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CGA C-6.3—2019

**STANDARD FOR VISUAL
INSPECTION OF LOW PRESSURE
ALUMINUM ALLOY
COMPRESSED GAS CYLINDERS**

FOURTH EDITION



The Standard For Safety Since 1913

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Cylinder Specifications Committee

NOTE—Technical changes from the previous edition are underlined.

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1 Introduction

Title 49 of the U.S. *Code of Federal Regulations* (49 CFR), Parts 100-180 of the Department of Transportation (DOT) as well as the *Transportation of Dangerous Goods Regulations* of Transport Canada (TC) and Canadian national standard CSA B339, *Cylinders, spheres, and tubes for the transportation of dangerous goods* require that a cylinder be condemned when it leaks or when internal or external corrosion, denting, bulging, or evidence of rough usage exists to the extent that the cylinder is likely to be weakened appreciably [1, 2, 3].¹ In addition, these regulations and standards identify the periodic inspection and hydrostatic test requirements for cylinders used in transportation. Cylinders identified with ICC stampings are also covered by DOT regulations in the United States. In Canada, cylinders approved by previous agencies are identified by CTC, BTC, and CRC markings and are currently subject to TC regulations.

2 Scope

This publication covers the periodic inspection of aluminum alloy compressed gas cylinders with service pressures of 500 psi (35 bar) or less. This publication may not cover all circumstances for each individual cylinder type or lading. Inspection agencies may find it necessary to amplify these requirements to fit their condition of service if the service is more severe than encountered in transportation.

Other publications offered by the Compressed Gas Association (CGA) that discuss visual inspection of cylinders are:

- [C-1](#), *Methods for Pressure Testing Compressed Gas Cylinders* [4];
- [C-6](#), *Standard for Visual Inspection of Steel Compressed Gas Cylinders* [5];
- [C-6.1](#), *Standard for Visual Inspection of High Pressure Aluminum Alloy Compressed Gas Cylinders* [6];
- [C-6.2](#), *Standard for Visual Inspection and Requalification of Fiber Reinforced High Pressure Cylinders* [7]; and
- [P-22](#), *The Responsible Management and Disposition of Compressed Gases and Their Containers* [8].

Experience in the inspection of cylinders is an important factor in determining the acceptability of a given cylinder for continued service. Users who lack this experience and have questionable cylinders shall return them to a manufacturer of the same type of cylinders or to a competent requalification facility for reinspection.

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.

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

3.1.5 Can

Indicates a possibility or ability.

3.2 Technical definitions**3.2.1 Bulges**

Abnormal outward protrusion of any portion of the cylinder.

3.2.2 Condemned

Cylinder no longer fit for service and for which rework is not allowed.

3.2.3 Corrosion

Loss of thickness caused by corrosive media.

3.2.3.1 General corrosion

Indicates a somewhat uniform loss of wall thickness in a relatively large area.

3.2.3.2 Line corrosion

Series of closely spaced pits that appear to be “in line”.

3.2.3.3 Pitting corrosion

Most common form of attack on aluminum. The pits can be small and localized or large and scattered. The amount and concentration of the pits determines the disposition of the cylinder.

3.2.4 Cuts, gouges, and digs

Imperfections that result in the loss of wall thickness caused by sharp objects that cut into or upset the metal.

3.2.5 Dents

Deformations in the cylinder caused by contact with a blunt object so the wall thickness is not materially reduced.

3.2.6 Low pressure aluminum alloy cylinders

Welded or seamless cylinders having service pressures of 500 psi (35 bar) or less and manufactured under DOT 4E and 3AL specifications, TC 4EM and 3ALM specifications or special permits or equivalency certificates covered by 49 CFR 173.306 or TC regulations [1, 2].

3.2.7 Minimum allowable wall thickness

Thickness defined by the specification under which the cylinder was manufactured.

4 Preparation for inspection and testing**4.1 Aluminum alloy cylinder identification**

Use DOT, TC, or other markings to identify the cylinder. Contact the owner or manufacturer when DOT or TC markings are not present or other markings do not identify the cylinder. When identification cannot be made, condemn the cylinder. With the approval of the owner, process the cylinder in accordance with [CGA P-22](#) [8].

4.2 Venting

Identify the lading, open cylinder valves, and vent residual gas to the atmosphere outside of the building through a vent valve in compliance with applicable environmental regulations. If the contents are suspected or determined to be poisonous, toxic, flammable, or radioactive, contact the owner for safe venting and purging procedures. When identification of the contents is not possible or if other hazards exist, refer to [CGA P-22](#) for handling or disposition of the cylinder [8].

