SAFETY RECOMMENDATIONS

Industrial Gases Association Switzerland

A07 Handling carbon dioxide

General information

Carbon dioxide is often referred to as carbonic acid in daily use. However, it is only correct to do so if referring to the aqueous solution of carbon dioxide (CO_2) in water (H_2O) (e.g. mineral water and carbonic acid).

Properties

As a gas, carbon dioxide is colourless, almost odourless and has a slightly acidic taste. It is therefore practically impossible for the human sensory organs to detect. Escaping CO_2 can displace the vital oxygen in our ambient air.
Although carbon dioxide is classified as non-toxic, there is a limit that must not be exceeded (SUVA publication “Occupational exposure limits” no. 1903.e). The ambient air that we breathe contains approximately 0.04% by volume of carbon dioxide. This concentration is vital as it stimulates our respiratory centre and controls our respiratory volume and breathing rate.
Carbon dioxide is a non-combustible gas that is 1.5 times heavier than air. Therefore CO_2 spreads along the ground and collects in cavities.
Although carbon dioxide is usually gaseous under atmospheric conditions, it can also be found as a solid (dry ice). CO_2 only exists in liquid form at pressures above 5.18 bar.

General hazard

The aggregate states of CO_2 (solid/liquid/gaseous) can easily change due to pressure and temperature. As a result, the volume and physical properties can also change relatively quickly.

Gaseous carbon dioxide

Gaseous carbon dioxide can be extracted directly from the cylinder or forms as a result of the evaporation of dry ice.

Hazards associated with gaseous CO_2

Asphyxiation hazard/CO_2 intoxication

- Gaseous CO_2 displaces oxygen and acts as a narcotic. Therefore the maximum allowable concentration (MAC) is 5,000 ppm (0.5% by volume).
- With a concentration of 10% by volume of CO_2 in breathing air, there is still a sufficient oxygen content of 19% by volume. However, this concentration of CO_2 can cause convulsions, loss of consciousness, apnoea and death. In such cases, the cause is not the displacement of oxygen but the direct effect of the carbon dioxide on the human respiratory process.
- This hazard can be minimised by providing sufficient ventilation (natural or artificial) and/or CO_2 monitoring.

A common mistake is to measure just the oxygen content and not the concentration of carbon dioxide. With CO_2, such a mistake can have fatal consequences.

CO_2 accumulation:

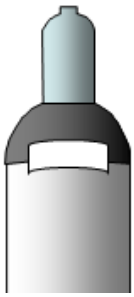
- Due to the high specific weight of the gas (1.5 times heavier than air), escaping CO_2 can collect in rooms on lower levels, hollows or recesses. This can enable a critical concentration of carbon dioxide to accumulate without being noticed and remain for a long period of time.
- Carbon dioxide must not be stored or used in poorly ventilated areas (e.g. basements).
- Extraction systems for mechanical ventilation systems must be installed near to the ground.

Liquid carbon dioxide

Liquid carbon dioxide is stored in gas cylinders, cryogenic containers or tanks. If the pressurised CO_2 is released at atmospheric pressure, gaseous CO_2 and dry ice ("snow") will immediately be created. In addition, the dry ice "snow" will then evaporate (sublimate) straight to a gas, bringing the properties and hazards associated with gaseous carbon dioxide into play **(see "Gaseous carbon dioxide")**.

Carbon dioxide in cylinders (shoulder colour "dusty grey")

Unlike most standard gases, the content of a CO_2 cylinder is in a liquid state, i.e. "liquefied under pressure". For that reason, the content of carbon dioxide cylinders is declared in kg rather than in litres. At 20°C, the pressure of the liquid in the gas cylinder is approximately 57 bar. The content of the cylinder cannot be determined by connecting a pressure gauge to it.
CO_2 cylinder valves have an overpressure protection device in the form of a rupture disk. In order to prevent any unintended and dangerous discharge of CO_2, this device must not be manipulated in any way.



t is essential to ensure that the cylinder is in the correct position before extracting any CO_2. If the cylinder has a dip pipe, CO_2 is extracted with the cylinder upright. The same applies to extracting gaseous carbon dioxide from a cylinder without a dip pipe. If the cylinder (with or without a dip pipe) is positioned horizontally, dry ice "snow" as well as large quantities of gaseous CO_2 can escape when the valve is opened. Connected pressure regulators can be destroyed by escaping liquid CO_2.

