CARBON DIOXIDE CYLINDERS AT USERS' PREMISES

Doc 67/20

Revision of Doc 67/08

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NOTE Technical changes from the previous edition are underlined

1 Introduction

This publication gives information and recommendations for safe handling of carbon dioxide cylinders at customer sites.

The recommendations given in this publication are intended to be used as a guide for the safe handling of carbon dioxide cylinders at customer sites. It should be read in conjunction with any national legislation relevant to the safe use and storage of carbon dioxide cylinders. Carbon dioxide is supplied from cylinders containing liquefied carbon dioxide under pressure. Carbon dioxide is used in many applications such as:

- carbonation and beverage dispense;
- modified atmosphere packaging for food storage;
- water hardening;
- supercritical fluid extraction;
- refrigeration as refrigerant R744; or
- firefighting.

2 Scope

The publication covers the use of both gas and liquid (syphon) withdrawal cylinders and non-thermally insulated high pressure tanks of less than 1000 litres.

This publication does not cover the use of transportable vacuum insulated vessels.

This publication does not cover the near consumer use of carbon dioxide which is generally less than one kg of carbon dioxide. For guidance see EIGA Doc 201, *Near-Consumer Use – Risk Assessment Methodology* [1].[1]

3 Definitions

For the purpose of this publication, the following definitions apply.

3.1 Publication terminology

3.1.1 Shall

Indicates that the procedure is mandatory. It is used wherever the criterion for conformance to specific recommendations allows no deviation.

3.1.2 Should

Indicates that a procedure is recommended.

3.1.3 May

Indicates that the procedure is optional.

[1] References are shown by bracketed numbers and are listed in order of appearance in the reference section.

3.1.4 Will

Is used only to indicate the future, not a degree of requirement.

3.1.5 Can

Indicates a possibility or ability.

3.2 Technical definitions

3.2.1 Pressure

In this publication bar shall indicate gauge pressure unless otherwise noted i.e., (bar, abs) for absolute pressure and (bar, dif) for differential pressure.

4 Properties of carbon dioxide

Carbon dioxide can also called carbonic acid gas or CO_2.

A safety data sheet is available from the gas supplier. A summary of the properties of carbon dioxide is given below.

NOTE Carbon dioxide is excluded from the REACH regulations

4.1 Physical properties and handling

4.1.1 Gaseous state

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

Carbon dioxide is classified as a non-toxic gas, but it does start to affect breathing at concentrations of about 1%, with affects becoming more serious with increasing concentrations. For more information see Appendix A and EIGA Info 24, *Carbon Dioxide Physiological Hazards - “Not just an Asphyxiant!”* [2].

Carbon dioxide is a non-flammable gas.

4.1.2 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. See Appendix B for the pressure and temperature diagram.

Carbon dioxide is transported, stored and handled in liquid form, either at ambient temperature (in cylinders or non-insulated storage tanks at a pressure of 45 to 65 bar) or refrigerated, insulated tankers and storage tanks, at a temperature range of –35 °C to +15°C and a pressure of 12 to 25 bar. The carbon dioxide in this state, is a liquid at equilibrium.

Below the triple point carbon dioxide can only exist in the solid and gas phase. Therefore, the liquid carbon dioxide cannot exist at atmospheric pressure. When the liquid carbon dioxide is depressurised below the triple point pressure of 4.18 bar to atmospheric pressure it is transformed to dry ice and gas. Consequently, when the liquid carbon dioxide is released to the atmosphere a dense white fog of powdery solid carbon dioxide particles and vapour is produced.

4.1.3 Solid state (dry ice)

The expansion of liquid carbon dioxide to atmospheric pressure is used to produce carbon dioxide snow at a temperature of –78.5 °C. The snow is pressed to dry ice blocks or pellets.

Dry ice is handled in insulated containers.

4.2 Chemical Properties

Carbon dioxide does not support combustion. When dissolved in water, carbonic acid (H_2CO_3) is formed. The pH value of carbonic acid varies from 3.7 at atmospheric pressure to 3.2 at 23.4 bar. The carbonic acid provides the biting taste of soda water and it reacts in alkaline solutions producing carbonates. It has very few vigorous reactions with other substances except under conditions of high temperature and pressure in the presence of reactive substances such as sodium and magnesium. For this reason, carbon dioxide shall not be used as a fire extinguishing agent for reactive metals such as sodium and magnesium.

5 Hazards of carbon dioxide

5.1 Substantial release of carbon dioxide

Any substantial release of carbon dioxide is a potential hazardous event especially inside a poorly ventilated building. Enclosed low-lying areas, where carbon dioxide gas could accumulate in high concentration, are particularly hazardous because the gas is slow to disperse unless the spaces are well ventilated.