4.3 Cleaning cylinders

Clean cylinders to permit visual inspection. Judgment is required to determine the extent of cleaning required and whether removal of paint or attachments is necessary.

4.3.1 Exterior cleaning

Paint stripping should be performed when necessary and shall only be performed with products compatible with the aluminum alloy of construction. Do not use solutions of strong alkali (caustic) or acid or heat sources such as furnaces or blowtorches. Using ferrous and abrasive materials on aluminum alloys can be detrimental to the cylinder wall. Care shall be exercised to maintain the minimum allowable wall thickness. For more information on compatible materials, contact the cylinder manufacturer.

4.3.2 Interior cleaning

Use nonabrasive methods for interior cleaning such as air, water, or steam. If additional cleaning is necessary, contact the owner, filler, or manufacturer before proceeding. Ferrous and abrasive materials can be detrimental to the cylinder wall. Do not use solutions of strong alkali (caustic) or acid for internal cleaning. When an oven is used for drying, the temperature shall not exceed 250 °F (121 °C).

5 Inspection equipment

5.1 Depth gauges, scales

Exterior corrosion, denting, bulging, gouges, or digs are normally measured by simple direct measurement with a steel scale or depth gauges. In brief, a rigid straight edge having a length greater than the span of the defect(s) being evaluated is placed over the defect and a steel scale is used to measure the distance from the bottom of the straightedge to the bottom of the defect. Commercial depth gauges are also available that are especially suitable for measuring the depth of small cuts or pits. Like the straight edge, a depth gauge or steel scale shall span the entire affected area. When measuring cuts, the upset metal shall be removed or compensated for so that only the actual depth of metal removed from the cylinder wall is measured. The minimum increment resolution of all inspection equipment shall be considered prior to taking any measurement.

5.2 Inspection light

One of the most useful tools for inspection is a high intensity light probe for the interior inspection of cylinders.

6 Inspection criteria

6.1 Corrosion limits

The following description provides requirements for the acceptance of aluminum alloy cylinders.

The following requirements apply only to cylinders with diameters greater than 4 in (10 cm). Cylinders with diameters less than 4 in (10 cm) that show visible corrosion shall be condemned.

6.1.1 General corrosion

Loss of wall thickness and/or strength due to general corrosion may be determined either by the permanent expansion during hydrostatic testing for specification cylinders or by modified hydrostatic testing as prescribed by special permits and equivalency certificates. Condemnation limits are 10% permanent expansion (12% for specifications DOT 4E and TC 4EM) or no visual distortion when proof pressure test is authorized.

6.1.2 General corrosion limits

The maximum allowable corrosion depth is 15% of the minimum allowable wall thickness. The area of corrosion shall not extend over 15% of the exterior or interior surface, whichever is being examined.

6.1.3 Isolated pit limits

The allowable depth of a pit shall not exceed 25% of the minimum allowable wall thickness.

6.1.4 Line corrosion limits

If the line corrosion is 3 in (7.6 cm) or less in length, the allowable depth of deepest pit shall not exceed 25% of the minimum allowable wall thickness. For line corrosion greater than 3 in (7.6 cm), the depth of the deepest pit shall not exceed 15% of the minimum allowable wall thickness.

6.2 Cuts, digs, gouges, and dents

6.2.1 Measurements

Cuts, digs, gouges, and dents shall be measured with suitable depth gauges or pipe gauges. Smooth off any upset metal to allow true measurement without causing further damage to parent metal.

6.2.2 Cuts, digs, and gouge limits

When the original wall thickness at time of manufacture is known or the actual wall thickness is measured, the cylinder shall be condemned if the original wall thickness minus the depth of the defect is less than 75% of the original wall thickness.

When the original wall thickness is unknown or cannot be measured, the maximum allowable depth of the cut, dig, or gouge shall not exceed 25% of the minimum designed wall thickness as determined by the cylinder specification. See Figure 1.

