INDOOR INSULATED CARBON DIOXIDE SUPPLY SYSTEM

Doc 260/25

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INDOOR INSULATED CARBON DIOXIDE SYSTEMS

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Disclaimer

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1 Introduction

This publication provides the minimum requirements and the practices for design, construction, installation, operation, and maintenance of indoor small stationary insulated carbon dioxide supply systems at users' premises and addresses the hazards specifically associated with it.

2 Scope and purpose

The purpose of this publication is to provide a guidance for small stationary insulated carbon dioxide systems with the capacity of each vessel 1000 litres or less. It is intended to assist designers, engineers, distributors, restaurant personnel, inspectors, other users, and all interested parties. This publication does not cover transportable vessels built under TPED standards

NOTE—TPED Transportable vessels and PED stationary vessels can look the same to the inexperienced user.

This guidance contains minimum requirements and recommended practice for the design, construction, installation, operation, and maintenance of small stationary insulated carbon dioxide systems for indoor installation.

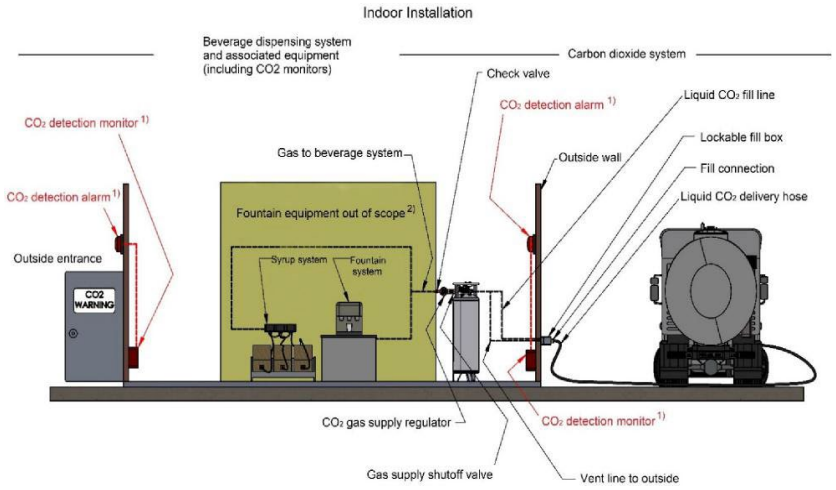
This document covers these systems from the fill connection to the carbon dioxide vessel gas outlet regulator, for indoor installation see Figure 1. These systems are primarily used for supplying carbon dioxide gas at beverage dispensing sites and can also be used in greenhouses, by welding fabricators, and for other applications. These systems might also be covered by various local codes. The details of these codes are not covered in this publication. Additional information on carbon dioxide is published in EIGA Safety Information 24 [1][1]

***CAUTION**: The piping and equipment beyond the small stationary insulated carbon dioxide storage vessel outlet valve is capable of releasing hazardous amounts of carbon dioxide. Installation of piping and equipment connected to the small stationary insulated carbon dioxide supply shall be performed by qualified personnel.*

Although this publication shows placement of carbon dioxide detection monitors in various portions of the user facility, the responsibility for the proper location, installation, maintenance, and monitoring of the detection monitoring systems and its component parts is not specifically identified in this publication. The user is generally responsible for these activities. If not, they should be fully described in an agreement between the user and their monitoring equipment manufacturer and installer, or in some instances between the user and their carbon dioxide supplier.

While this guidance is to be used as a guide for user installations, final approval of the design, equipment, accessories, and installation rests with local authority.

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



1) Carbon dioxide (CO2) gas detection monitor shown is for illustrative purposes only. See 4.2 and Figures 3-6 for more information. Carbon dioxide gas detection system component location(s) should comply with manufacturer's recommendations.

2) Fountain, keg room, and other associated equipment using carbon dioxide are outside the scope of this publication but may have requirements for installed carbon dioxide monitors.

Figure 1—Typical indoor small stationary insulated carbon dioxide supply system for beverage carbonation and dispensing

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.

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 Accessories

All system components (excluding the vessel) such as PRDs, liquid level gauges, valves, pressure gauges, vaporizers, pumps, control equipment, and regulators.