More details about physiological effects are given in Appendix A.

In case of a substantial release of carbon dioxide in confined areas, evacuate all personnel as soon as possible. Never enter such areas before they are properly ventilated, <u>and the carbon dioxide level measured with a gas detection system</u>.

When it is necessary to enter confined spaces before they are properly ventilated, the person entering these areas shall be trained and wear self-contained breathing apparatus. <u>For entry into a confined space it is necessary to have an appropriate rescue plan and appropriately trained staff available to implement the plan.</u>

WARNING: *Canister respirators give no protection in atmospheres containing dangerous concentrations of carbon dioxide and shall not be used for this purpose.*

Substantial releases of carbon dioxide can occur through:

- failure of the cylinder or pipe work containing carbon dioxide;
- release from a relief valve or bursting disc;
- inadvertent opening of a drain or vent valve while the system contains carbon dioxide;
- failure of connections, for example, flexible hoses and flanges; or
- failure of a regulating device resulting in gas release through the body vent holes.

5.2 Low temperature of product, extreme cold

The snow produced from leaks of liquid carbon dioxide is extremely cold (–78.5°C) and can cause frost bites if touched with bare hands. If carbon dioxide snow comes into contact with the eyes it can cause severe eye injuries.

Touching of pipes and connections containing liquid carbon dioxide can cause frost bite.

Where there has been a major release of gas, the atmosphere will be very cold, and visibility is likely to be limited. These factors can make escape or rescue difficult.

5.3 Dry ice plugs in pipes and hoses

Dry ice plugs can be formed inside hoses and piping when liquid carbon dioxide is decreased below its triple point pressure of 4.18 bar. The dry ice can be compacted into a plug which can trap gas. The pressure behind or within a plug can increase as the dry ice sublimes until the plug is forcibly ejected or the hose or pipe ruptures. A dry ice plug can be ejected from an open end of hose or pipe with enough force to cause serious 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.

Liquid carbon dioxide shall 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.

6 Cylinder labelling

Cylinders are labelled in accordance with Regulation (EC) No 1272/2008 *on classification, labelling and packaging of substances and mixtures.* EIGA Doc 169, *Classification, and Labelling Guide in accordance with* EC Regulation 1272/2008 *(CLP Regulation)* gives EIGA's interpretation of the regulations [3, 4].

Figure 1 shows a typical cylinder label.

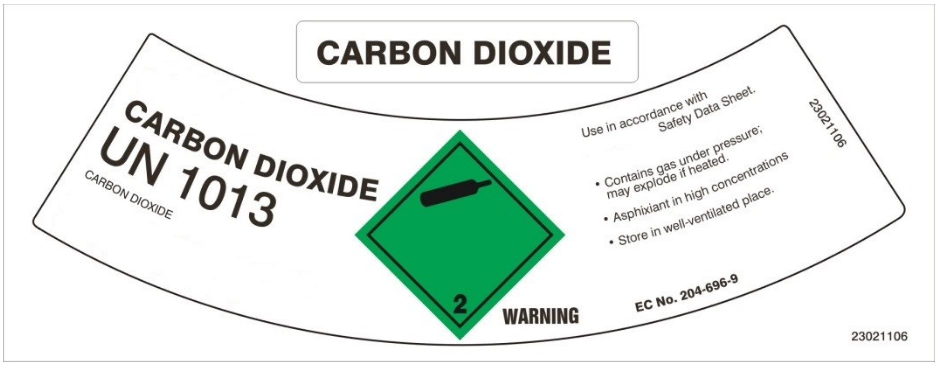


Figure 1: Typical cylinder label

Carbon dioxide cylinders used in food applications contain additional information according to legal requirements, see EIGA Doc 125, *Guide to the Supply of Gases for Use in Foods* and Regulation (EC) No 1333/2008 *on food additives* [5, 6].

7 Cylinders (General)

Cylinders for carbon dioxide are commonly made from carbon steel alloys and designed according to recognised standards.

In 2014 the first study by National Research Council, Istituto Geochimica e Georisorse; Florence, Italy (CNR-IGG), on the migration process of potential metal contamination from carbon steel cylinders to food gases, was published. The result was no hazardous contamination in the food gases. Currently this study supports the authority request about the compatibility of cylinders in contact with food gases, for more information see *Migration processes of metal elements from carbon steel cylinders to food gases* [7].

