smart
GasDetection
Technologies

An underrated, silent killer

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CO_2 - an underrated, silent killer

Carbon dioxide is one of the most frequently overlooked of all toxic gases. Even to refer to CO_2 as a toxic gas is a surprise to many safety professionals. Let's take a closer look.

In the past, the majority of atmospheric monitoring programs have treated CO_2 as only a "simple asphyxiant". An asphyxiant is a substance that can cause unconsciousness or death by suffocation (asphyxiation). Asphyxiants, which have no other health effects, are referred to as "simple" asphyxiants.

As carbon dioxide was not considered to be a toxic hazard, rather than directly measuring the CO_2 concentration in a confined space or workplace environment, it was seen as adequate to simply measure the oxygen concentration. But is this assessment really valid?

The effects of CO_2

To answer this question, it helps to have a look at the physical effects of different CO_2 concentrations as listed by some Health Authorities. The levels of CO_2 in the air and potential health problems are:

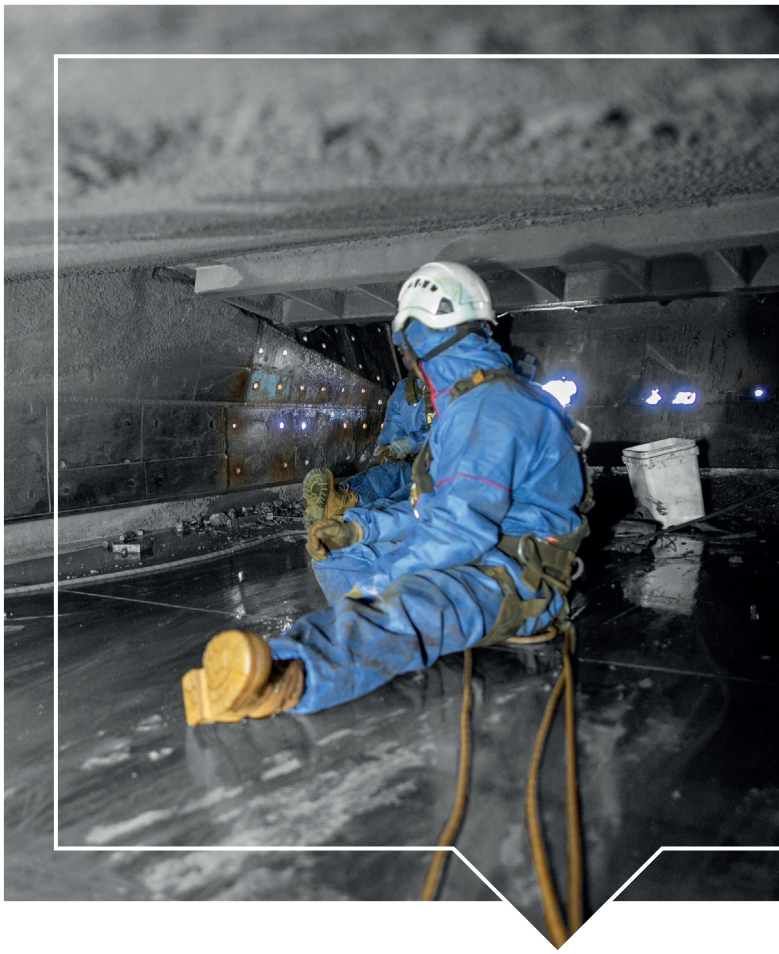
Concentration	%	Symptom / Limit
400 ppm	0.04	The average outdoor air level.
< 1,000 ppm	< 0.1	A typical level found in occupied spaces with good air exchange.
< 2,000 ppm	< 0.2	A level associated with complaints of drowsiness and poor air.
< 5,000 ppm	< 0.5	A level associated with headaches, sleepiness, and stagnant, stale, stuffy air. Poor concentration, loss of attention, increased heart rate and slight nausea may also be present.
5,000 ppm	0.5	This is the OSHA permissible exposure limit (PEL) for daily workplace exposures. It indicates unusual air conditions where high levels of other gases could also be present. Toxicity or oxygen deprivation could occur.
40,000 ppm	4.0	This level is immediately harmful due to oxygen deprivation.

Source: Wisconsin Department of Health Services

The Food Safety and Inspection Service of the U.S. Department of Agriculture goes even beyond those concentrations when listing the symptoms for short time exposure:

Concentration	%	Symptom / Limit
5,000 ppm	0.5	OSHA Permissible Exposure Limit (PEL) and ACGIH Threshold Limit Value (TLV) for 8-hour exposure
10,000 ppm	1.0	Typically no effects, possible drowsiness
15,000 ppm	1.5	Mild respiratory stimulation for some people
30,000 ppm	3.0	Moderate respiratory stimulation, increased heart rate and blood pressure, ACGIH TLV-Short Term
40,000 ppm	4.0	Immediately Dangerous to Life or Health (IDLH)
50,000 ppm	5.0	Strong respiratory stimulation, dizziness, confusion, headache, shortness of breath
80,000 ppm	8.0	Dimmed sight, sweating, tremor, unconsciousness, and possible death

Source: Carbon Dioxide Health Hazard Information Sheet by fsis.usda.gov



It also states: "The response to CO_2 inhalation various greatly even in healthy individuals. The seriousness of the symptoms is dependent on the concentration of CO_2 and the length of time a person is exposed. Since CO_2 is odorless and does not cause irritation, it is considered to have poor warning properties. Fortunately, conditions from low to moderate exposures are generally reversible when a person is removed from a high CO_2 environment."

