



REFRIGERATED CARBON DIOXIDE STORAGE AT USERS' PREMISES

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Prepared by WG-6 Cryogenic Vessels

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Amendments to 66/08

Section	Change
	Editorial to align with EIGA Style Manual
All	Complete re-write to align with EIGA Doc 224, <i>Static Vacuum Insulated Vessels Operation and Inspection</i> [1]

NOTE Technical changes from the previous edition are underlined

1 Introduction

This publication provides the minimum requirements and the practices for design, construction, installation, operation, and maintenance of refrigerated liquefied carbon dioxide (CO₂) storage at users' premises.

2 Scope and purpose

Refrigerated liquefied carbon dioxide can be stored at users' premises in two types of vessel; vacuum insulated cryogenic vessels or pressure vessels with foam insulation and cladding. General and detailed requirements for storage of gases at users' premises, particularly vacuum insulated vessels, can be found in EIGA Doc 224, *Static Vacuum Insulated Cryogenic Vessels – Operation and Inspection* [1].¹

This publication describes the operation and hazards specific to refrigerated liquefied carbon dioxide vessels at users' premises.

This publication covers outdoor refrigerated liquefied carbon dioxide vessels up to 40 bar design pressure, and a water capacity up to 125 000 litres.

For installations in excess of 125 000 litres, this publication can also be used as guidance. In this situation local regulations can require different safety distances.

Subjects covered in this publication include:

- general information on equipment;
- layout and design features for installation;
- putting into service / commissioning (documents, installation, checking);
- maintenance and repair, taking out of service;
- inspections (daily, filling and periodic); and
- training of personnel.

This publication does not address the tankers and containers used for bulk transport and delivery of liquefied carbon dioxide, which are covered by the Transportable Pressure Equipment Directive (TPED) and transport of dangerous goods regulations (ADR) [2, 3].

This publication applies to new installations and may be used as guidance for existing installations.

This publication does not address usage equipment connected after / downstream the vessel or vaporiser system, such as gas mixers and applications equipment.

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.

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

3.1.2 Should

Indicates that a procedure is recommended.

3.1.3 May

Indicates that the procedure is optional.

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 General information

Carbon dioxide may also be called carbonic acid gas or CO₂.

A complete Safety Data Sheet is available from the gas supplier. A short summary of the properties of carbon dioxide is this section.

4.1 Physical properties

Carbon dioxide is a colourless, odourless, slightly acidic gas that is approximately 50% heavier than air. It is non-flammable and will not support combustion. Carbon dioxide can exist as a solid, liquid, gas, or supercritical fluid, depending upon conditions of temperature and pressure.

Carbon dioxide at its triple point exists simultaneously as a liquid, gas, and solid at –56.6 °C and 4.18 bar. Any change in pressure or temperature causes carbon dioxide to revert to a two-phase condition (see Figure 1 in Appendix A).

Carbon dioxide at its critical point exists simultaneously as a liquid, gas, and supercritical fluid at 31.1 °C and 72.8 bar. At pressures and temperatures greater than the critical point, carbon dioxide exists only as a supercritical fluid.

Carbon dioxide is classified as a non-toxic gas but affects breathing at concentration greater than 1%, with affects becoming more serious with increasing concentrations (see EIGA Safety Info 24, *Carbon Dioxide Physiological Hazards “Not just an asphyxiant”* and EIGA Doc 23.06, *Safety Training Leaflet – Carbon Dioxide* [4, 5]).

Liquid carbon dioxide is transported, stored and handled either at ambient temperature in cylinders or non-insulated storage vessels at pressures in the range of 45 to 65 bar or as refrigerated liquid in insulated transportable vessels and storage vessels at a temperature range of –35 °C to –15 °C and at pressures of 12 to 25 bar. The carbon dioxide, in refrigerated state is a liquid at its boiling point.

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 into dry ice blocks or pellets. Dry ice is handled in insulated atmospheric 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. Carbonic acid is corrosive and provides the biting taste of soda water; 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 should not be used as a fire extinguishing agent for reactive metals like sodium and magnesium.

4.3 Precautions

The properties of liquid carbon dioxide require that a number of specific precautions are taken.

4.3.1 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 CO_2 gas could accumulate in high concentration, are particularly hazardous because the gas is slow to disperse unless the spaces are well ventilated.

Further information on the hazard from oxygen deficiency in EIGA Doc 44, *Hazards of Inert Gases and Oxygen Depletion* [6]. More details about physiological effects are found in EIGA Safety Info 24 [4].

Emergency procedures for a substantial release of CO_2 should be established, including an evaluation of the need of self-contained breathing apparatus and a recommendation to inform the supplier as soon as possible.

In case of a substantial release of carbon dioxide in confined areas, evacuate all personnel as soon as possible. Personnel shall not enter such areas before they are completely ventilated to a safe atmosphere.

When confined spaces are entered before they are properly ventilated, the personnel entering such areas shall use self-contained breathing apparatus, be trained in its use and follow tried and tested procedures. Confined space entry may be governed by national regulations.

WARNING Canister respirators give no protection for atmospheres containing dangerous concentrations of carbon dioxide.

Substantial releases of carbon dioxide may occur through:

- failure of pipework containing carbon dioxide;
- failure of flexible hoses through movement of the road tanker while the hoses are still connected between road tanker and storage vessel;
- release from a relief valve;
- inadvertent opening of a drain or vent valve while the system contains CO_2 ;
- failure of connections, for example flexible hoses, flanges etc; or
- failure of a regulating device resulting in gas release through the body vent holes.

4.3.2 Low pressure in storage vessel

When compressed gas is allowed to expand or liquid to evaporate, the temperature of the system falls. If larger quantities of carbon dioxide gas are rapidly lost from the storage vessel, either accidentally through automatic or manual relief, or through excessive withdrawal of CO_2 , the temperature in the vessel could fall below the minimum permitted operating temperature.