

CGA C-11—2019

**PRACTICES FOR INSPECTION OF
COMPRESSED GAS CYLINDERS
AT TIME OF MANUFACTURE**

SIXTH EDITION

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Work Item 18-005
Cylinder Specifications Committee

NOTE—Technical changes from the previous edition are underlined.

NOTE—Appendices A through H (Normative) are requirements.

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1 Introduction

Specification tests and inspection procedures are necessary to ensure compliance with applicable specifications. However, specifications and inspection procedures are distinctly different and have to be separated. A product specification is legislative while inspection procedures are judicial.

Acceptance and certification of a product to a given specification is usually in batch or lot size quantities and can be based on testing or inspection frequencies from 100% of product for certain attributes to one item per lot for other attributes. Between these extremes, intermediate frequencies of examination are permitted to allow the inspector to certify acceptance of a lot to a given specification. In no case shall the frequency of specific inspections or tests be less than required by applicable specifications.

Aside from frequency of testing, the method of arriving at decisions concerning compliance is vital. One important distinction is the difference between witnessing and verifying. Witnessing implies a physical presence, whereas verifying usually involves gaining information without physical presence by examining records or statements of other persons in whom trust has been placed.

For U.S. Department of Transportation (DOT) regulations, either witnessing or verifying may be delegated by the certifying inspector, but this individual retains responsibility for the decision. Where an independent inspection agency (IIA) is required by specification, the delegation of witnessing and verification is limited to an agency employee.

For Canadian regulations, the inspections shall be performed by the staff of the independent inspector as described in the application for registration.

Calibration of testing and inspection equipment used to validate the certificate of compliance and test report shall be performed on a regularly scheduled basis by qualified persons to ensure accuracy.

2 Scope and purpose

2.1 Scope

This publication is applicable to cylinders, tubes, and spheres, hereafter referred to as cylinders, and to inspection by either an approved IIA or inspectors of the manufacturer.

2.2 Purpose

The purpose of this publication is to promote safety by outlining inspection requirements of DOT in Title 49 of the U.S. *Code of Federal Regulations*, CSA B339, *Cylinders, spheres, and tubes for the transportation of dangerous goods*, and CSA B341, *UN pressure receptacles and multiple-element gas containers for the transport of dangerous goods* as adopted by the *Transportation of Dangerous Goods Regulations* of Transport Canada (TC) for cylinders as interpreted and practiced by manufacturers and inspectors [1, 2, 3, 4].¹

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.

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

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 Certifying inspector**

Any individual with the authority to sign and submit reports as required by DOT/TC regulations.

NOTE—In this publication, certifying inspector and inspector are used interchangeably (For qualifications, see Section 4).

3.2.2 Chemical analysis

Ascertainment of the kind and amount of the elements constituting a material. The analysis shall determine at least those elements prescribed for the material grade.

3.2.3 Cylinder

Pressure vessel designed for a minimum pressure of 25 psi (1.7 bar).

3.2.4 Heat, cast, or inspection lot number²

Material defined and identified by the producer thereof as originating either from one melting cycle in a furnace or from several melting cycles so conducted as to render a cast product essentially identical with respect to its inherent characteristics.

3.2.5 Independent inspection agency (IIA)

For DOT regulations, an organization approved in writing by the Office of Hazardous Materials Safety. For TC regulations, an independent inspector (third-party) is an organization holding a Certificate of Registration from TC. In either case, the organization shall not manufacture cylinders nor be directly or indirectly controlled by a cylinder manufacturer (formerly "disinterested" inspector).

3.2.6 Inspection

Act of viewing, measuring, or examining closely and critically using aids as needed.

3.2.7 Inspector of the manufacturer

Competent individual employed by the cylinder manufacturer and designated as the certifying inspector (formerly "interested" inspector). For TC regulations, employees of the manufacturer shall not be permitted to act as the certifying inspector.

3.2.8 Lot

Quantity of cylinders having the same size, design, construction, material grade, and heat treatment (when applicable) that are designated by the manufacturer for approval through sample testing as defined by the applicable regulations.

3.2.9 Test

Particular procedure or method used to measure or assess the physical characteristics of a cylinder.

3.2.10 Verify

To confirm either by examination, evidence, testimony, research, demonstration, or comparison.

² The steel industry uses a heat number to identify a single melt in a particular furnace, and the ingots cast from that melt are identified by the heat number. The aluminum industry uses a cast or melt number in similar fashion and this identity accompanies cast ingots. In addition, aluminum producers supply extruded billets that are identified by an inspection lot number. The billet lot may originate as several different melts of the same alloy that was stored in ingot form under a "bonded stock" system.

3.2.11 Witness

To see or know by personal presence or personal observation.

4 Qualifications of the certifying inspector

The certifying inspector shall:

- have at least 5 years of experience in cylinder manufacturing operations or related industries or one year of on the job experience with an engineering degree, technical diploma, or similar education;
- have a full understanding of applicable DOT/TC/ISO/UN cylinder specifications;
- have a full understanding of any other specifications or regulations required by reference in the applicable DOT/TC/ISO/UN cylinder specifications;
- have an understanding of the applicable cylinder manufacturing process and quality control procedures;
- have a thorough understanding of specified tests, test apparatus, test procedures, inspection techniques, and equipment as they relate to the applicable cylinder specifications;
- be capable of reading and writing English to achieve an understanding of these requirements and associated documents; and
- be capable of directing subordinate persons to coordinate the results of tests and inspections into an accurate and reliable report of each cylinder lot produced.

In addition to the previous, the certifying inspector shall have knowledge of the following:

- compressed gases in cylinders;
- cylinder material properties;
- wall stress/sidewall thickness relationship;
- volumetric expansion test and interpretation of results;
- metal working effects; and
- heat treatment/physical property relationships.