7.1 Types

Two main types of carbon dioxide cylinder are available, those which discharge gas (without a dip / syphon tube) and those which discharge liquid (fitted with a dip / syphon tube). Figures 2 and 3 show an illustration of these cylinders.

Two types of valve are in common use:

- non-syphon valves for gas withdrawal, see Figure 2; or
- syphon (dip) tube fitted valves for liquid withdrawal, see Figure 3.

NOTE There are specialist valves available with twin outlets, one with a syphon tube and one without a syphon tube. These are normally only used for sampling and for refrigerant gas (R744). If this type of valve is used, then each outlet shall be separately marked.

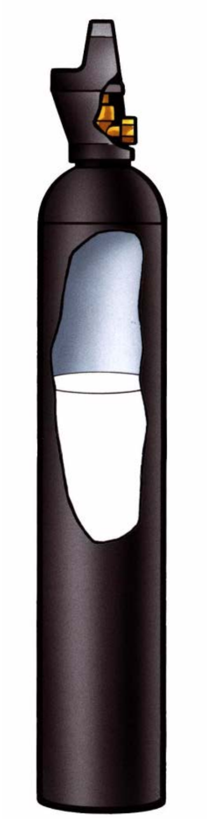


Figure 2: Cylinders for discharging gaseous carbon dioxide

NOTE Carbon dioxide vapour withdrawn through valve

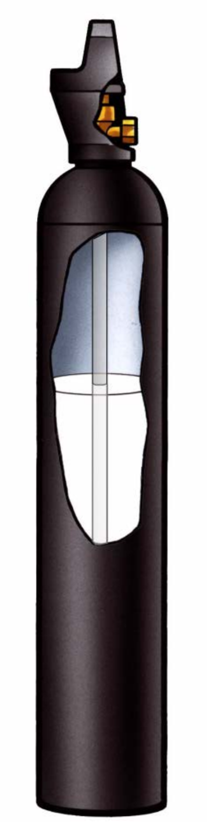


Figure 3: Cylinders for discharging liquid carbon dioxide

NOTE Liquid carbon dioxide withdrawn through dip tube

7.2 Valve protection

Valve protection shall be in accordance with the *European Agreement Concerning the Carriage of Dangerous Goods by Road* (ADR) [8]. Typically types of protection used include:

- screwed cap, which is removed for use; and
- fixed cage or a swivel cage or valve guard.

7.3 Valves

Cylinders shall be fitted with valves that comply with the requirements of ADR [8].

To avoid backflow and to protect cylinder integrity residual pressure valves (RPVs) are strongly recommended. For information about RPVs see EIGA Doc 64, *Use of Residual Pressure Valves* [9].

For food applications protection against back flow contamination shall be provided, for example an RPV see EIGA Doc 125 [6].

7.3.1 Valves with integrated pressure regulators

Beside the RPV, more sophisticated valves with an integrated pressure regulator (VIPR) are in use. This type of valve has not only a residual pressure function but also delivers the carbon dioxide at the required pressure and gas flow. VIPRs also prevent the backflow contamination.

7.4 Pressure relief devices

Whilst pressure relief devices (PRDs) are only mandatory for UN cylinders, a pressure relief device shall be fitted unless a risk assessment has been carried out to not fit a PRD, see EIGA Doc 91, *Use of Pressure Relief Devices for Gas Cylinders* [10].

Alternatively, since rupture discs are not authorised to be used in some countries for some applications (for example medical applications in UK) and in addition to systematic weight check of cylinders to avoid cylinder failure, the liquid shall be filled into the cylinder at a temperature of at least 10°C. This requirement shall also be applied to all customer owned cylinders, which are not equipped with rupture discs.

In general, bursting discs are fitted to the cylinder valve as a safeguard against the risk of developing an excessive pressure within the cylinder through over filling and / or over heating of the contents.

WARNING: *The use of anything other than the correct bursting disc is dangerous and prohibited.*

7.5 Cylinder pressure

The withdrawal or evaporation of liquid carbon dioxide produces a cooling effect and decreasing pressure in the cylinder. As shown in Appendix B, the cylinder pressure is dependent on the heat transfer through the cylinder wall and the discharge rate of the carbon dioxide. Cylinders containing carbon dioxide should not be heated to increase the cylinder pressure or to enable an increased rate of discharge. In particular, aluminium cylinders shall not be exposed to elevated temperatures.

7.5.1 Before connection

Before connecting a carbon dioxide cylinder to any equipment ensure the valve outlet connection is clean by wiping with a clean cloth.

7.6 Bundles of cylinders

For high flow demand of carbon dioxide, bundles of cylinders are commonly used.