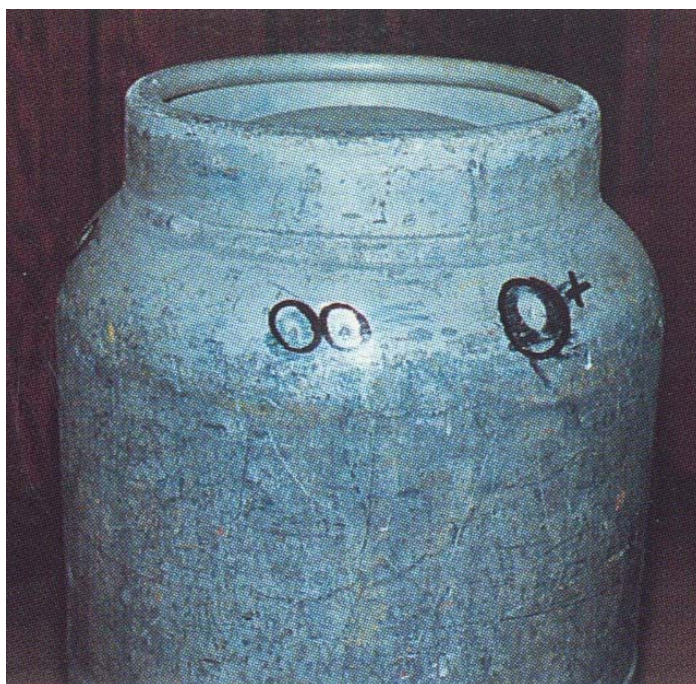


Figure 1—Cylinder exhibiting cuts, digs, and gouges

6.2.3 Dent limits

The maximum allowable depth of a dent shall not exceed one-tenth the average diameter of the dent. When denting occurs so that any part of the deformation includes a weld, the maximum allowable depth of the dent shall be 0.25 in (6.4 mm). See Figures 2, 3, 4, and 5.



