



CGA G-6.3—2021 CARBON DIOXIDE CYLINDER FILLING AND HANDLING PROCEDURES

FIFTH EDITION

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Full document details: CGA G-6.3-2021

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Work Item 14-038
Carbon Dioxide Committee

NOTE—Technical changes from the previous edition are underlined.

FIFTH EDITION: 2021
FOURTH EDITION: 2013
THIRD EDITION: 2002
SECOND EDITION: 1995

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1 Introduction

This publication is one of a series compiled by the Compressed Gas Association, Inc., to satisfy the demand for information on the production, handling, storage, transportation, and use of carbon dioxide in gaseous liquid and solid states. There are other CGA publications that provide similar information on other products.

2 Scope and purpose

2.1 Scope

The scope of this publication includes the inspection, filling, handling, labeling, and shipping of uninsulated carbon dioxide cylinders, and the preparation of shipping papers.

In addition to the cylinder filling procedures in this publication, filling carbon dioxide cylinders for medical, food, or beverage use requires the use of product that meets appropriate CGA quality verification levels (QVL) as listed in CGA G-6.2, *Commodity Specification for Carbon Dioxide*, and requires additional procedures per regulatory requirements [1].¹

CGA G-6, *Carbon Dioxide*, contains information critical to safe storage and handling of carbon dioxide [2]. To ensure personnel safety and proper system design, reference to CGA G-6 is highly recommended [2]. Without obtaining CGA G-6, the reader will not be provided with significant information related to the physical properties and common hazards associated with storage, production, transportation, and handling of carbon dioxide [2]. This publication does address the hazards specifically associated with insulated liquid carbon dioxide systems at consumer sites.

This publication does not cover stationary, in place, high pressure cylinder filling systems and processes where individual cylinder fill capacity is not measured by weight. These systems shall have an engineered safety risk-analysis before installation and use.

2.2 Purpose

The primary purpose of this publication is to provide information to personnel engaged in handling, filling, and transporting carbon dioxide cylinders.

3 Definitions

For the purposes of this publication, the 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.

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

3.2 Technical definitions

3.2.1 Authorized regualifier

Facility that is registered with and approved by the U.S. Department of Transportation (DOT) and/or Transport Canada (TC) for the requalification of cylinders or containers.

3.2.2 Bar

Metric unit of pressure. 1 bar = 100 kPa.²

NOTE—1 bar is equal to approximately 14.5 psi. To convert psi to bar, multiply by 0.06895.

3.2.3 Blow-down valve

Valve used to depressurize lines or systems.

3.2.4 Capacity

Maximum weight of carbon dioxide a container holds when filled to the proper level.

3.2.5 Condemned cylinder

Cylinder that is no longer fit for service.

3.2.6 Container

Insulated pressure vessel, which is American Society of Mechanical Engineers (ASME) coded for the storage of carbon dioxide.

3.2.7 Cylinder

Pressure vessel designed for pressure higher than 40 psia and having a circular cross section.

NOTE—For the purpose of this publication, cylinder does not include portable tanks, cargo tanks, tank cars, or multi-unit tank car tanks.

3.2.8 Filling density

Percent ratio of the weight of gas in a cylinder to the weight of water that the cylinder will hold at 16 °C (60 °F) (1 lb of water = 27.737 in³ at 60 °F) [4].

3.2.9 Fill weight

Weight of the cylinder valve, hose, and the net weight of the carbon dioxide in the cylinder.

3.2.10 Gross weight

Weight of an empty cylinder and valve assembly plus the weight of carbon dioxide when properly filled. This is the cylinder tare weight added to the contents weight without the hose attached.

3.2.11 Hydrostatic cylinder test

Procedure that measures the expansion of a cylinder pressurized with water to a given pressure.

3.2.12 Liquid carbon dioxide

Carbon dioxide can exist as a liquid only at pressures between 75.1 psia and 1070.6 psia (518 kPa, abs and 7382 kPa, abs) and temperatures between –69.9 °F and 87.9 °F (–56.6 °C and 31.1 °C).

3.2.13 Mass weight (M)

Indicates the weight of the cylinder only, does not include the valve or any other attachments or contents.

NOTE—For example, cylinders manufactured after 2002 will be marked M-??-lb (XX kg), where ?? equals the mass weight in pounds and XX equal the mass weight in kilograms.

3.2.14 Net weight

Weight of the actual contents in the cylinder.

² kPa shall indicate gauge pressure unless otherwise noted as (kPa, abs) for absolute pressure or (kPa, differential) for differential pressure. All kPa values are rounded off per CGA P-11, *Guideline for Metric Practice in the Compressed Gas Industry* [3].