A bundle of cylinders is an assembly of cylinders in a frame, which are connected together with hoses or pipes. It is not recommended using individual cylinder valves on each cylinder within a bundle of cylinders, to avoid over filling if a valve is closed.

7.7 High pressure tanks

Carbon dioxide can be supplied in high pressure thermally non-insulated tanks. These are used for high flow applications. Typically, the working pressure is up to 100 bar. These tanks need to be periodically inspected, usually every five years.

8 Cylinders (gas withdrawal)

8.1 Cylinder position

Cylinders for gas withdrawal are supplied without a syphon (dip) tube. They shall be used in the vertical position to avoid liquid discharge.

NOTE High gas flow to atmosphere pressure can lead to dry ice formation.

8.2 Pre-use check

Care should be taken to ensure gas is present at the cylinder valve before connection i.e. there is no dry ice present.

NOTE This action should be done in a suitably ventilated area. See Section 10.

8.3 Carbon dioxide withdrawal

The maximum permissible gaseous withdrawal rate from a cylinder is approximately 10% of the total contents per hour at an ambient temperature of 15 to 20 °C. If a greater discharge rate is required, two or more cylinders may be connected together. Further advice may be obtained from the gas supplier.

8.4 Cooling effect

As gas is discharged, liquid will evaporate, and the gas pressure will be maintained. Due to the cooling effect produced by evaporation, a layer of frost can be formed on the external surface of the cylinder. The gas flow is limited by the rate at which the heat required for evaporation can enter the cylinder and any attempt to obtain a higher flow will result in reduced supply pressure.

NOTE Excessive flow rates can result in the formation of dry ice in the cylinder which will then be apparently empty. However, any dry ice will sublime and restore pressure within the cylinder as it warms up. Dry ice has a surface temperature of –78.5 °C and care should be taken to avoid frost burns.

9 Cylinders (liquid withdrawal)

9.1 Cylinder position

Cylinders for liquid withdrawal are supplied with a syphon / dip tube. They shall be used in the vertical position to avoid gas discharge. Cylinders and / or valves with syphon (dip) tube, for liquid withdrawal, should be marked accordingly to differentiate them from those for gas withdrawal.

NOTE There are different solutions on the market for this marking due to no European or international standard to reference how to mark cylinders or valves with syphon / dip tube.

WARNING: *Cylinders with syphon / dip tubes shall not be connected to a pressure regulator. Liquid carbon dioxide can cause damage to the valve seats and diaphragms of pressure regulating valves. Cylinders with syphon / dip tubes shall not be directly connected to carbon dioxide systems designed for gas use.*

9.2 Carbon dioxide withdrawal

For high flow rates, cylinders with syphon / dip tubes may be used to obtain carbon dioxide indirectly in gaseous form. This is achieved using a high-pressure vaporiser, sized to provide the heat input necessary for evaporation. Care should be taken to prevent liquid carbon dioxide entering equipment used for gaseous carbon dioxide.

10 Cylinder handling

10.1 General handling instructions

Before handling cylinders note should be taken of manual handling regulations. Cylinders shall be handled at all times as high-pressure containers. Care shall be taken to avoid violent external blows on the cylinder or valve. Under no circumstance shall the cylinders be dropped or used as roller supports. Any cylinder that suffers visible damage during handling or use shall be set aside immediately and clearly marked. An assessment of the apparent damage should be made by a competent person and further action then agreed with the supplier.

For more information see ISO 11625, *Gas cylinders – Safe Handling*, and EIGA Doc 229, *Guideline for Manual Handling Activities of Cylinders* [11, 12].

10.2 Use of trolleys

Cylinder handling trolleys are available for holding and moving one or more cylinders at a time. These assist in the safe handling of the cylinders. Care shall be taken to ensure the cylinder retaining devices, for example, chains are secured before movement.

10.3 Other handling

If mechanical handling of cylinders is employed, with or without the use of pallets, care shall be taken that cylinders do not roll, shift or fall.

When transporting cylinders always make sure that the valve is protected for example, by a guard or cap. Refer to EIGA SL 08, *Safe Transport of Gases*, for guidance on safe transportation of gas cylinders [13].

10.4 Protective equipment

Protective gloves (preferably textile or leather) should be worn at all times for the manual handling of cylinders, to minimise the risk of hand injury. During discharge, parts of the cylinder and valve are likely to become very cold and therefore there is also the risk of frostbite if the cylinders are handled with unprotected hands, particularly if hands are wet.