3.2.2 Blow-down valve

Manually operated valve used to depressurize lines or systems.

3.2.3 Capacity

Amount of carbon dioxide the vessel will hold under equilibrium conditions at normal working pressure and temperature when filled to its design level.

3.2.4 Carbon dioxide leak detection system

System of components used to measure and announce potentially hazardous concentrations of carbon dioxide. This can include sensors, monitor, control unit, and audible and visual notification devices.

3.2.5 Vessel

Thermally insulated vessel intended for use with liquid CO_2, consisting of an inner vessel, an outer jacket, the associated piping system and accessories, forming a functional whole, ready to put into service.

NOTE - Vessel is intended for on-site use only.

3.2.6 Maxumium allowable pressure (service pressure Ps)

Maximum pressure permissible at the top of the vessel in its normal operating position.

3.2.7 Fill box

Connection point of the fill line that allows the carbon dioxide delivery truck to transfer liquid into the vessel. Typically, the vent line discharges to the atmosphere through a separate fitting in the fill box.

3.2.8 Fill connection

A fitting that includes an integral check valve permanently attached to the fill box or vessel to which the liquid carbon dioxide fill gun is attached.

3.2.9 Fill gun

The assembly attached to the delivery end of the liquid carbon dioxide delivery vessel fill hose. The fill gun contains a liquid carbon dioxide fill connection that attaches to the vessel fill connection.

3.2.10 Fill line

Line connecting the fill box to the vessel for transferring liquid carbon dioxide under pressure.

3.2.11 Liquid carbon dioxide

Carbon dioxide can exist as a liquid only at pressures between 4,16 bar and 72,80 bar and temperatures between –56.6 °C and 31.1 °C. Additional information on NIST Chemistry WebBook [2].

3.2.12 Triple point

In thermodynamics, the triple point of a substance is the temperature and pressure at which the three phases (gas, liquid, and solid) of that substance coexist in thermodynamic equilibrium (for CO_2: 4,16 bar and –56,6°C)

3.2.13 Working pressure

Pressure at which the system normally operates

3.2.14 Pressure relief device (PRD)

Device designed to open at a pre-set pressure to prevent the internal pressure from rising above a specified value.

3.2.15 Purging

Procedure for removing air, moisture, and other foreign materials by using carbon dioxide vapor.

3.2.16 Qualified technician

Person who by reason of education, training, and experience knows the properties of carbon dioxide; is familiar with the equipment used to store, transfer, and use carbon dioxide; and understands the precautions necessary to safely operate carbon dioxide equipment.

3.2.17 Vent line

Line used to conduct gas from a PRD or vent valve (including purging process) to a safe location (e.g. outside the facility).

4 Hazards

4.1 General

Personnel handling liquid carbon dioxide should be thoroughly familiar with the hazards associated with this product. There are several conditions in which extreme danger to personnel and equipment can exist. The following describes these conditions and offers procedures and guidelines to prevent dangerous conditions from developing.

4.2 Personnel overexposure

Personnel handling liquid carbon dioxide should be thoroughly familiar with the hazards associated with this product. There are several conditions in which extreme danger to personnel and equipment can exist. The following describes these conditions and offers procedures and guidelines to prevent dangerous conditions from developing. See Figures 2, 3, 4, and 5.