3.2.15 Service pressure

Authorized pressure marked on the container (e.g., cylinders marked "DOT-3AA-2265" or "CTC-3AA-2265," the service pressure is 2265 psig [15 620 kPa] at 70 °F [21.1 °C]).

3.2.16 Sublimation

Process of changing from the solid phase directly to the gas phase without passing through the liquid phase.

3.2.17 Tare weight (T)

Indicates the weight of the empty cylinder ready for filling, including the weight of the valve and other permanent attachments.

NOTE—This is marked as the T weight, on the current TC cylinder. For example, cylinders manufactured after 2002 will be marked T-??-lb (XX kg), where ?? equals the tare weight in pounds and XX equal the tare weight in kilograms. T = M + Valve and other permanent attachments (excluding removable caps).

3.2.18 Triple point

Temperature and pressure at which a material exists simultaneously as a solid, liquid, and gas. For carbon dioxide the triple point is 75.1 psia (518 kPa, abs) and −69.9 °F (−56.6 °C).

4 Physiological effects and hazards of carbon dioxide**4.1 Physiological effects**

For information on the physiological effects of carbon dioxide, see CGA G-6 [2].

4.2 Hazards

The hazards outlined in CGA G-6 can occur in this operation [2]. Cylinder filling and handling can be more prone to dry ice blocking/plugging and trapped liquid. For information on and remediation of these and all hazards of carbon dioxide, see CGA G-6 [2].

5 Cylinder regulations**5.1 Cylinder pressure**

A carbon dioxide cylinder is a pressure vessel used in high pressure service. The pressure in liquid carbon dioxide cylinders varies with ambient temperatures. Removal of carbon dioxide from the cylinder will cause the remaining liquid to boil, causing the cylinder to cool slightly and absorb heat from the surrounding environment. The cylinder eventually warms up to ambient temperature conditions restoring it to its equilibrium pressure. Because the carbon dioxide is stored as a liquefied compressed gas, carbon dioxide cylinders shall only be filled by weight and not by pressure. As long as some liquid remains in the cylinder, the pressure in the cylinder remains unchanged for a constant temperature condition. A very high amount of energy is stored in carbon dioxide cylinders and they should be handled carefully. A 20 lb (9.1 kg) capacity cylinder with a pressure of 838 psi at 70 °F (5870 kPa at 21.1 °C) exerts a force of 35 000 lb (155 700 N) across the bottom surface alone. Failure of a carbon dioxide cylinder due to overfilling, corrosion, or mishandling can cause considerable damage and personal injury.

5.2 Materials of construction

Carbon dioxide cylinders are fabricated from steel or aluminum with a minimum rated service pressure of 1800 psi (12 400 kPa). For more information on cylinder specifications see CGA P-15, *Standard for the Filling of Industrial and Medical Nonflammable Compressed Gas Cylinders* [5]. Typical dimensions and capacities of the most commonly used carbon dioxide cylinders are listed in Table 1.

5.3 Regulatory authorization

The cylinders commonly used by industry are manufactured from steel or aluminum as authorized by DOT and TC. DOT-3A and -3AA are seamless steel cylinders. DOT-3AL and CTC-SP922 are seamless aluminum cylinders. Cylinders may also be made to a DOT exemption or special permit (DOT-EXXX or DOT-SP XXX) or a

TC special permit (TC-SPXXXX). Cylinders may also be manufactured to a DOT or TC specification for UN refillable seamless steel cylinder, such as ISO 9809-1, ISO 9809-2, or ISO 9809-3.

Current authorizing agencies are DOT in the United States and TC in Canada. Previous authorizing stampings included Interstate Commerce Commission (ICC) in the United States and Canadian Transport Commission (CTC), Railroad Transport Commission (RTC), and Board of Trade Commissioners (BTC) in Canada.

For shipments made using an exemption or special permit, the shipper shall have a copy of the exemption or special permit and shall comply with all requirements before filling E-xxxx or SP-xxxx cylinders. These are available from the cylinder manufacturer, the authorizing agency, or the owner.

