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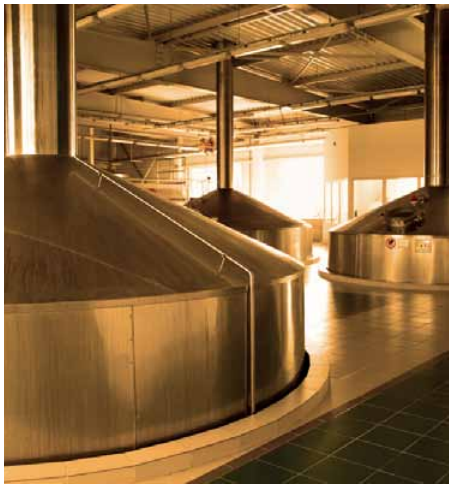
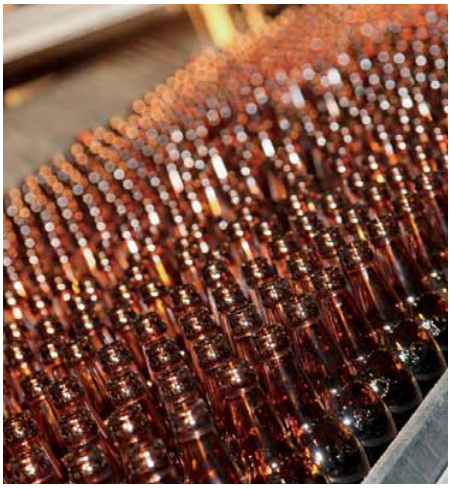
Know the Risks - Work Safely with CO_2





In addition to its vital role in photosynthesis, respiration and carbon cycle, carbon dioxide (CO_2) has many industrial applications. Both solid and liquid CO_2 are used in refrigeration and cooling. In the beverage industry, CO_2 gives the fizz to the drinks and prevents bacterial and fungal growth in soft drinks, beer and wine. CO_2 is an environmentally friendly propellant in aerosols and due to its unreactive nature it is used as an inert gas in various processes, packaging and fire extinguishers, to mention some applications. CO_2 is produced in combustion processes of carbon containing material.

In addition to its excellent refrigerant properties, the safety and the non-flammable nature of CO_2 have already been realized in the early days of refrigeration. CO_2 is one of the natural refrigerants that does not harm the ozone layer and has no or negligible climate impact. CO_2 has replaced the restricted CFC, HCFC and HFC refrigerants, which cause ozone depletion and are powerful greenhouse gases.

CO_2 Exposure Limits in the Working Environment

CO_2 is a non-toxic and non-flammable gas. However, it does not support life and exposure to elevated CO_2 concentrations can induce a risk to life. The leakage of odorless and colorless CO_2 refrigerant cannot be detected without proper sensors. Although CO_2 is considered to be a non-toxic gas, CO_2 concentration can reach dangerously high levels in poorly ventilated spaces.

There are guidelines and regulations related to the acceptable levels of CO_2 in working environments. For example, the U.S. Occupational Safety & Health Administration, OSHA, has set limitation to CO_2 exposure. The permissible exposure limit (PEL) describes the maximum daily human exposure to a substance allowed in a workroom's air over an 8-hour shift.

PEL for CO_2 is 5 000 ppm measured as time weighted average (TWA) level of exposure. In addition, the American Conference of Governmental Industrial Hygienists, ACGIH, has set the short-term exposure limit to 30,000 ppm of CO_2.

Risks of CO_2

CO_2 is always present in the atmosphere at a low level of approximately 400 ppm. However, high concentrations of CO_2 are extremely dangerous. Drowsiness is experienced under continuous CO_2 exposure at a level of 10,000 ppm (1%). At 2-3% of CO_2 heaviness in the chest is experienced and breathing becomes more frequent and deeper. Headache and sweating will also develop during the exposure. Levels above 5% of CO_2 are considered toxic. At 4-5% of CO_2, breathing becomes uncomfortable and lack of oxygen starts causing dizziness. At 6% of CO_2 the sensory processing abilities start deteriorating after some minutes. Less than one minute of exposure to 10-15% of CO_2 results quickly in unconsciousness. When the CO_2 level is between 17 and 30%, fatal exposure occurs in less than one minute.

At all places where CO_2 gas or CO_2 ice is used, produced, shipped or stored, the levels of CO_2 can rise dangerously high and the environment must be monitored with an appropriate sensor.

Selecting the Location for the CO_2 Measurement

When measuring CO_2 for the safety of the personnel, the CO_2 transmitter should be installed as close as possible to potential leakage points for early detection. Transmitters should also be placed in all human occupied spaces. When designing the CO_2 safety monitoring solution, the geometry of the monitored area should be considered, taking into account ventilation and air flow in the space. The number and location of the CO_2 transmitters should always be based on risk assessment of the monitored area.