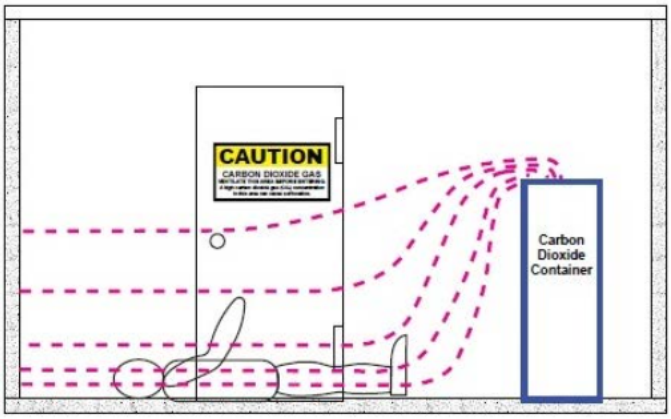


Figure 2 - Example of an unsafe, enclosed space

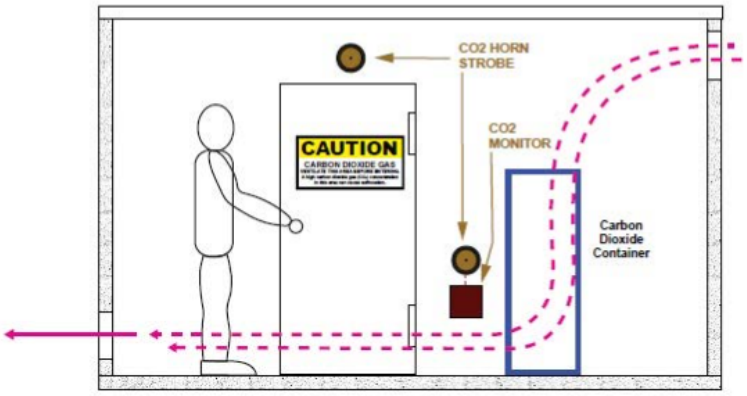


Figure 3 - Example of naturally ventilated and monitored enclosed space

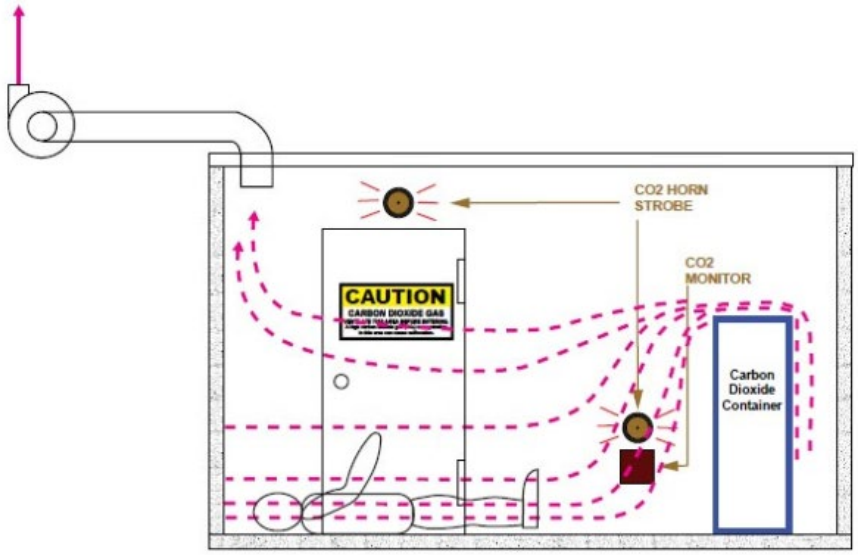


Figure 4 - Example of properly monitored but improperly ventilated enclosed space

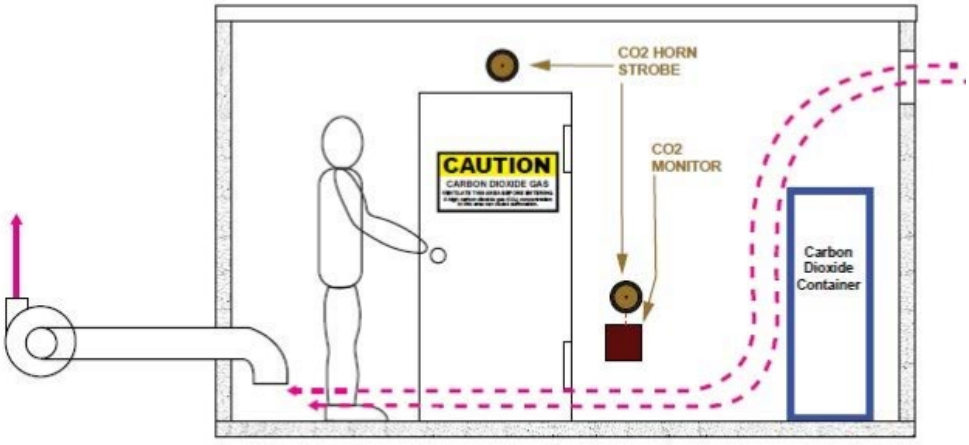


Figure 5 - Example of properly ventilated and monitored enclosed space

NOTE Small enclosures not large enough for human access or occupancy are not subject to these criteria.