Figure 2—Cylinder exhibiting dent in bottom sidewall



Figure 3—Cylinder exhibiting a dent on the knuckle radius

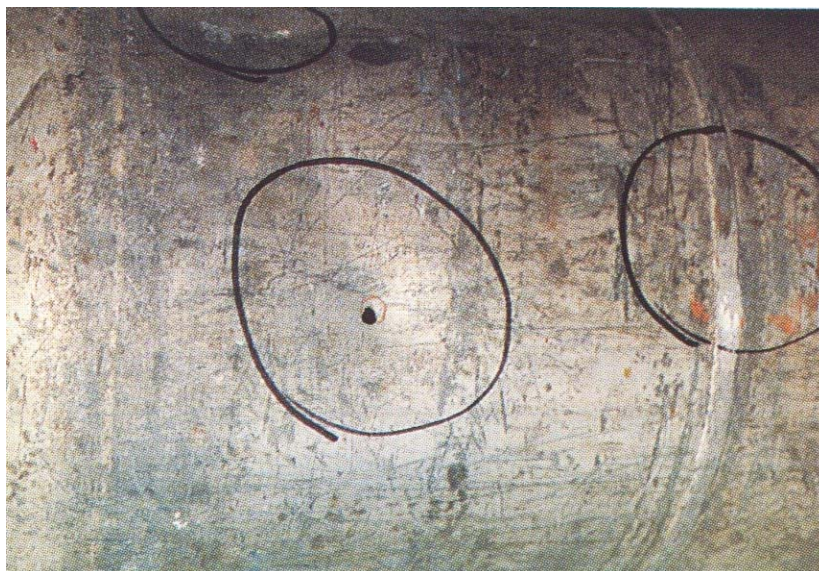


Figure 4—Cylinder exhibiting dents in the weld and cylinder sidewall

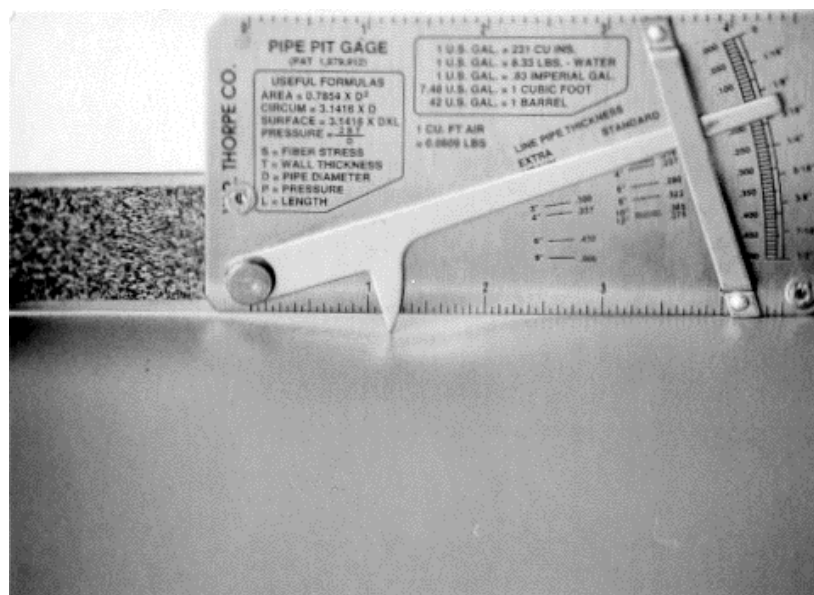


Figure 5—Measuring length and depth of a dent

6.3 Arc burn (arc strike)

Evidence of an arc burn (arc strike) can be localized melting of cylinder, removal of weld material by scarfing, cratering, or addition of welding metal. Cylinders with arc burn (arc strike) shall be condemned.

6.4 Bulges

Cylinders are manufactured with a reasonably symmetrical shape. Those with definite visible bulges shall be condemned. See Figure 6.



Figure 6—Fire damaged cylinder exhibiting bulging

6.5 Fire/heat exposure damage

6.5.1 Inspection for fire/heat damage

Aluminum alloy cylinders subjected to the action of fire shall be condemned as required by 49 CFR 180.205 and CSA B339 [1, 3]. Evidence of exposure to fire is charring or burning of paint or other protective coating, melting or scarfing of the metal, distortion of the cylinder, melting of fuse plugs, or melting of the valve handwheel or valve protector. See Figure 7. Fire damage shall not be concealed by paint.

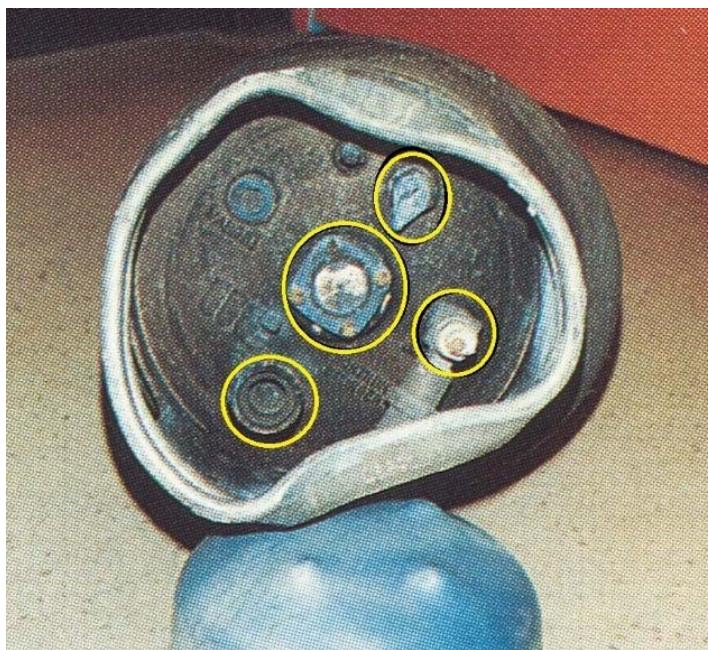


Figure 7—Fire damaged cylinder exhibiting melting

6.5.2 Inspection for thermal damage

Aluminum alloy cylinders can be thermally damaged by exposure to elevated temperatures. Reconditioning is not permitted. Cylinders exposed to temperatures greater than 350 °F (177 °C) shall be condemned. Evidence of exposure to elevated temperatures includes distortion of the cylinder, discoloration, charring or burning of paint or other protective coating, melting of fuse plugs, melting of the plastic handwheel or valve protector, or charring or burning of labels.

6.6 Foot rings and shrouds (collars)

Foot rings and shrouds (collars) shall be examined for completeness of markings, distortion, material removal (cut collars), looseness, and failure of welds. Foot rings and shrouds (collars) that exhibit damage that cannot be returned to the original form and function shall be removed from service. After examination, foot rings and shrouds (collars) can be replaced (rebuilt—See 49 CFR 180.211, CSA B339, Clause 24.5) or the cylinder shall be condemned [1, 3]. See Figure 8.



Figure 8—Example of cut collars

6.7 Neck defects

Examine cylinder necks for cracks, folds, and other flaws. Cylinders with a neck crack shall be condemned.

6.8 Rebuilding

The cylinder shall be rebuilt in accordance with 49 CFR 180.211 or 180.212 or TC regulations (CSA B339, Clause 24) by an approved requalification/repair facility or the cylinder shall be condemned [1, 2, 3].