Table 1—Typical dimensions and capacities of carbon dioxide cylinders

Nominal carbon dioxide capacity	Internal volume	Water weight capacity	Overall length	Diameter
(lb)	(in ³)	(lb)	(in)	(in)
0.22 (3.5 oz)	9	0.32	5 5/16	2
0.45 (7oz)	18	0.65	9 3/8	2
0.66 (10.5 oz)	27	0.97	13	2
0.75 (12 oz)	31	1.1	9 3/8	2 1/2
1	41	1.5	7 13/16	3 3/16
1.25	51	1.6	9 3/8	3 3/16
1.5	61	2.2	11 1/8	3 3/16
1.75	71	2.6	12 1/2	3 3/16
2	84	3	9 1/4	4 3/8
5	205	7.4	14 3/4	5 1/4
10	408	14.7	16 3/4	6 7/8
15	612	22.1	23 3/8	6 7/8
20	816	29.4	23 5/8	8
35	1429	51.5	38 5/8	8
50	2040	73.5	46 5/8	8 5/8
50	2370	85.2	51	8 1/2
60	2675	96	51	9
75	3055	110.3	56	9 5/16
100	4080	147.3	58	10 5/8

NOTE—Many cylinders have similar dimensions but have different water capacities. Check the marked tare weights and internal volume on any cylinders in question before filling.

5.4 Cylinder markings

Certain markings shall be stamped directly into the cylinder as required by Federal authorities such as the DOT, TC, and others and are the responsibility of either the cylinder manufacturer or the regualifier. See CGA P-15 for figures showing the required markings on the cylinder [5].

5.5 Cylinder regualification

Cylinders are periodically regualified in accordance with CGA publications C-1, C-6, C-6.1, and C-20 [6, 7, 8, 9].

Carbon dioxide cylinders are used extensively in the manufacturing and distribution of carbonated beverages. It is possible to have water flow back into cylinders in some circumstances. When water collects in the bottom of the cylinder, it combines with carbon dioxide to form carbonic acid. This causes internal corrosion and potential cylinder failure.

Carbon dioxide cylinders shall be visually inspected before each fill and are requalified at no more than 5-year intervals. The requalification includes a hydrostatic test as required by Title 49 of the U.S. *Code of Federal Regulations* (49 CFR) Part 180 Subpart C and corresponding Canadian regulations [4]. The hydrostatic test is used to measure the volumetric expansion of the cylinder that is caused by the test pressure. Cylinders with defects or internal corrosion fail the hydrostatic test because the cylinder wall expands too much. For more information see CGA C-1 [6].

Requalification may also be performed by ultrasonic examination (UE) under DOT special permits. UE measures actual wall thickness and can detect defects in the cylinder wall. See CGA C-20 for more information [9].

Cylinders due for requalification may remain in service but may not be refilled until they are requalified.

6 Cylinder valves

6.1 Standard fill valve

The standard fill valve on carbon dioxide cylinders uses the CGA 320 connection. See Figure 1 and CGA V-1, *Standard for Compressed Gas Cylinder Valve Outlet and Inlet Connections* [10]. There are two types of sealing methods used to prevent leakage during filling or use. Fiber or plastic washers may be inserted between the cylinder valve outlet and its connection, or an O-ring seal may be incorporated into the mating connection.

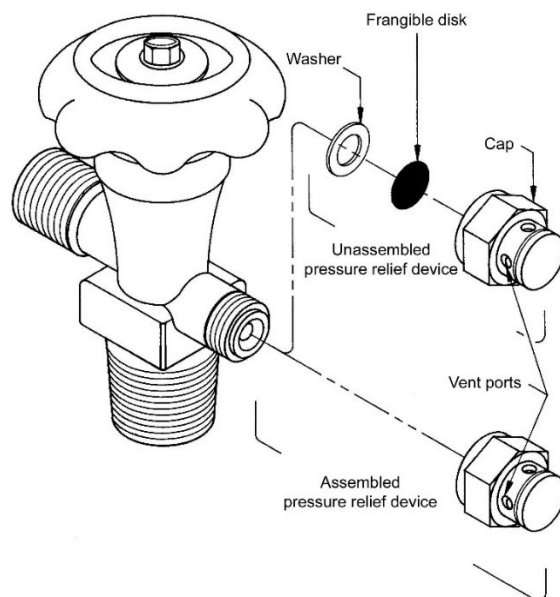


Figure 1—Carbon dioxide cylinder valve and typical pressure relief devices

6.2 Fire extinguishing cylinder valves

Carbon dioxide fire extinguishing cylinders may require special adapters other than the CGA 320 connection. Fire extinguishing valves are siphon-tube type to facilitate liquid withdrawal.

Certain types of high flow fire discharge cylinder valves rely upon a mechanical locking pin system to keep the valve closed during filling and transportation (see Figures 2 and 3). Care must be taken when filling or transporting these cylinders to prevent an accidental uncontrolled release of pressure and potential resulting injury. See CGA V-22, *Potential Hazards of Quick Opening Cylinder Valves used with Firefighting Gases* [11].