Those symptoms are not a result of oxygen deficiency, but a direct effect of CO_2 concentration. It's true, many gases are toxic at much lower concentrations, but if the concentration is high enough, so is CO_2. It is also important to remember that people react differently to the same gas concentrations and might show symptoms or suffer damage earlier.

The relation between O_2 and CO_2

Not even the Wisconsin Department of Health Services makes a clean distinction between the effects of carbon dioxide and a lack of oxygen: "40,000 ppm = This level is immediately harmful due to oxygen deprivation." However, the correlation is not quite that simple.

Carbon dioxide is a primary by-product of bacterial decomposition. In many confined spaces, there is a direct relationship between low concentrations of oxygen and elevated concentrations of CO_2.

In the case of a confined space where CO_2 is generated as a by-product of aerobic bacterial action, a concentration of 19.5 % O_2 (the hazardous condition threshold for oxygen deficiency in most jurisdictions) would be associated with an equivalent concentration of at least 1.4 % (= 14,000 ppm) CO_2. This is substantially higher than the generally accepted workplace exposure limit for CO_2 (5,000 ppm calculated as an 8-hour TWA).

The true concentration of CO_2 could be substantially higher, if the oxygen deficiency is due to displacement rather than consumption of the oxygen in the confined space. Fresh air contains only 20.9 % oxygen by volume. The balance consists mostly of nitrogen, with minor or trace concentrations of a wide variety of other gases including argon, water vapor and carbon dioxide.

As oxygen represents only about one-fifth of the total volume of fresh air, every 5 % of a displacing gas that is introduced into a confined space reduces the oxygen concentration by only 1 %. As an example, consider an oxygen deficiency due to the introduction of dry ice into an enclosed space. In this case a reading of 19.5 % O_2 would not be indicative of 1.4 % CO_2, it would be indicative of 5 x 1.4 % = 7.0 % (= 70,000 ppm) CO_2. This is a concentration where even brief exposure can have serious health effects.

The bottom line is that if you wait until the oxygen deficiency alarm is activated, and the deficiency is caused by the presence of CO_2, you will have substantially exceeded the toxic exposure limit long before leaving the affected area.

CO_2 is a toxic gas

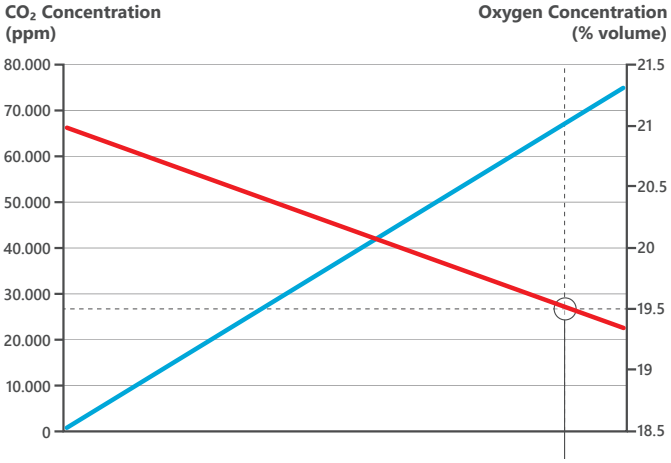
Carbon dioxide is listed as a toxic contaminant with strictly defined occupational exposure limits in almost every country. The most widely recognized exposure limits for CO_2 reference is an 8-hour Time Weighted Average (TWA) of 5,000 ppm, with a 15-minute Short Term Exposure Limit (STEL) of either 15,000 ppm or 30,000 ppm. The following table lists several of the most commonly cited workplace exposure limits:

Standard / Country	8-hour TWA	15-Minute STEL
USA NIOSH REL	5,000 ppm	30,000 ppm
USA OSHA PEL	5,000 ppm	None Listed
ACGIH® TLV®	5,000 ppm	30,000 ppm
United Kingdom WEL	5,000 ppm	15,000 ppm

Carbon dioxide is heavier than air, with a density of 1.5 times that of fresh air. When carbon dioxide is released into an enclosed or confined space, it tends to settle on the bottom of the space, reaching the highest concentration in the lowest parts of the space. Because of this tendency to settle, as CO_2 is produced it can reach higher and higher concentrations in localized regions of the space (such as the headspace immediately above the liquid in fermentation vats).

According to NIOSH concentrations of 40,000 ppm or higher should be regarded as immediately dangerous to life and health. Exposure to very high concentrations (e.g. exposure to 6 % volume CO_2 for several minutes or 30 % volume CO_2 for 20 - 30 seconds), has been linked to permanent heart damage, as evidenced by altered electrocardiograms.
Concentrations greater than 10 % are capable of causing loss of consciousness within 15 minutes or less.

Effects of CO_2 introduced into a confined space on the concentration of oxygen in the space



It takes about 67,000 ppm CO_2 (6.7 % volume) to displace enough oxygen to cause the concentration to drop below 19.5 % oxygen deficiency alarm threshold.

Source: GfG

Monitor both gases

If there is a chance for increased levels of CO_2 or the risk of oxygen deficiencies, fixed gas detection systems and portable multi-gas monitors can provide ample warning. However, as shown, it's important to monitor both gas concentrations separately and educate employees about the respective hazards. Carbon dioxide might become hazardous long before the oxygen level drops to dangerous levels and low oxygen concentrations can occur due to a multitude of reasons.

GfG offers a wide variety of transmitters and portable devices to monitor these and many other gases. Feel free to contact us to find out more about how you can increase employee health and safety or visit our website GfGsafety.com.

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