4.3 Carbon dioxide detection system

A job hazard analysis shall be performed to assess the highly possible risk of intoxication and associated risk with carbon dioxide use (liquid and gas).

Carbon dioxide detection shall be installed as standard unless the job hazard analysis demonstrates safe atmospheric level can be permanently ensured. Additional measures described in EIGA Safety Information 24 shall be considered [1].

4.4 Overfilling vessels

When liquid carbon dioxide is stored in a vessel and there is no product withdrawal, heat leak causes the temperature and pressure to rise and the liquid to expand. As long as there is a vapor space in the vessel, the pressure rises about 0.62 bar per °C. When the vessel becomes full of liquid, the hydrostatic pressure rises at the rate of 5.50 bar per °C.

Vessels shall be filled following manufacturer's guidelines and shall not exceed maximum design fill level. Filling level shall consider the risk of ice plug formation in venting system of PRD The maximum filling level depends on the temperature of the liquid being transferred into the container. The colder the liquid, the more vapor space required for liquid expansion.

Do not fill vessels using a pump without having an engineered system design with safeguards to prevent overfilling and exceeding maximum allowable pressure (see EIGA Doc 151) [3].

5 Physiological effects of Carbon dioxide

For information on the physiological effects of carbon dioxide, see EIGA Safety Information 24 [1].

6 Design of Carbon dioxide supply systems

6.1 Vessels

The vessels shall be designed, manufactured, and certified in accordance with the requirements of PED.

6.2 Pressure relief devices

Vessels for liquid CO2 shall be provided with suitable devices connected to the gas phase which prevent over-pressurisation above the maximum allowable pressure of the vessel.

Selection and sizing of pressure relief devices should be in accordance with applicable standards.

For example: the capacity of pressure relief devices should take into consideration the maximum heat input through

- the insulation,
- the failure of pressure building system
- failure of vacuum insulation.

It is normal practice for a vessel to be equipped with at least two suitable sized pressure relief devices directly connected with the gas phase.

An adequately sized three-way valve selector valve is recommended to allow for periodic maintenance and pressure relief devices testing without removing the vessel from service.

If a three-way valve is installed to accommodate two or more pressure relief devices operating, either simultaneously or alternatively, the size of the valve, regardless of the position of the actuating device, shall be such that the vessel is adequately protected. For diverter valve only sized for full flow on one side, the diverter valve should be locked in the adequate position (sealing of diverter valve lever/handle wheel). The three-way valve should be provided with a position indicator showing which relief devices are on-line.

Pressure relief devices shall be installed in such a way that dirt, moisture or other foreign objects cannot accumulate on the valve seat and the relief valves are not enveloped by ice and shall be installed in accordance with manufacturer recommendations (e.g. vertical position). Each relief valve shall be clearly marked with information required by applicable standard (e.g. opening set pressure, size orifice, flow direction, serial number, manufacturer identification)

Bursting / rupture discs are not recommended for refrigerated liquid carbon dioxide vessels due to the risk of premature failure, vessel depressurisation and formation of solid carbon dioxide.

NOTE – Burst discs may be used on small liquid carbon dioxide vessels, typically less than 500 litres, with stainless steel inner vessels.

Follow the manufacturer's recommendations regarding the installation and external venting of PRDs. Under no circumstances should the design of the discharge piping pressure drop be restricted sufficiently to exceed a 10% backpressure on the valve under full-flow conditions (see ISO 21013-3) [4]. The outlet venting piping of the PRD shall be designed to ensure that draining of any condensate is adequate. All PRDs shall be discharged to a safe location.

WARNING: *Any modification to the pressure relief device that does not meet design requirements can lead to vessel overpressurization that can cause equipment damage, personal injury, or death.*

6.3 Other accessories

Each vessel shall be provided at least with a level and pressure indicator. The supply system shall have a supply pressure indicator.