Carbon dioxide cylinders contain a gas under pressure and the use of eye protection is recommended when connecting and disconnecting cylinders.

See EIGA Doc 136, *Selection of Personal Protective Equipment* for guidance on the selection of personal protective equipment [14].

11 Cylinder storage

11.1 Storage recommendations

Outdoor storage is recommended where possible. Some countries have limits on the storage of cylinders underground such as in cellars.

For confined spaces, a risk assessment shall be undertaken for cylinder storage areas and appropriate mitigation measures prescribed and reference shall be made to any local regulations.

Carbon dioxide cylinders shall be stored in an adequately ventilated area. In areas with cold weather conditions it could be appropriate to store and use the cylinders indoors in a heated room, although carbon dioxide cylinders should not be stored in warm areas. Avoid storage in direct sunlight or near steam pipes, radiators or other sources of heat. The temperature of a cylinder and its contents may not always correspond to ambient temperature. There can be a considerable increase of temperature and pressure due to exposure to sources of radiant heat.

11.2 Mitigating the risk of exposure to high carbon dioxide concentration

Dependent upon the results of the risk assessment, then mitigating measures shall be considered to reduce the risk to as low as reasonably practical (ALARP). Such measures may include carbon dioxide detectors and alarms and mechanical ventilation. Alarms shall be set to activate at a level equivalent to the exposure limit for carbon dioxide, refer to EIGA SI 24 [2].

NOTE Devices based on oxygen depletion monitoring are not suitable to be used for carbon dioxide alarms.

11.3 Position of cylinders in storage

Cylinders should be stored in the vertical position and adequately restrained. If it is necessary to store them in the horizontal position an adequate number of suitable chocks should be placed on each side of the base of the stack.

11.4 Segregation

Full and empty cylinders should be stored separately. In the storage area, cylinders for different gases or gas mixtures should be segregated. For specific advice on the storage of gas cylinders, the gas supplier should be consulted. For practical purposes within gas supplier's facilities, cylinders may be segregated for different applications or markets. Containers should be checked for product leakage, correct labelling and product identification.

12 Use of carbon dioxide

12.1 General advice

It is important to ensure that equipment used is suitable for purpose, that is designed for the appropriate pressures and temperatures and compatible with carbon dioxide.

During use the cylinder should be in the vertical position, with the valve uppermost and the cylinder firmly secured against a wall or other suitable support.

12.2 Valve operation

Cylinder valves open by turning anti-clockwise or by actuation of a lever. Generally, they are of the on / off type and are unsuitable for flow control or pressure regulation. An additional control valve shall be incorporated with the ancillary equipment if flow control or pressure regulation is required.

Do not use excessive force or any form of wrench to open the valve. If the valve spindle will not move, this indicates that the valve operating mechanism has been damaged. The cylinder shall then be labelled to indicate the fault and returned to the supplier.

12.3 Equipment

Ensure the equipment coupled to the cylinder has the correct thread. The gas supplier should be consulted for thread details.

All installed ancillary equipment such as valves, piping, hoses, vaporisers or other fittings, coupled directly to a cylinder shall be leak tight and designed and constructed for high pressure carbon dioxide use.

If a vaporiser is not used on a liquid syphon cylinder when gas discharge is required damage can occur to downstream equipment. If a gaseous carbon dioxide non-syphon cylinder is used on high flow applications, a heater is needed to prevent the regulator from freezing.

12.4 Operation

Turn off the cylinder valve when the cylinder is not in use.

Operating instructions should be displayed in the working area concerned with the cylinder installation and associated equipment. Reference shall be made to the detailed equipment data and instructions available from suppliers when operating instructions are prepared.

12.5 Safety considerations

Pipework shall have safety devices to protect against pressure rises above its design pressure, paying particular attention to sections of piping where liquid lock can occur. In any system where there is a possibility of other materials or products returning to the cylinder, causing contamination and possible corrosion, a non-return valve shall be fitted.

Heaters may be used to prevent ice formation inside regulators.

No attempt should be made to seal any leaks until the equipment concerned has been depressurised.

When the cylinder has been emptied, the valve should be closed, leaving a small positive pressure in the cylinder to prevent contamination and internal corrosion. Some cylinders are fitted with residual pressure devices. These maintain a small positive pressure within the cylinder at all times.

12.6 After use

After use, ensure that the pressure in the equipment has been released before the cylinder is disconnected. Return the empty cylinder to the supplier as soon as possible. Appendix C shows some typical installation sketches.