6.9 Threads and valving

6.9.1 Cylinder neck threads

Examine neck threads whenever the valve is removed from the cylinder. Condemn cylinders exhibiting defects so a gas-tight seal cannot be obtained by valving methods.

6.9.2 O-ring seals

Aluminum alloy cylinders can have O-ring seals and straight threads in place of tapered threads. O-rings shall be replaced and O-ring lubricants and materials shall be compatible with the lading.

6.9.3 Cylinder valving

Tighten the valve to the recommended torque or number of turns as recommended by the cylinder manufacturer. Overtorquing of a valve can cause galling and deformation of the aluminum thread.

7 Requalification methods

7.1 Water jacket/direct expansion method of requalification

7.1.1 Test period

Certain low pressure aluminum alloy cylinders are authorized to be periodically requalified by the water jacket method or by the direct expansion method to determine the expansion of the cylinder. The cylinder shall be dried for a sufficient amount of time following the test to vaporize the moisture. The drying temperature shall not exceed 250 °F (121 °C).

7.1.2 Acceptance criteria

A low pressure aluminum alloy cylinder shall be condemned if its percent permanent expansion exceeds the requirement of the individual specification.

7.1.3 Markings

Permanently stamp retest dates in close proximity to the original test date in accordance with 49 CFR 180.213 or CSA B339 [1, 3].

7.2 Proof pressure method of requalification

7.2.1 Test pressure

Certain low pressure aluminum alloy cylinders are authorized to be requalified by the proof pressure test method. This method consists of pressurizing the cylinder to two times the marked service pressure of the cylinder without determination of expansion readings. See 49 CFR 180.209 or CSA B339 for details of the test as appropriate [1, 3].

7.2.2 Acceptance criteria

Condemn the cylinder if it exhibits visible bulging, distortion, or leaks. See 49 CFR 180.205 or CSA B339 for details of the test as appropriate [1, 3].

7.2.3 Markings

Mark cylinders in accordance with 49 CFR 180.213 or CSA B339 [1, 3]. Rechargeable fire extinguisher cylinders tested in accordance with 49 CFR 180.213 shall be marked in accordance with 49 CFR 180.213. Rechargeable fire extinguisher cylinders described in 49 CFR 173.309(a)(3) shall be marked according to that section and shall be in compliance with 29 CFR 1910.157(e) and (f) [1, 9].

7.3 Visual inspection requalification

7.3.1 General

Certain low pressure aluminum alloy cylinders are authorized to be requalified by the visual inspection method. This method consists of conducting a visual examination of the cylinder as outlined in Section 6. See 49 CFR 180.209 or CSA B339, Clause 24.2.9 for details of the test as appropriate [1, 3].

7.3.2 Acceptance criteria

The cylinder shall be condemned if it fails to meet the criteria of Section 6.

7.3.3 Markings

All cylinders shall be marked in accordance with 49 CFR 180.213 or CSA B339 [1, 3].

8 References

Unless otherwise specified, the latest edition shall apply.

[1] *Code of Federal Regulations*, Title 49 (Transportation), Parts 100-180, U.S. Government Printing Office. www.gpo.gov

[2] *Transportation of Dangerous Goods Regulations*, Transport Canada, Canadian Government Publishing. www.tc.gc.ca

[3] CSA B339, *Cylinders, spheres, and tubes for the transportation of dangerous goods*, Canadian Standards Association. www.csagroup.org

[4] **CGA C-1**, *Methods for Pressure Testing Compressed Gas Cylinders*, Compressed Gas Association, Inc. www.cganet.com

[5] **CGA C-6**, *Standard for Visual Inspection of Steel Compressed Gas Cylinders*, Compressed Gas Association, Inc. www.cganet.com

[6] **CGA C-6.1**, *Standard for Visual Inspection of High Pressure Aluminum Alloy Compressed Gas Cylinders*, Compressed Gas Association, Inc. www.cganet.com

[7] **CGA C-6.2**, *Standard for Visual Inspection and Requalification of Fiber Reinforced High Pressure Cylinders*, Compressed Gas Association, Inc. www.cganet.com

[8] **CGA P-22**, *The Responsible Management and Disposition of Compressed Gases and Their Cylinders*, Compressed Gas Association, Inc. www.cganet.com

[9] *Code of Federal Regulations*, Title 29 (Labor), U.S. Government Printing Office. www.gpo.gov



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