loading/unloading the room to provide for further air movement in the room.

The best tool to use when loading and unloading product from a CA room is an electric forklift. Electric forklifts do not emit carbon monoxide. Although electric forklifts cost more to buy, additional benefits include a lower average annual operating cost compared to a propane-powered forklift, a longer operating life, and, because CA rooms are designed to restrict air and other gas transfer with outside air, electric forklifts minimize the risk of carbon monoxide (CO) poisoning for the forklift operator.

Employers should conduct air sampling to determine if the propane-powered forklift operator is exposed to CO exceeding the permissible exposure levels mandated by MIOSHA Occupational Health Standard Part 310, Air Contaminants. The standard requires that the airborne concentration of carbon monoxide should not exceed 35 ppm for an average 8-hour day during a 40-hour work week or 200 ppm

during any part of the workday. To determine room concentrations of CO, stationary CO monitors may be placed in the CA room (ideally integrated with the room's environmental monitoring system). A CO direct reading personal monitor, with prices ranging around $200, can be used to determine real-time exposure.

Additional sources of CO are recirculating oxygen burners of the ARCAT or COB type and open flame burners such as the Wilde or Anderson type. These devices can introduce levels as high as 3000 ppm into the storage room. Space heaters have also been a source of illness and death in CA buildings/rooms. Recognize that CO can permeate through walls and openings in the CA storage and raise the adjoining working environment to levels that may be of concern to human safety.