13 Summary of recommendations

The following is a summary of the recommendations for using carbon dioxide cylinders:

- 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, for example by welding or striking electric arcs or impact by sharp objects, shall be avoided.
- Do not use cylinders as rollers or work supports.
- Secure carbon dioxide cylinders during 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 shall not be altered.
- Never heat cylinders, for example by direct flame, electrical devices, or hot water, to raise the pressure or the flow rate.
- Cylinders shall never be directly connected to low pressure equipment.
- Cylinders used for the discharge of carbon dioxide gas (without syphon / dip tube) must be connected to a suitable reducing valve to obtain a desired pressure and flow rate.

- Cylinder valves are unsuitable for pressure and flow regulation.
- To prevent contamination and internal corrosion, the cylinder should be returned for filling with a positive pressure.
- Do not attempt to transfer carbon dioxide from one cylinder to another.
- Keep cylinder valve outlets and other carbon dioxide equipment free from contaminants.
- Do not repair or modify cylinders, cylinder valves or safety relief devices (bursting discs). Any damage should be made known to the supplier.

14 Refilling

For safety reasons cylinders owned and supplied by companies may only be filled by, or on the authority of that company. For more information see EIGA Position Paper 18, *Transfilling of Industrial Gas Cylinders* [15].

15 Maintenance

The cylinders and any associated equipment are a high-pressure installation and arrangements shall be made to ensure that it is covered by an adequate system of inspection and maintenance. Periodic inspection and testing of gas cylinders is covered by standards referenced in ADR [8].

16 Action in the event of fire

Evacuate the area and call the emergency services, for more information see EIGA Info 02, *Handling of Gas Cylinders during and after Exposure to Heat or Fire* [16].

16.1 Carbon dioxide and fire

No fire risk will arise with carbon dioxide, which is non-flammable, but care shall be taken if the fire is in an area adjacent to a carbon dioxide storage area or usage point. A rise in the outside temperature will rapidly be transmitted to the contents of the cylinders and the internal pressures will increase.

If pressures reach the set point of the burst discs, (usually 190 bar), these will rupture and discharge the entire contents to atmosphere. Ruptured burst discs shall be replaced with the same specification.

If possible, cylinders should be moved immediately away from the area to a safe cool place. However, since the product is non-flammable, and in view of the safe guard afforded by the cylinder burst discs, no serious risks should be taken by personnel in attempting removal.

Firefighting efforts should otherwise be concentrated on isolating cylinders from heat and flames as far as possible and spraying them with water to keep contents cool.

If any cylinder is involved in a fire, it shall be set aside, clearly identified and the supplier shall then be contacted immediately. If the metal of the cylinder has been subjected to a high temperature, some change in the metal structure can occur, rendering the cylinder unfit and dangerous for further use.

17 Action in the event of a gas leak

Evacuate personnel from areas where a high concentration of carbon dioxide could accumulate and away from the point of leakage.

Where practicable, steps should be taken to isolate the leakage. Risks should not be taken by personnel attempting to isolate the leakage. Personnel should concentrate on ensuring evacuation of all affected areas is complete.

Areas affected by carbon dioxide gas should be entered with extreme caution. Self-contained breathing apparatus shall be worn by trained personnel attempting to rescue or isolate leakage.

NOTE A carbon dioxide detector may be used to identify if the carbon dioxide levels are high.

18 First aid

18.1 Inhalation

In high concentrations inhalation of carbon dioxide can cause death. Symptoms at lower concentrations can include loss of mobility / consciousness. The victim may not be aware of symptoms. Remove the victim to an uncontaminated area, rescuers should wear self-contained breathing apparatus. Keep victim warm and rested. Seek medical assistance. Apply artificial respiration if breathing stopped. Further information is given in EIGA SI 24 [2].

18.2 Skin / eye contact

Immediately flush eyes thoroughly with water for at least 15 minutes. In case of frostbite spray with tepid water for at least 15 minutes. Apply a sterile dressing. Seek medical assistance.

18.3 Ingestion

Ingestion is not considered a potential route of exposure.

19 References

Unless otherwise specified the latest edition shall apply.

[1] EIGA Doc 201, *Near-Consumer Use – Risk Assessment Methodology*, www.eiga.eu.

[2] EIGA Info 24, *Carbon Dioxide Physiological Hazards - “Not just an Asphyxiant!”*, www.eiga.eu.

[3] Regulation (EC) No 1272/2008 *on classification, labelling and packaging of substances and mixtures*, www.europa.eu.

[4] EIGA Doc 169, *Classification, and Labelling Guide in accordance with EC Regulation 1272/2008 (CLP Regulation)*, www.eiga.eu.

