

Safety advice.

Carbon Dioxide.

Properties

Physical Properties

Gaseous state: at normal temperature (+15°C) and atmospheric pressure, CO₂ has a density of 1.87 kg/m³, is 1.5 times heavier than air and spreads along the ground collecting in low-lying areas such as pits and cellars. It is a colourless and odourless gas (with a slightly pungent odour at high concentrations).

Liquid state: carbon dioxide can exist as a liquid below the critical temperature of 31°C and above the triple point with a temperature of -56.6°C and 4.18 bar gauge, see also P-T-Diagram.

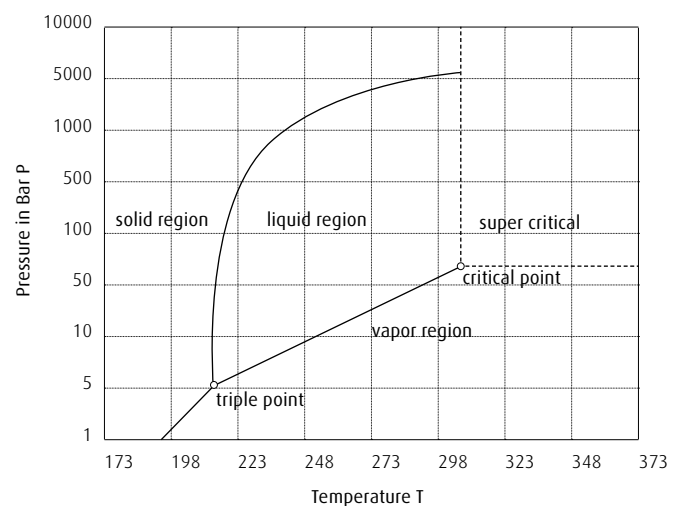
CO₂ is transported, stored and handled in liquid form, either at ambient temperature (in cylinders or non-insulated storage tanks at a pressure of 45-65 bar) or refrigerated (in insulated tankers and storage tanks) at temperatures between -35°C and -15°C and pressures of 12 to 25 bar.

Solid state (Dry ice): the expansion of liquid CO₂ to atmospheric pressure is used to produce CO₂ snow at a temperature of -78.5°C. The snow is pressed to dry ice blocks or pellets.

Chemical Properties

Carbon dioxide does not support combustion. When dissolved in water, carbonic acid (H₂CO₃) is formed.

P-T-Diagram of Carbon Dioxide



Triple point: T = 56.6°C (216.55K) P = 5.18 bar abs
 Critical point: T = 31°C (304.15K) P = 5.18 bar abs

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Hazards

Substantial Release of Carbon Dioxide

Any substantial release of carbon dioxide is potentially hazardous especially inside a poorly ventilated building. Enclosed low-lying areas, where CO₂ gas could accumulate in high concentration, are particularly hazardous because the gas is slow to disperse unless the spaces are well ventilated. As an example, in cutting and welding applications when CO₂ or CO₂ mixtures are used such as arc welding, a large amounts of CO₂ may be released. The health effects of inhaling carbon dioxide includes headache, dizziness, restlessness; breathing difficulty; sweating, malaise (vague feeling of discomfort); increased heart rate, cardiac output and blood pressure coma; asphyxia; convulsions and

unconsciousness. In low concentrations the health effects of carbon dioxide are physiological reversible but in high concentrations it can cause unconsciousness and be fatal.

Carbon Dioxide has typically been assigned a work place occupational exposure limit of 5000 ppm averaged over an 8 hour period and 9000 to 9150 ppm (depending on the country) averaged over a 15 minute period.



CO ₂ (Vol %)	Likely Health 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 a 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 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



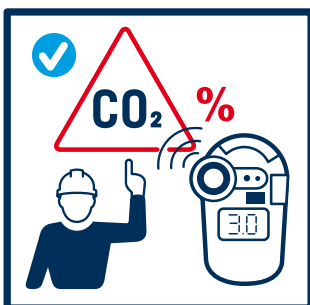
The effects of CO₂ are independent of the effects of oxygen deficiency.

The oxygen content in the atmosphere is therefore not an effective indication of the danger. It is possible to have a low oxygen content of 18 % and a high CO₂ content of 14 % which is very dangerous. Therefore monitoring the oxygen content in areas where CO₂ is released will not provide adequate protection or warning against an increase of carbon dioxide. Canister type respirators give no protection in atmospheres containing dangerous concentrations of CO₂.



Gas Under pressure

A carbon dioxide cylinder contains a liquefied gas under pressure. It may rupture (or burst) if heated or in case the container is overfilled resulting hydraulically full. The filling ratio of common gases is usually regulated by local legislation.



Use portable CO₂ detectors that can indicate the CO₂ content.



Low Temperature

The snow produced from leaks of liquid carbon dioxide is extremely cold (-78,5 °C) and may cause frostbite in contact with skin. If carbon dioxide snow comes into contact with the eyes it may cause severe eye injury. Also rapid evaporation of the liquid can cause frostbite and cold burn.