Get familiar with Vaisala's reliable and accurate CO_2 transmitters at www.vaisala.com/GMT220

Typical Concentrations and Effects

Effect	CO_2 Concentration
Typical atmosphere	350 - 450 ppm
Acceptable indoor air quality	600 - 800 ppm
Tolerable indoor air quality	1000 ppm
Average exposure limit over 8 hours	5000 ppm
Concern, short exposure only	6000 - 30000 ppm
Increased respiration and headache	3 - 8 %
Nausea, vomiting, unconsciousness	10 % +
Sudden unconsciousness, death	20 % +

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CO_2 Measurements in Breweries and Wineries

Carbon dioxide safety measurement is especially needed in breweries.

Carbon dioxide is used for the carbonation of beverages. CO_2 is the gas that gives the fizz to soft drinks and sparkling wines. In breweries, CO_2 is recovered as a by-product of fermentation. As high concentrations of CO_2 are clearly hazardous, most countries, including the USA, have set workplace exposure limits. Carbon dioxide monitoring is essential for employee safety in the brewing and carbonated drinks industry.

Carbon dioxide can be a safety hazard. When CO_2 rises, people start feeling tired. Very high concentrations can lead to unconsciousness or even death. Occupations where carbon dioxide can rise to dangerous levels include the brewing and carbonated drinks industries, as well as wineries. It is therefore vital to measure the level of carbon dioxide in every place where there is a risk of CO_2 build-up or leakage.

Most countries have set workplace exposure limits for CO_2. For instance, in the United States, OSHA's (Occupational Safety & Health Administration, U.S. Department of Labor) general exposure limit of CO_2 to not exceed 5,000 ppm during an eight hour working shift.

Carbon dioxide safety measurement is especially needed in beverage production, because the fermentation tanks have pressure relief valves. If the pressure in the tanks builds up too high, the gas will exit through these valves. There is also a risk that gas can leak from the tanks or pipelines.

Measuring CO_2 in Breweries

Carbon dioxide is generated as a natural process of fermentation and is found in most brewing tanks and around filler machines, packaging and closer areas. Excessive levels of carbon dioxide can displace oxygen, causing asphyxiation.

Breweries throughout the world therefore pose unique challenges to employee safety. There are various areas within a brewery where fermentation gases may collect, becoming a hazard to employees.

In some breweries, CO_2 is recovered as a by-product of fermentation. It can then be purified and compressed for further use. In beverage production the gas for carbonation is usually delivered by gas suppliers, because it has to be very clean in order not to affect the taste.

Confined spaces are among the most hazardous places in breweries. They include beer storage tanks, brew kettles, vats, sumps, pits and other confined areas where carbon dioxide may be present.

Safe CO_2 Levels in Wineries

Similar problems arise at wineries. During the fermentation process, wine grape sugar is metabolized by yeast which converts the sugar to water, alcohol and carbon dioxide. During the active fermentation process, concentrations of carbon dioxide within the headspace of a fermenting tank may reach levels approaching 100 % by volume.

From the trucking in and crushing of freshly harvested grapes to the final aging and bottling process, care must be taken to protect people from potential hazards. Areas of concern within wineries include pits, sumps and storage tanks, as well as fermentation rooms, barrel cellars and bottling rooms. Carbon dioxide is one of the main gas hazards.

The dangers posed by this type of CO_2 build-up include the displacement of oxygen and the potential asphyxiation of employees, as well as the dangers of being exposed to high concentrations of carbon dioxide for extended periods of time.

In wineries, too, the average exposure limit of CO_2 should be kept below 5,000 ppm during an eight hour working shift. In addition, during the active fermentation process, closed buildings should be monitored for carbon dioxide build-up before entering, as concentrations may exceed safe levels.

CO_2 %	Symptoms
2 – 3	Symptoms of simple asphyxia occur
3 – 8	Increased respiration and heart rate, headache
< 10	Headache, nausea, vomiting, unconsciousness
10 >	Unconsciousness in less than 1 minute, death

Table 1. *Effects of CO_2 overexposures.*
Sources: NIOSH / OSHA and University of California.

The following exposure limits are recommended		
PEL-OSHA 5000 ppm	9000 mg/m³	TWA
TLV-ACGIH 5000 ppm 30000 ppm	9000 mg/m³ 54000 mg/m³	TWA STEL
REL-NIOSH 5000 ppm 30000 ppm	9000 mg/m³ 54000 mg/m³	TWA STEL

Table 2. *Recommended exposure limits.*

PEL	Permissible Exposure Limit
TWA	Time Weighted Average
TLV	Threshold Limit Value
STEL	Short Term Exposure Limits
REL	Recommended Exposure Limit
OSHA	Occupational Safety and Health Administration
ACGIH	American Conference of Governmental Industrial Hygienists
NIOSH	National Institute for Occupational Safety and Health

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