[5] EIGA Doc 125, *Guide to the Supply of Gases for Use in Foods*, www.eiga.eu.

[6] Regulation (EC) No 1333/2008 *on food additives*, www.europa.eu.

[7] *Migration processes of metal elements from carbon steel cylinders to food gases*, National Research Council, Istituto Geochimica e Georisorse; Florence, Italy (CNR-IGG), Packaging Technology and Science, Volume 27 Issue 10 2014, www.onlinelibrary.wiley.com.

[8] *European Agreement Concerning the Carriage of Dangerous Goods by Road* (ADR) www.unece.org.

[9] EIGA Doc 64, *Use of Residual Pressure Valves* www.eiga.eu.

[10] EIGA Doc 91, *Use of Pressure Relief Devices for Gas Cylinders*, www.eiga.eu.

[11] ISO 11625, *Gas cylinders – Safe Handling*, www.iso.org.

[12] EIGA Doc 229, *Guideline for Manual Handling Activities of Cylinders*, www.eiga.eu.

[13] EIGA SL 08, *Safe Transport of Gases*, www.eiga.eu.

[14] EIGA Doc 136, *Selection of Personal Protective Equipment*, www.eiga.eu.

[15] EIGA PP 18, *Transfilling of Industrial Gas Cylinders* www.eiga.eu.

[16 EIGA Info 02, *Handling of Gas Cylinders during and after Exposure to Heat or Fire*, www.eiga.eu.

Appendix A: Physiological effects of carbon dioxide

Carbon dioxide is classified as a non-flammable, non-toxic liquefied gas. It is normally present in atmospheric air at a level of approximately 400 parts per million (0.04%). It is a normal product of metabolism being held in bodily fluids and tissues where it forms part of the body's normal chemical environment. In the body it acts in the linking of respiration, circulation and vascular response to the demands of metabolism both at rest and in exercise.

The effects of inhaling low concentrations of carbon dioxide are physiological reversible but in high concentrations the effects are toxic and damaging.

The effects of carbon dioxide are entirely 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 an oxygen content of 18% and a high carbon dioxide content, being 14% very dangerous.

Individual tolerances can vary widely, dependent on the physical conditions of the person and the temperature and humidity of the atmosphere, but as a general guide, the effects of inhaling varying concentrations of carbon dioxide are likely to be as follows:

Concentrations by volume - 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 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.

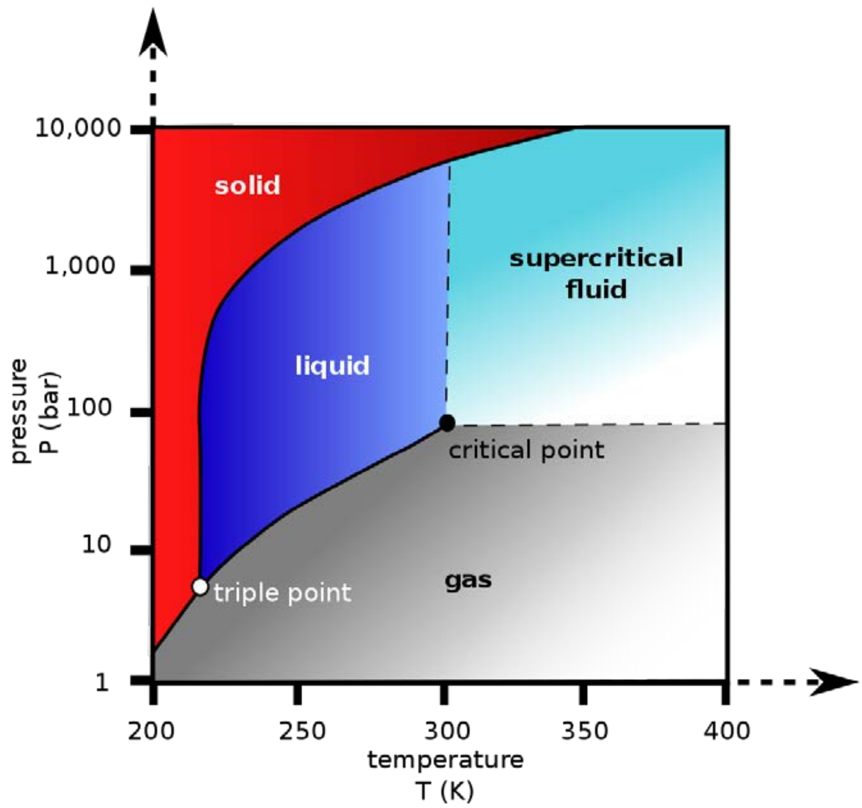
The recommended exposure limit for carbon dioxide is 5000 parts per million (0.5%) by volume, calculated on an 8 hour time weighted average concentration in air.

