



CGA C-6—2022

STANDARD FOR VISUAL INSPECTION OF STEEL COMPRESSED GAS CYLINDERS

THIRTEENTH EDITION



Documents

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Cylinder Specifications Committee

NOTE—Technical changes from the previous edition are underlined.

NOTE—Appendix A (Informative) is for information only.

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1 Introduction

Title 49 of the U.S. *Code of Federal Regulations* (49 CFR), Parts 100-180, Hazardous Materials Regulations of the U.S. Department of Transportation (DOT) as well as the regulations of Transport Canada (TC) require that a cylinder is condemned when it leaks, when there is internal or external corrosion, denting, bulging, or when evidence of rough usage exists to the extent that the cylinder is likely to be weakened appreciably [1].¹ Until 1970, U.S. regulations applicable to compressed gas cylinders were under the authority of the Interstate Commerce Commission (ICC). Therefore, older cylinders can be identified by an ICC stamping. Such cylinders are now regulated according to DOT requirements.

NOTE—Under prescribed conditions of use, a formal visual inspection has been authorized in lieu of the periodic pressure requalification for certain low pressure cylinders used for noncorrosive gas service. See 49 CFR 180.209 for DOT requirements or Clause 24 of CSA B339, *Cylinders, spheres, and tubes for the transportation of dangerous goods*, for TC requirements [1, 2]. For further information on pressure requalification test methods, see CGA C-1, *Methods for Pressure Testing Compressed Gas Cylinders and Tubes* [3].

NOTE—Wherever reference is made to DOT regulations, similar requirements can be found in TC regulations. Older cylinders can be marked CTC, BTC, or CRC.

2 Scope

This standard provides cylinder users (requalifiers, owners, fillers, operators, etc.) with criteria to accept, reject, and condemn steel compressed gas cylinders. This standard does not cover all circumstances for each individual cylinder type and condition of lading.

NOTE—Special permit cylinders may contain their own visual inspection criteria in the special permit. Equivalency certificate cylinders may contain their own visual inspection criteria in the equivalency certificate.

In situations where a particular cylinder design type is not covered by this standard, users shall modify their inspection procedures. If a particular compressed gas service has unique detrimental effects on a cylinder's internal or external condition, these shall also be considered by the user.

Experience in the inspection of cylinders is an important factor in determining the acceptability of a given cylinder for continued service. Users lacking this experience who have questionable cylinders should return them to a manufacturer of the same type of cylinders or to a competent requalification agency for re-inspection.

Suggestions contained in this standard do not apply to cylinders manufactured under specification DOT-3HT, CTC-3HT, or TC-3HTM. Because of the special provisions of this specification, separate recommendations covering service life and standards for visual inspection of these cylinders are contained in CGA C-8, *Standard for Requalification of DOT-3HT, CTC-3HT, and TC-3HTM Seamless Steel Cylinders* [4].

For cylinders manufactured under specification DOT-8, DOT-8AL, CTC-8, CTC-8AL, CTC-8WC, TC-8WM, or TC-8WAM, see CGA C-13, *Standard for Periodic Visual Inspection and Requalification of Acetylene Cylinders* [5].

For aluminum alloy cylinders, see CGA C-6.1, *Standard for Visual Inspection of High Pressure Aluminum Alloy Compressed Gas Cylinders*; CGA C-6.2, *Standard for Visual Inspection and Requalification of Fiber Reinforced High Pressure Cylinders*; and CGA C-6.3, *Standard for Visual Inspection of Low Pressure Aluminum Alloy Compressed Gas Cylinders* [6, 7, 8].

Inspection procedures include preparation of cylinders for inspection, exterior inspection, interior inspection (if required), nature and extent of damage to be looked for, and tests that indicate the conditions of the cylinder, etc. A sample inspection report for low pressure cylinders exempt from pressure testing is shown in Appendix A. This sample inspection report may be revised to suit user or regulatory requirements.

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

3 Definitions

For the purpose of this standard, 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 Corrosion or pitting

Loss of wall thickness in a cylinder by corrosive media.

NOTE—There are several kinds of corrosion or pitting to be considered.

3.2.1.1 Crevice corrosion

Corrosion that occurs in the area of the intersection of the footing or headring with the cylinder.

NOTE—Examples of crevice corrosion are shown in Figures 1 and 2.