6.4 Material selection– piping, tubing, hoses, fittings and accessories

All stationary piping, tubing, hoses, fittings and accessories shall meet the requirements of this section. Materials shall be selected that are compatible with carbon dioxide (gas and liquid) and rated for the temperatures and pressures encountered in the system.

For food and beverage application, compliance to the applicable food safety and quality regulations shall be required

In case of over withdrawal flow or excess venting (leak on safety valves or back pressure regulator), pressure and temperatures inside the pressure vessel could drop and leading to dry ice formation. The material selection for equipment exposed to liquid (e.g. vessel, external vaporizer), should consider such low temperature risk -78.5°C and if a such condition occurs, see 9.3

Material specifications shall also take into consideration and be rated for environmental conditions encountered where the system is installed. Stainless steel, copper, brass, and some properly rated plastic/polymer materials are suitable for these systems. Cast iron or galvanized materials shall not be used in these systems

All hoses, fittings, and tubing used in carbon dioxide service shall be designed according to PED and local regulation.

7 System installation

7.1 General guidelines

Vessels shall be installed, put into service, tested and maintained in accordance with the applicable codes, local legislation and manufacturer recommendations. Vessels shall be sited and operated taking into account the safety of staff and other persons, property and the environment. The location of potentially hazardous processes in the vicinity, which could jeopardize the integrity of the storage installation, shall be assessed.

For installations where piping is run through spaces that are not air-conditioned, such as an attic, the materials used shall be suitable for the high ambient temperatures that can be present. This is of particular concern when plastic/polymer materials are used.

Barbed connections shall not be used. Any types of push-on connectors shall be installed according to the manufacturer's instructions and be rated for the pressures and temperatures encountered. Plastic/polymer fill and vent lines shall be a continuous run and shall not be made of multiple portions.

Carbon dioxide piping shall be routed as directly as practical and be adequately supported to prevent undue strain on the piping or fittings. Where required, provide for expansion, contraction, and vibration. Piping shall be routed to prevent or protect it from mechanical or heat damage.

The system shall be free of water, oil, grease, and other foreign material before being placed in service.

7.2 Venting

Any liquid or gas vent valves used for depressurizing or maintenance shall be piped so they discharge in safe location.

DANGER: *Never discharge carbon dioxide vapor or liquid inside a facility as it could lead to personal injury or death.*

Follow the manufacturer's recommendations regarding the installation and external venting of PRDs. Because carbon dioxide vapor is heavier than air, it will collect in basements and stairwells and other enclosed areas both interior and exterior to the building.

Unless the job hazard analysis demonstrates safe atmospheric level can be permanently ensured, relief devices shall be vented to an area outside the building where hazardous levels of carbon dioxide will not accumulate. Venting of PRDs shall be to areas where the vapor will not re-enter the building. Following discharge locations shall be avoided (not limited to):

- Any below grade areas including basements, enclosed stairwells, below grade enclosed loading docks;
- Interior hallways, such as service areas of enclosed access corridors;
- Rooftops with parapet walls, especially where rooftop ventilation intakes are present;
- Courtyards, having solid walled enclosures, even if there is no roof;
- Above windows that can open to the interior of a building or into enclosed spaces;
- Locations near intakes for ventilation systems; and
- Outside enclosed areas without at least 25% free air flow at the bottom of the enclosure walls

Relief device shall be provided in each section of pipe, hose, or tubing in which liquid CO_2 can be trapped.

7.3 Putting into service / commissioning – Checks and testing

Prior to putting the installation into service inspections and in-service tests, such as pressure tests shall be performed in accordance with written / established procedures.

Further information on putting into service can be found in EIGA Doc 224 [5], including:

- checking the indoor installation, including compliance to job hazard analysis
- checking the markings;
- ready for start-up review;
- checking the equipment;
- testing the installation;
- pressure test;
- pressure relief devices;
- adjustment of controlling devices; and
- commissioning;

For further information on leak detection fluid, see harmonized document EIGA Doc 78, *Leak Detection Fluids Use with Gas Cylinder Packages* [6].