Depending on regulations in individual countries carbon dioxide concentration peaks up to 30 000 parts per million (3%) in air are allowed, where by the duration of exposure is between 10 minutes and 1 hour.

Cardiac or respiratory defects are likely to increase the hazards of inhalation.

Wherever any doubt exists, the recommended exposure limit of 5000 parts per million carbon dioxide in air should be regarded as the maximum level of the individual concerned.

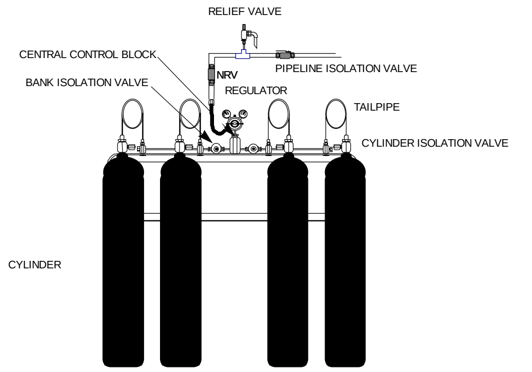
Appendix B: Pressure-temperature diagram of carbon dioxide



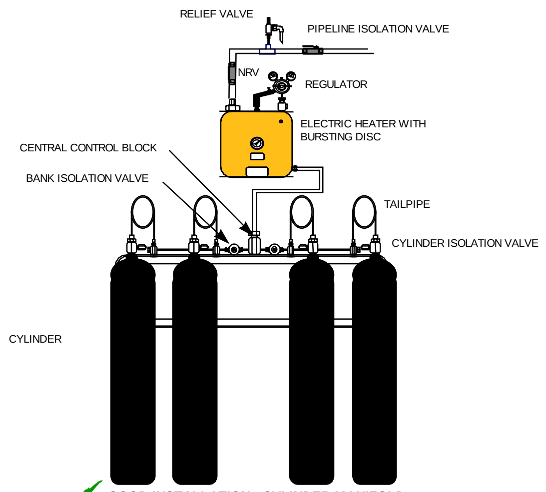
	T (K)	T (°C)	P (bar abs)
Triple point	216.55	-56.6	5.18
Critical point	304.15	31.0	73.83

Appendix C: Typical installation sketches

Good installation

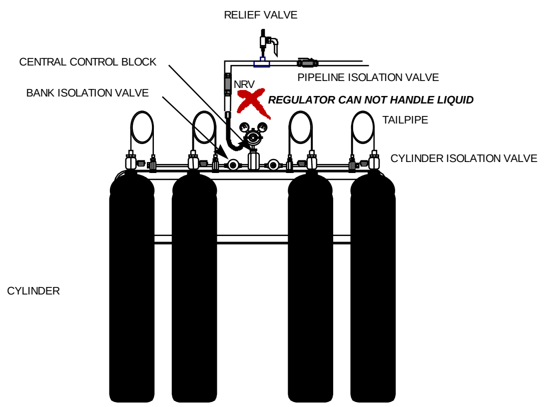


GOOD INSTALLATION - CYLINDER MANIFOLD INSTALLATION
GAS USE **(NON-SYPHON) CYLINDERS**

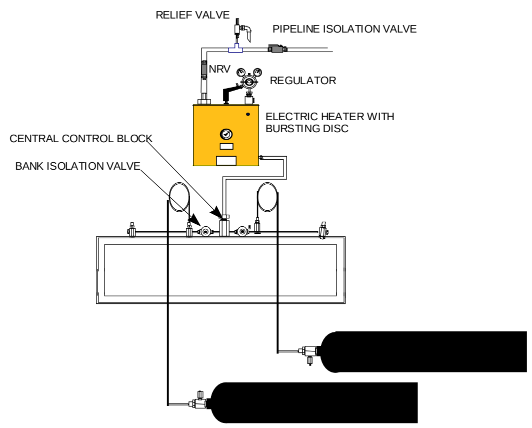


GOOD INSTALLATION - CYLINDER MANIFOLD INSTALLATION LIQUID USE (SYPHON) CYLINDERS

Unacceptable installation examples



BAD INSTALLATION - CYLINDER MANIFOLD INSTALLATION LIQUID USE (SYPHON) CYLINDERS



BAD INSTALLATION - LYING CYLINDERS UNACCEPTABLE FOR EITHER CYLINDER TYPE