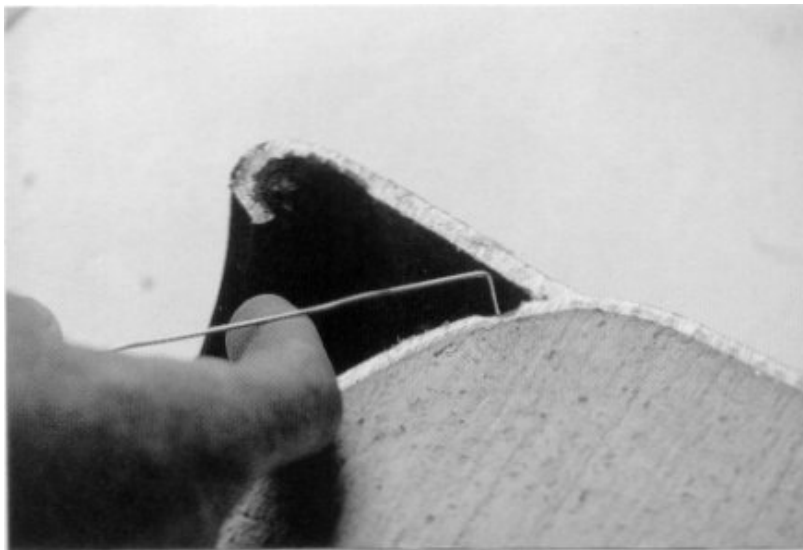


Figure 1—Crevice corrosion near the cylinder footing

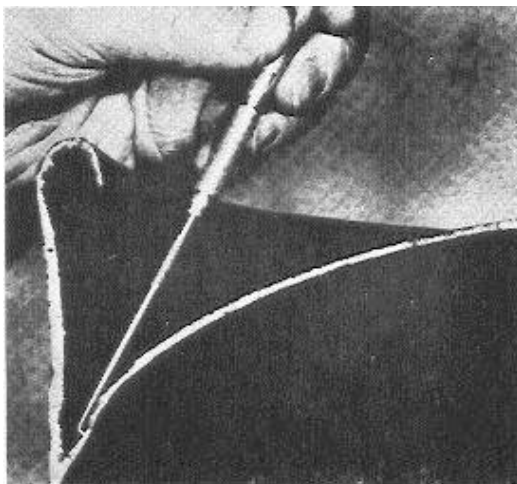


Figure 2—Crevice corrosion (cutaway view)

3.2.1.2 General corrosion

Corrosion that covers considerable surface areas of the cylinder.

NOTE—Examples of general corrosion are shown in Figures 3 and 4.

NOTE—General corrosion reduces the structural strength. It is often difficult to measure or estimate the depth of general corrosion because direct comparison with the original wall cannot always be made. General corrosion is often accompanied by pitting.



Figure 3—General corrosion with pitting

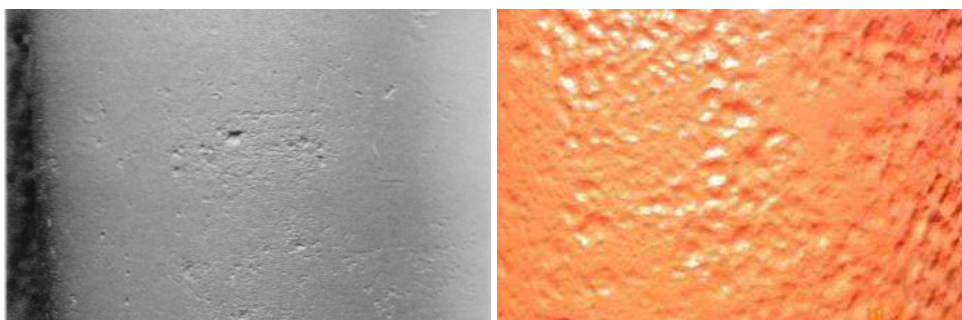


Figure 4—General corrosion with pitting on cylinder wall

3.2.1.3 Isolated pitting

Any area of corrosion that is smaller in diameter than two times the minimum allowable design thickness (t_d) or 0.6 in (15 mm), whichever is less; and for which the distance from the center of the pit to the center of the next nearest pit is greater than the sum of the diameters of the two pits.

NOTE—See Figures 13a and 13b. An example of isolated pitting is shown in Figure 5.



Figure 5—Isolated pitting

3.2.1.4 Line corrosion

Series of pits closely spaced as to appear to be in a line.

NOTE—This condition is more serious than isolated pitting. An example of line corrosion is shown in Figure 6.



Figure 6—Line corrosion

3.2.2 Cuts, gouges, or digs

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

3.2.3 Cylinder

3.2.3.1 High pressure

Cylinders with a marked service pressure of 900 psi (6210 kPa) or greater.²

3.2.3.2 Low pressure

Cylinders with a marked service pressure less than 900 psi (6210 kPa).

3.2.4 Cylinder disposition

The following definitions apply to terms for the disposition of cylinders failing visual inspection.

3.2.4.1 Condemned

No longer fit for service.

NOTE—A condemned cylinder is required to be removed from service.

3.2.4.2 Rejected

Not fit for service in present condition.

NOTE—Rejected cylinders may be requalified by either additional testing to verify adequacy of cylinder for continued service or by reheat treatment, repair, or rebuilding to correct the defect as specified in 49 CFR Part 180 Subpart C [1]. A cylinder may also have its pressure downgraded with written approval from the authority having jurisdiction (AHJ).

3.2.5 Cylinder sidewall

Portion of the cylinder that is parallel to the centerline axis of the cylinder, excluding the cylinder ends.

3.2.6 Dents

Deformations in a cylinder caused by its coming in contact with a blunt object so that the thickness of metal is not materially impaired.