7.4 Fill connections

All liquid fill line should be piped to an outside connection.

Fill connections may include a cap or a cover to protect it from contamination. Pressure accumulation risk should be considered (eg. wheep hole on cap or purge valve to release pressure before opening)

Fill connection should be protected from non-authorize access (e.g. Fill box)

8 Filling small insulated carbon dioxide system

8.1 General

Liquid transfers are generally accomplished with a single transfer hose, that is compatible with carbon dioxide and rated for the temperatures and pressure encountered in the system. See EIGA Technical Bulletin 26 *Cryogenic Flexible Hoses* [7].

Where the maximum delivery pressure of the transfer pump can exceed the upper pressure limit of the storage vessel, protective measures should be considered to prevent overpressure. See EIGA Doc 151 *Prevention of Excessive Pressure during Filling of Cryogenic Vessels*, for more information [3]. All liquid fill line should be piped to an outside connection.

8.2 Transfer procedure

The following step(s) should be included in the transfer procedure for filling small insulated carbon dioxide systems:

a) For transfilling with road tanker in public area, the hazard area shall be clearly defined using suitable notices during the transfer period. Access to this area during transfer shall be strictly controlled.

b) Before filling the indoor vessel, the operator/driver shall verify that the system is within normal working pressure range.

c) Inspect and confirm the transfer hose is in good condition and the cleanliness of the fill connection;

d) Connect the transfer hose to the fill connection and purge;

e) Prior to starting product transfer, pressurize the system between the delivery connection of road tanker and the fill connection of the CO2 vessel (i.e delivery flexible hose and extended fill line) with gas to avoid dry ice formation.

f) Open the fill valve to start the transfer. The filling procedure shall specify venting procedure for excess pressure in the filled vessel (manually or automatic excess pressure management)

CAUTION: *During the initial filling or liquid transfer, when the internal pressure reaches the design opening set pressure of the automatic fill regulator, verify that the venting gas is flowing from the vent line outlet. If no vent flow is observed, stop filling and investigate why the vent gas is not flowing to the outside.*

g) When the defined filling level or the maximum allowable pressure of the vessel is reached (e.g. full level indicator at filling connection or automatic stop filling) stop transfilling process on the road tanker and close the delivery valve of the road tanker

h) Close the fill valve and properly purge any remaining liquid from the fill hose and piping with a vapor purge;

i) Depressurize the fill hose and piping.

j) Disconnect the fill hose and return the hose to the stored position.

k) Close filling connection and perform a general visual check of all parts (mobile equipment and customer installation.

Note: EIGA Doc 56 *Guide for the Delivery of Bulk Carbon Dioxide* [8] should be considered.

9 Inspection and maintenance

If leaks are suspected in buildings where carbon dioxide is used, entry into the space shall only be permitted when properly functioning carbon dioxide gas detection and alarm systems indicate it is safe or the atmosphere is tested for safe carbon dioxide concentrations.

WARNING: *Entry into areas with unsafe concentrations of CO2 may cause personal injury or death.*

Installed carbon dioxide monitors should be checked according to the carbon dioxide monitor manufacturer's guidelines for proper operation and inspection frequency, and according to local regulation. Ensure placement of carbon dioxide monitors and warning signs meet the local regulation.

9.1 Inspection

A rigorous preventive maintenance programme is a crucial element of any food safety programme The customer should check the overall installation for normal working pressure, liquid carbon dioxide contents, leaks, or any other evidence of system malfunction. Checks should be made following operation manual.

A qualified technician shall inspect the entire system periodically and in accordance with local regulation. Mechanical damage, corrosion, abnormal frost spots, leaks, or any unsafe condition noted shall be corrected promptly or the system shall be taken out of service until corrected.

For leak detection use a properly applied leak detection solution compatible with system components. Follow manufacturer’s instructions for mixing of leak detection solution concentrate and application rates.

Failure to use leak detection solutions correctly has the potential to damage materials. Repair or replace any sections or components showing evidence of leaks. Service or repairs to an installation shall only be performed by trained and qualified technician.