Documentation shall exist to verify that the certifying inspector has demonstrated knowledge of the previous qualifications.

Every inspector of the manufacturer or other person performing work that is verified by the certifying inspector shall have the training, qualifications, and experience that enables them to perform this work and shall have training to perform such functions documented.

5 Inspection requirements—seamless cylinders

Seamless cylinders are those having integrally formed heads and bottoms with no welding allowed except as authorized by the individual specification under which these cylinders are manufactured. With few exceptions, seamless cylinders require inspection by an IIA.

5.1 Duties of certifying inspector

The certifying inspector shall ensure that the following duties are performed in accordance with the individual DOT/TC/ISO/UN specification under which the cylinders are being manufactured:

- determine that the design being manufactured is registered with the applicable regulatory authority, if required;
- determine that materials are in compliance with the requirements of the specification;

- verify that material was identified;
- perform internal inspection before closing;
- perform, witness, or verify external inspection;
- verify that the minimum design sidewall thickness (minimum wall thickness) and the end thickness requirements (when specified) were met by measurement or by witnessing measurement;
- verify actual heat treatment parameters used in the process;
- select or approve the selection of samples to be tested;
- witness or perform pressure test, burst test, tensile test, flattening test, bend test, impact test, and leakage test as required by the specification;
- verify cycle test, hardness test, magnetic particle inspection, ultrasonic examination (UE), or other nondestructive tests for flaws;
- verify threads by gauge;
- verify required markings; and
- prepare and retain the required report.

The inspector shall verify that applicable tests are completed in accordance with the relevant ISO pressure receptacle standard. For UN specifications, where there is conflict between the inspector responsibility to verify or witness a test in this publication and the design specification, the more stringent requirement shall apply.

5.2 Inspection practices

5.2.1 Material

The use of specified material shall be verified by the inspector by examination of documentation furnished by the material supplier. Each certified chemical analysis shall be checked against the limits set forth for the grade. In the absence of a certified chemical analysis, a check analysis of samples taken from each heat is acceptable to verify compliance with requirements. In the absence of heat identity, each starter unit (such as individual coil, sheet, plate billet, tube, etc.) shall be analyzed.

A code representing this heat shall be associated with each cylinder (or production lot if allowed by specification) at a suitable point during manufacture. Permanent marking in nonstressed or low stress areas of the cylinder may be mandated by individual specifications.

Material used for attachments to cylinders by welding, where permitted, shall be verified by the inspector as for weldability and compliance with the specification concerned.

5.2.2 Internal and external visual inspection

Each shell or pipe, regardless of the process by which it is made, shall be given an internal and external visual inspection for defects. Internal inspection shall be accomplished before ends are closed. Criteria for rejection shall be as defined in the applicable DOT/TC/ISO/UN specification.

Thickness of cylindrical walls and heads shall be verified to be not less than the minimum specified. X-rays or beta rays for measuring or ultrasonic means of thickness gauging are acceptable for this verification.

Irregularities in the shape of heads or cylindrical portions shall be rejected if determined to be injurious to the finished cylinder.

Removal of metal from the cylindrical walls or heads is permitted provided they are re-inspected and measured for compliance with the minimum thickness specified.

The closing in (or necking) should be monitored as needed for any evidence of material defects not previously observed in the shell or pipe ends, and for uniformity in shape of the closed end and neck.

Critical observation shall be made for DOT-3HT and TC-3HTM cylinders because of extra-high stress design. Magnetic particle inspection shall be witnessed or verified by the inspector.

5.2.3 Heat treatment

The inspector shall verify that cylinders have been heat treated in accordance with the specification for the cylinder being manufactured by periodic observation of the equipment, instrumentation, and charts.

The inspector shall be responsible for confirming that the method of selecting and preparing sample specimens from heat treatment lots for physical tests is in accordance with regulations.

After heat treatment, any nondestructive inspection required by the DOT/TC/ISO/UN specifications shall be verified by the inspector.

5.2.4 Pressure tests

The inspector shall be responsible for ensuring that the internal pressure testing of each cylinder is as prescribed by the individual DOT/TC/ISO/UN specification.

NOTE—For DOT/TC specification cylinders, see CGA C-1, *Methods for Pressure Testing Compressed Gas Cylinders* [5].

Where volumetric expansion measurement is required, the test shall be witnessed by the inspector at the time of test. As a minimum, total expansion and permanent expansion shall be recorded at the time of test.

Where proof testing only is performed, the tests shall be witnessed by the inspector.

Any cylinder not complying with the acceptance criteria shall be rejected subject to rework or retest as authorized by the specification.

5.2.5 Leakage test

Where required by DOT/TC/ISO/UN cylinder specifications, cylinders shall be subjected to the leakage test. The inspector shall witness the test.

5.2.6 Tensile test

Tensile testing of the specimens shall be witnessed or performed by the inspector as required by DOT/TC/UN specifications.

The inspector shall confirm the test results by examination of the data including specimen dimensions and calculations. Results shall be compared with acceptability criteria for the particular cylinder design.

When the test results do not meet the requirements specified, the cylinder lot shall be rejected subject to reheat treatment or retest as authorized by the specification.

Retesting is authorized if an improper test was made due to the presence of a flaw in the specimen or if the equipment or procedure was faulty.

5.2.7 Flattening test

The inspector shall witness or perform the flattening test of a representative sample from each production lot as required by the applicable DOT/TC/ISO/UN specifications. Where specified as an alternative, a bend test shall be witnessed or performed by the inspector as required by the specification.

Flattening tool surfaces shall be verified by the inspector for dimensional conformance.