Dry Ice Plugs in Pipes and Hoses

Dry ice plugs can be formed inside tanks, hoses and piping when liquid carbon dioxide is decreased below its triple point pressure of 4,18 barg. The dry ice can be compacted into a plug which can trap gas.

The pressure behind or within a plug may increase as the dry ice sublimates, (changes back to a gas) until the plug is forcibly ejected or the tank, hose or pipe ruptures. A dry ice plug may be ejected from an open end of hose or pipe with enough force to cause serious or fatal injury to personnel, both from the impact of the dry ice plug and or the sudden movement of the hose or pipe as the plug ejects.

Precautions

- Use suitable gloves for handling cylinders.
- Do not drag cylinders (this causes base wear, especially for aluminium alloy cylinders).
- For capped cylinders, ensure the cap is fitted when they are being stored or transported.
- External damage of cylinders and valves (e.g. by welding or striking electric arcs or impact by sharp objects) must be avoided.
- Do not use cylinders as rollers or work supports.
- Secure CO₂ cylinders during use, storage and transport on vehicles to prevent movement.
- A cold and wet or frosted cylinder could indicate a leakage and appropriate measures should then be taken.
- Any stamping or means of identification on the cylinder must not be altered.
- Never heat cylinders e.g. by direct flame, electrical devices, or hot water, to raise the pressure or the flow rate.

- Cylinders must be connected to low pressure equipment only using proper pressure regulators.
- Cylinder valves are unsuitable for pressure and flow regulation.
- Cylinders used for the discharge of CO₂ gas (without dip tube) must be connected to a suitable reducing valve to obtain a desired pressure and flow rate.
- Do not extract liquid CO₂ out of standard cylinders without dip-tube. The cylinders are not designed for operation upside down.
- To prevent contamination and internal corrosion, the cylinder should be returned for filling with a positive pressure.
- Do not attempt to transfer CO₂ from one cylinder to another.
- Keep cylinder valve outlets and other CO₂ equipment free from contaminants.
- Do not repair or modify cylinders, valves or safety relief devices (bursting discs). Any damage should be made known to the supplier.
- Regular maintenance of storage vessel must ensure that safeguards such as safety valves are properly functioning.

Confined spaces

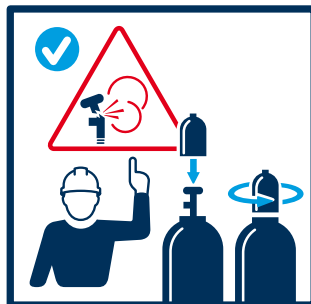
For any entry or work in a confined space there must be a particular risk assessment carried out and a permit to work used to ensure a safe system of work.

Dry Ice Plugs

Liquid carbon dioxide must be purged from the hose or pipe before reducing the pressure below 5 bar. This can be done by supplying carbon dioxide vapour to one end of the hose or piping system to maintain the pressure above the triple point while removing the remaining liquid from the other end.



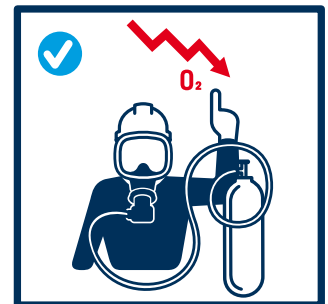
Proper clothes and personal protection equipment e.g. gloves and safety shoes must be worn.



Cylinder valves must be protected against damage by screwing on cylinder caps.



Permission to enter a confined space shall be given only after the issue of an entry permit.



Breathing equipment must be used in situations where oxygen deficiency due to high CO₂ (>3%) content has to be expected.

Emergency

Spill or leak

1. Evacuate contaminated area and ensure adequate ventilation
2. Stop leak, if possible
3. If safe to do so, isolate container and position it so that the leak is from the gas phase
4. Prevent entry into waterways, sewers, basements or confined areas
5. Use water spray to reduce vapours or divert vapour cloud drift
6. Do not direct water at spill or source of leak (risk of ice building/blockages)

Carbon dioxide is asphyxiant and toxic in high concentration. Leaks should only be approached using self-contained breathing apparatus. Damaged containers should be handled only by specialists.

First aid

1. Inhalation: remove victim to uncontaminated area and fresh air. Keep victim warm and rested. Call a doctor. Apply artificial respiration if breathing stopped
2. Skin/eyes contact: in case of frostbite spray with water for at least 15 minutes. Do not remove any clothing. Apply a sterile dressing. Obtain medical assistance. Immediately flush eyes thoroughly with water for at least 15 minutes seek medical advice

Fire

1. Use extinguishing medium for the type of surrounding fire
2. Remove containers to safe area, if possible
3. Cool containers with water from a protected position. **Exposure to fire may cause containers to rupture or explode**
4. Do not direct water at source of leak or safety device
5. Advise Fire Service of containers location and contents

Refer to the relevant Safety Data Sheet for further information/
Contact your local Linde supplier for specific questions



Proper clothes and personal protection equipment e.g. gloves and safety shoes must be worn.



The safety data sheet informs users about chemical and physical properties of a material and its generic use, provides advice on the safe handling, storage, transport, use and disposal of the material, provides information about the health effects, exposure control, environmental effects and emergency procedures.