NOTE—An example of a dent is shown in Figure 7.



Figure 7—Measuring the length of a dent

² psi, bar, and kPa shall indicate gauge pressure unless otherwise noted as (psia; bar, abs; and kPa, abs) for absolute pressure or (psid; bar, dif; and kPa, dif) for differential pressure. All kPa values are rounded off per CGA P-11, *Guideline for Metric Practice in the Compressed Gas Industry* [9].

3.2.7 **Mass weight**

Weight of the empty cylinder including all permanent attachments (collar, neckring, or footring) but not including:

- cylinder cap or valve guard;
- valve;
- valve outlet cap/plug; or
- eductor (dip or siphon) tube.

NOTE—Mass weight, where used, is indicated by the letter “M” instead of the letter “T” on the cylinder.

3.2.8 **Minimum allowable design thickness (t_d)**

Minimum design thickness required by the specification under which the cylinder was manufactured.

3.2.9 **Multi-element gas containers (MEGCs)**

Assembly of UN cylinders, UN tubes, or UN bundles of cylinders that are interconnected by a manifold and are assembled within a framework.

NOTE—The MEGC module includes service equipment and structural equipment necessary for the transport of gases.

3.2.10 **Regualification**

Test(s) required to be performed on a cylinder to determine its suitability for continued service.

3.2.11 **Tare weight**

Weight of an empty cylinder presented for filling including:

- valve;
- valve guard when affixed to the valve or cylinder;
- valve outlet cap/plug if permanently attached by a chain;
- eductor (dip or siphon) tube (if applicable);
- any permanent attachments (for example, collar, neckring, or footring); and
- coatings.

NOTE—The tare weight may include the valve guard not permanently affixed to the valve or cylinder.

NOTE—The tare weight does not include the cylinder cap or any outlet cap/plug not permanently attached by a chain.

3.2.12 **Tube trailer**

Modules of cylinders mounted on motor vehicles or in frames as defined in 49 CFR 173.301(i) [1].

4 **Inspection equipment**

4.1 **Depth gauges, metallic scales, etc.**

Exterior corrosion, denting, bulging, gouges, or digs are normally measured by simple direct measurement with metallic scales or depth gauges. In brief, a rigid straightedge having a length greater than the span of the defect(s) being evaluated is placed over the defect and a metallic scale is used to measure the distance from the bottom of the straightedge to the bottom of the defect. Commercial depth gauges that are especially suitable for measuring the depth of small cuts or pits are also available. Like the straightedge, a depth gauge or 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.

4.2 Ultrasonic devices

There are a variety of commercial ultrasonic devices available that can be used to detect subsurface faults and measure wall thicknesses. The ultrasonic devices shall be calibrated for the cylinder to be inspected.

4.3 Magnetic particle inspection

Magnetic particle inspection can be adapted for cylinder inspection to quickly locate surface faults not readily visible to the naked eye. Inspection of cylinders using this method shall only be performed by a trained person qualified in accordance with a recognized standard such as The American Society for Nondestructive Testing (ASNT) SNT-TC-1A, *Personnel Qualification and Certification in Nondestructive Testing* [10]. It is particularly important that the cylinder is demagnetized.

4.4 Penetrant inspection materials

Dye penetrant materials that show surface faults not readily visible to the naked eye are available. Inspection of cylinders using this method shall only be performed by a trained person. It is particularly important that the inspected cylinder surface be cleaned before and after this test is performed.

4.5 Weight scales

On cylinders marked with tare or mass weights, weight scales can be used to detect wall loss by comparing the current weight to the tare or mass weight, as applicable, or to reveal a change in the accessories that were installed at time of manufacture (for example, valves, collars, footrings, etc.).

Weight scales shall be capable of verifying the cylinder tare or mass weight to an accuracy of 1% of the tare or mass weight of the cylinder being weighed.

5 Markings

Cylinders requalified in accordance with this standard shall be marked according to 49 CFR Part 180, CSA B339, special permits, or equivalency certificates, as applicable [1, 2].

6 Low pressure cylinders exempt from pressure testing

This section covers cylinders exempt from pressure requalification requirements of DOT or TC by virtue of their exclusive use in certain noncorrosive gas service. They are not subject to internal corrosion and do not require internal shell inspection. If, due to unusual circumstances, cylinders of these types are known to have internal corrosion, they shall be inspected in accordance with the procedures in Section 7.

6.1 Preparation for inspection

At the time of requalification, rust, scale, multilayered paint or coatings, other foreign materials, sleeves, or labels and attachments that could interfere with the inspection shall be completely removed from the external surface so it is prepared for inspection.

Typical labels can be found in CGA C-7, *Guide to Classification and Labeling of Compressed Gases* and are discussed in 49 CFR 172 [11, 1].

6.2 Exterior inspection

Cylinders shall be inspected as outlined in 6.2.1 through 6.2.9 for corrosion, dents, cuts, digs, gouges, leaks, fire damage, general distortion, or any other defect that could indicate a weakness that would render them unfit for service.