Risk of cylinders bursting:

- Decanting carbon dioxide from one gas cylinder to another without authorisation is dangerous. The filled state of a CO_2 cylinder cannot be determined by measuring the pressure but only by weighing. An "overfilled" CO_2 cylinder without a rupture disk can even burst at room temperature.

Additional hazards associated with liquid carbon dioxide

Asphyxiation hazard/CO_2 intoxication:

- When liquid carbon dioxide evaporates, its volume increases dramatically so that, when 1 kg of liquid is vented to atmospheric pressure, approximately 550 litres of gaseous carbon dioxide are produced. This will increase the concentration of CO_2 very quickly and cause the intensive displacement of oxygen in the ambient air.

Freezing hazard:

- The freezing effect of carbon dioxide can also be harmful to human health. If CO_2 cooled by venting in the form of dry ice "snow" (-78°C) comes into contact with human skin, it can cause painful frostbite. Sensitive tissue such as that of the cornea are particularly at risk.

Overpressure in containers:

- If liquid CO_2 evaporates inside a sealed container (e.g. a tank), it can lead to a dramatic increase in pressure. Any such container can burst if the pressure is not released in an appropriate way.

Unintended release:

- If the pressure in an installation filled with liquid CO_2 falls below 5.1 bar, solid and gaseous CO_2 will form spontaneously. Solid CO_2 can cause damage to valves and safety devices, resulting in serious damage to installations.

Solid carbon dioxide ⇨ Dry ice

Dry ice consists of compressed CO_2 "snow" that is produced by venting liquid carbon dioxide. Dry ice has a temperature of -78°C at atmospheric pressure. If dry ice heats up at atmospheric pressure, it does not melt but rather sublimates (evaporates) into gaseous CO_2 without leaving any residue. This state brings the properties and hazards associated with gaseous carbon dioxide into play **(see "Gaseous carbon dioxide")**.

Additional hazards associated with dry ice

Asphyxiation hazard/CO_2 intoxication:

- Sublimation can turn 1 kg of dry ice into 300-400 litres of gaseous carbon dioxide depending on the degree of compression. This will increase the concentration of CO_2 very quickly and cause the intensive displacement of oxygen in the ambient air.
- A properly insulated transport box can massively reduce (but not prevent) the rate of evaporation.
- Access must only be granted to rooms in which dry ice is stored if there is sufficient ventilation for removing the resulting gaseous CO_2.
- Dry ice must only be transported in a vehicle's cargo compartment if they are separated from the driver's cab or passenger compartment by a gastight bulkhead or if sufficient ventilation can be ensured.

Freezing hazard:

- Dry ice is not for consumption and must never be put in the mouth or directly into drinks without using safety tongs.

- Only handle dry ice when wearing gloves or using tongs. Direct contact with unprotected skin can cause serious frostbite (-78°C).

- Safety glasses must be worn in order to protect the eyes against dry ice particles when crushing dry ice manually using a suitable tool.

Overpressure in containers:

- If dry ice sublimates inside a gastight sealed container (e.g. a sealed coolbox), it can lead to a considerable increase in pressure. Any such container can burst if the pressure is not released in an appropriate way.
- Only store in suitable containers that are properly insulated but not tightly sealed.

Unauthorised access:

- Dry ice is not a toy and must be kept away from children!
- No untrained persons may be allowed access to dry ice.

Final remarks

Information on the safety-related properties of carbon dioxide and dry ice can be found in the safety data sheets (SDSs). For further information on handling, please contact your gas suppliers.

Carbon dioxide is “not just an asphyxiant” – carbon dioxide intoxication can even occur if there is still sufficient oxygen in the ambient air.

Scope/Definition

This document replaces the existing IGS safety recommendations entitled “Handling dry ice safely” IGS-TS-009/06”

The scope of these safety recommendations covers compressed-gas containers (gas cylinders) and cryogenic containers that are used to transport and store gases. This documentation cannot be used for gas tanks.

Further documentation (not exhaustive)

- SUVA publication entitled “Occupational exposure limits” no. 1903.e
- EIGA Safety Information publication entitled “Physiological hazards of carbon dioxide” no. 24/11/E

Do you have any questions?
We hold further documents ready for you.

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