EIGA Safety Information

Prepared by the Safety Advisory Council

Safety Info 24/11/E

# Carbon Dioxide Physiological Hazards
## *"Not just an asphyxiant!"*

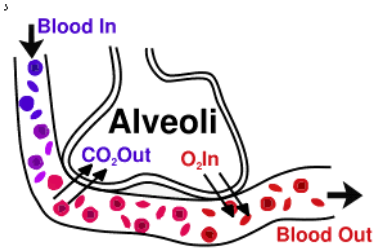
The Safety Advisory Council (SAC) of EIGA have received various reports about serious incidents involving carbon dioxide ($CO_2$). Tragically, some have resulted in fatalities. A common cause in these incidents has been a failure to recognise the actual carbon dioxide concentration in the working environment and therefore the hazard.
While the asphyxiation hazard is well known, carbon dioxide intoxication hazard is not well understood by those involved in the supply and/or use of carbon dioxide. Therefore SAC has prepared this safety information about the physiological hazards of carbon dioxide.

## Carbon Dioxide

Carbon dioxide is naturally present in air at a level of approximately 380 parts per million (0.038%).
It is a normal product of metabolism in human beings. It forms part of the body's normal chemical environment by linking respiration, circulation and vascular response to the demands of metabolism.
Like other inert gases, carbon dioxide is an asphyxiant and doesn't support life. However the specific hazards of carbon dioxide are more complex as it also has acute systemic effects.

## What happens when you breathe?

When air enters the lungs *(see Fig.1)*, it goes through a maze of smaller and smaller tubes until it reaches tiny air sacs called alveoli. Here oxygen from the air diffuses across the alveolar membrane into the blood, while at the same time the carbon dioxide from the blood enters the alveoli. The concentration of carbon dioxide in the blood is high, so carbon dioxide leaves the blood and passes across alveolar membranes into the alveoli where concentration is low (gas always flows from highest concentration – partial pressure to the lower concentration). The carbon dioxide then leaves the alveoli and finally the body during exhalation. The exchange of gases occurs rapidly and constantly.



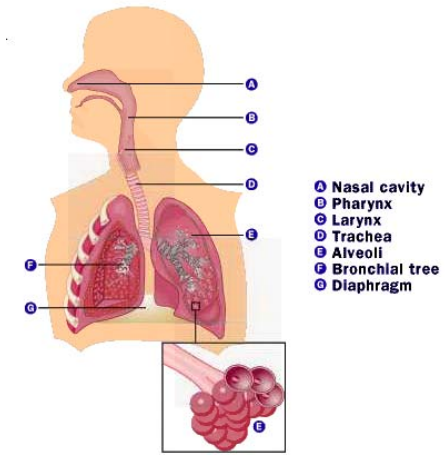




*Fig.1: Pulmonary gas exchange principle*



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## Hazard of carbon dioxide intoxication

If the concentration of the carbon dioxide in the ambient air is increased, the pulmonary gas exchange described above is compromised. In simple terms, as its concentration in the ambient air increases, lower quantities of carbon dioxide leave the blood stream and/or alveoli and therefore there is less room for oxygen. And without oxygen one cannot live.
This effect is called intoxication. Carbon dioxide intoxication is entirely independent of the effects of oxygen deficiency (i.e. asphyxiation) therefore the oxygen content in the air is not an effective indication of the danger of intoxication. For example, as a result of a carbon dioxide release in the air, it is possible to have a slightly lower oxygen concentration of 19%, which on its own is not harmful, but an increased carbon dioxide concentration of 9.5%, which presents a very dangerous situation (see below).

Individual tolerances can vary widely, depending on the physical condition of the person and the temperature and humidity of the air, but as a general guide, the effects of inhaling varying concentration of carbon dioxide are likely to be as follows:

### Carbon Dioxide - Physiological Effects

| Volume Carbon Dioxide in Air | Likely Effects |
|---|---|
| **1 – 1.5 %** | **Slight effect on chemical metabolism after exposures of several hours** |
| **3 %** | **The gas is weakly narcotic at this level, giving rise to deeper breathing, reduced hearing ability, coupled with headache, an increase in blood pressure and pulse rate.** |
| **4 – 5 %** | **Stimulation of the respiratory centre occurs resulting in deeper and more rapid breathing. Signs of intoxication will become more evident after 30 minutes exposure.** |
| **5 – 10 %** | **Breathing becomes more laborious with headache and loss of judgement.** |
| **10 – 100 %** | **When the carbon dioxide concentration increases above 10%, unconsciousness will occur in under one minute and unless prompt action is taken, further exposure to these high levels will eventually result in death.** |

## Avoid fatal mistakes when analysing the ambient air

Due to the health risks associated with carbon dioxide the average exposure of a healthy employee during an eight-hour working shift should not exceed 0.5 % (5,000 ppm).

A common mistake is to only measure the oxygen concentration instead of carbon dioxide. The consequence of this is shown in the following example:

Scenario: Following a release of carbon dioxide into the air in a factory the oxygen concentration was measured on oxygen monitors as falling from the normal 21% to 19%.

*What does this mean*?: Based on the composition of air (21% oxygen and 79 % nitrogen; ratio of 1:3.76) the 2% reduction in oxygen corresponds to a total amount of 9.5% air (2% oxygen and 7.5% nitrogen) which has been replaced by the carbon dioxide that was released.
Therefore a reduction of “only” 2% oxygen results in a concentration of 9.5% carbon dioxide which, according to the table above, represents a significant hazard of intoxication to any people in this area.





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# Are your workplaces safe?

The beneficial applications of carbon dioxide in industry are varied, including:

- Food industry (packaging)
- Beverage industry (carbonation)
- Agricultural and biological applications
- Caffeine removal
- Wine making
- Pharmaceutical or chemical processing
- Polymers and plastics
- Pneumatic systems
- Blasting (Cleaning)
- Fire extinguisher
- Welding
- Lasers
- Refrigerant
- Dry ice (applications)
- Oil recovery
- Pest control
- Waste water treatment
- Food freezing

Carbon dioxide can be used safely provided sensible precautions are in place.

**SAC therefore recommend that the risk of intoxication is considered for each workplace or application where carbon dioxide is used and that companies:**

- **Provide employees with information on the intoxication hazards of carbon dioxide, including the safety data sheet;**
- **Carry out a detailed job hazard analysis where carbon dioxide is used;**
- **Train and educate employees on the specific hazards of intoxication and preventive measures.**

**When, as a result of the job hazard analysis, a risk of intoxication is considered possible, one or more of the following measures should be implemented:**

- **Ensure effective ventilation, especially in lower levels of the room;**
- **Install a carbon dioxide monitor and alarm system, ensure people are trained in the response required to any alarm. Location of the monitors must be evaluated based on the job hazard analysis;**
- **Carry out regular maintenance and calibration of the carbon dioxide monitor and alarm system, as well as of any mechanical ventilation systems;**
- **Ensure that if the carbon dioxide monitor and alarm system is operating at subzero temperatures, it is designed for operating in those conditions and for the application or process;**

**and**

**… Always remember: Carbon Dioxide is "*not just an asphyxiant!*"**

**Useful EIGA document references:**
EIGA IGC Doc. 67 "Carbon dioxide cylinders at users' premises"
EIGA IGC Doc. 56 "Refrigerated Carbon dioxide storage at users' premises"





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