The vessel PRD maintenance shall be performed in accordance with local regulation. No field adjustments shall be made to PRDs. At no time shall all PRDs be closed off at the same time with an isolation valve or a solid plug or cap.

The vessel shall be inspected by the notified body according to local regulation.

9.2 Maintenance

Systems shall be maintained by qualified technicians in accordance with the manufacturer's instructions.

Any time a vessel is disconnected or taken out of service, the vessel fill valve (located in the fill box) should be locked, disabled, or removed and the fill box should be tagged "out of service, do not fill."

WARNING: *Inadvertently filling an out of service vessel where the fill and/or vent lines are not connected to the vessel could cause discharge of carbon dioxide into an enclosed space causing personal injury or death.*

9.3 Loss of pressure and dry ice formation

Should the functioning of a PRD or high vapor withdrawal use cause the vessel pressure to drop below the triple point, the liquid will convert to solid carbon dioxide (dry ice). If this occurs, the liquid level and pressure gauges can give inaccurate readings. Vessels that have converted to dry ice should be removed from service and properly repressurized by a qualified technician using procedures approved by the manufacturer and following harmonized document EIGA Doc 164 *Safe Handling of Liquid Carbon Dioxide Vessels That Have Lost Pressure* [9].

In the event that a PRD sticks open and the vessel contents converts to dry ice, the PRD vent line, when made of plastic/polymer, shall be inspected and/or replaced due to the effects of the abnormally cold gas or dry ice exposure which may cause cracks, leaks, or failure of the vent line.

WARNING: *A leaking vent line can cause unsafe concentrations of CO2 which may cause personal injury or death.*

10 Training of personnel

All personnel directly involved in the commissioning, operation, inspection and maintenance of liquid carbon dioxide storage systems shall be aware of the hazards associated with carbon dioxide and trained to carry out their functions.

The gas supplier shall ensure training and qualification of user representative before starting operation and shall provide operating manuals of the equipment.

It is also the responsibility of the user to ensure that this training and awareness is ongoing and current. Training and information shall be carried out under a formalised system by the user. A training record shall be maintained which details the training and information personnel has received and what additional training is required, the training program shall be repeated, and refresher courses organised on a periodic basis

The training programme shall include, but not necessarily be limited to, the following subjects:

- normal operating procedures / safe operating limits;
- information on cryogenic equipment and accessories;
- product and hazard identification;

- physical and chemical properties of carbon dioxide and its effect on the human body;
- site safety regulations;
- emergency procedures;
- use of protective clothing / apparatus including self-contained breathing apparatus where appropriate;
- first aid treatment for cryogenic burns; and
- fire-fighting equipment.

11 References

Unless otherwise specified, the latest edition shall apply.

[1] EIGA Safety Info 24, *Carbon Dioxide Physiological Hazards - 'Not just an asphyxiant'* www.eiga.eu.

[2] E. W. Lemmon, I. H. Bell, M. L. Huber, M. O. McLinden *"Thermophysical Properties of Fluid Systems"* in NIST Chemistry WebBook, NIST Standard Reference Database Number 69, Eds. P.J. Linstrom and W.G. Mallard, National Institute of Standards and Technology, Gaithersburg MD, 20899, NIST Chemistry WebBook

[3] EIGA Doc 151, *Prevention of Excessive Pressure during Filling of Cryogenic Vessels* www.eiga.eu.

[4] ISO 21013-3, *Cryogenic vessel – Pressure-relief accessories for cryogenic service*, www.iso.org.

[5] EIGA Doc 224, *Static Vacuum Insulated Cryogenic Vessels Operations and Inspection,* www.eiga.eu.

[6] EIGA Doc 78, *Leak Detection Fluids Use with Gas Cylinder Packages*, www.eiga.eu.

[7] EIGA Technical Bulletin 26, *Cryogenic Flexible Hoses*, www.eiga.eu.

[8] EIGA Doc 56, *Guide for the Delivery of Bulk Carbon Dioxide*, www.eiga.eu.

[9] EIGA Doc 164, *Safe Handling of Liquid Carbon Dioxide Vessels That Have Lost Pressure*, www.eiga.eu.