

(3) The flattening must be between 60 degrees included-angle, wedge shaped knife edges, rounded to a 0.5 inch radius.

(4) Cylinders and test rings may not crack when flattened so that their outer surfaces are not more than six times wall thickness apart when made of steel or not more than ten times wall thickness apart when made of aluminum.

(5) If any cylinder or ring cracks when subjected to the specified flattening test, the lot of cylinders represented by the test must be rejected (see paragraph (h) of this section).

(h) *Rejected cylinders.* Rejected cylinders must conform to the following requirements:

(1) If the cause for rejection of a lot is determinable, and if by test or inspection defective cylinders are eliminated from the lot, the remaining cylinders must be qualified as a new lot under paragraphs (f) and (g) of this section.

(2) Repairs to welds are permitted. Following repair, a cylinder must pass the pressure test specified in paragraph (f) of this section.

(3) If a cylinder made from seamless steel tubing fails the flattening test described in paragraph (g) of this section, suitable uniform heat treatment must be used on each cylinder in the lot. All prescribed tests must be performed subsequent to this heat treatment.

(i) *Markings.* (1) The markings required by this section must be durable and waterproof. The requirements of § 178.35(h) do not apply to this section.

(2) Required markings are as follows:

(i) DOT-39.

(ii) NRC.

(iii) The service pressure.

(iv) The test pressure.

(v) The registration number (M****) of the manufacturer.

(vi) The lot number.

(vii) The date of manufacture if the lot number does not establish the date of manufacture.

(viii) With one of the following statements:

(A) For cylinders manufactured prior to October 1, 1996: "Federal law forbids transportation if refilled-penalty up to \$25,000 fine and 5 years imprisonment (49 U.S.C. 1809)" or "Federal law for-

bids transportation if refilled-penalty up to \$500,000 fine and 5 years imprisonment (49 U.S.C. 5124)."

(B) For cylinders manufactured on or after October 1, 1996: "Federal law forbids transportation if refilled-penalty up to \$500,000 fine and 5 years imprisonment (49 U.S.C. 5124)."

(3) The markings required by paragraphs (i)(2)(i) through (i)(2)(v) of this section must be in numbers and letters at least 1/8 inch high and displayed sequentially. For example:

DOT-39 NRC 250/500 M1001.

(4) No person may mark any cylinder with the specification identification "DOT-39" unless it was manufactured in compliance with the requirements of this section and its manufacturer has a registration number (M****) from the Associate Administrator.

[Amdt. 178-114, 61 FR 25942, May 23, 1996, as amended at 65 FR 58631, Sept. 29, 2000; 66 FR 45389, Aug. 28, 2001; 67 FR 51654, Aug. 8, 2002; 68 FR 75748, 75749, Dec. 31, 2003; 85 FR 85430, Dec. 28, 2020]

§ 178.68 Specification 4E welded aluminum cylinders.

(a) *Type, size and service pressure.* A DOT 4E cylinder is a welded aluminum cylinder with a water capacity (nominal) of not over 1,000 pounds and a service pressure of at least 225 to not over 500 psig. The cylinder must be constructed of not more than two seamless drawn shells with no more than one circumferential weld. The circumferential weld may not be closer to the point of tangency of the cylindrical portion with the shoulder than 20 times the cylinder wall thickness. Cylinders or shells closed in by spinning process and cylinders with longitudinal seams are not authorized.

(b) *Authorized material.* (1) The cylinder must be constructed of aluminum of uniform quality. The following chemical analyses are authorized:

TABLE 1 TO PARAGRAPH (b)(1)—AUTHORIZED MATERIALS

Designation	Chemical analysis—limits in percent 5154
Iron plus silicon	0.45 maximum.
Copper	0.10 maximum.
Manganese	0.10 maximum.
Magnesium	3.10/3.90.

TABLE 1 TO PARAGRAPH (b)(1)—AUTHORIZED MATERIALS—Continued

Designation	Chemical analysis—limits in percent 5154
Chromium	0.15/0.35.
Zinc	0.20 maximum.
Titanium	0.20 maximum.
Others, each	0.05 maximum.
Others, total	0.15 maximum.
Aluminum	remainder.

(2) The aluminum used in the construction of the cylinder must be as specified in Table 1 to paragraph (b)(1) of this section. Analyses must regularly be made only for the elements specifically mentioned in the table. If, however, the presence of other elements is indicated in the course of routine analysis, further analysis should be made to determine conformance with the limits specified for other elements. The cylinder manufacturer must maintain a record of intentionally added alloying elements.

(c) *Identification.* Material must be identified by any suitable method that will identify the alloy and manufacturer's lot number.

(d) *Manufacture.* Cylinders must be manufactured using equipment and processes adequate to ensure that each cylinder produced conforms to the requirements of this subpart. No defect is permitted that is likely to weaken the finished cylinder appreciably. A reasonably smooth and uniform surface finish is required. All welding must be by the gas shielded arc process.

(e) *Welding.* The attachment to the tops and bottoms only of cylinders by welding of neckrings, flanges, footrings, handles, bosses, pads, and valve protection rings is authorized. However, such attachments and the portion of the cylinder to which it is attached must be made of weldable aluminum alloys.

(f) *Wall thickness.* The wall thickness of the cylinder must conform to the following:

(1) The minimum wall thickness of the cylinder must be 0.140 inch. In any case, the minimum wall thickness must be such that calculated wall stress at twice service pressure may not exceed the lesser value of either of the following:

(i) 20,000 psi.

(ii) One-half of the minimum tensile strength of the material as required in paragraph (j) of this section.

(2) Calculation must be made by the following formula:

$$S = [P(1.3D^2 + 0.4d^2)] / (D^2 - d^2)$$

Where:

S = wall stress in psi;

P = minimum test pressure prescribed for water jacket test;

D = outside diameter in inches;

d = inside diameter in inches.

(3) Minimum thickness of heads and bottoms may not be less than the minimum required thickness of the side wall.

(g) *Opening in cylinder.* Openings in cylinders must conform to the following:

(1) All openings must be in the heads or bases.

(2) Each opening in cylinders, except those for safety devices, must be provided with a fitting, boss, or pad, securely attached to cylinder by welding by inert gas shielded arc process or by threads. If threads are used, they must comply with the following:

(i) Threads must be clean-cut, even, without checks and cut to gauge.

(ii) Taper threads to be of length not less than as specified for American Standard taper pipe threads.

(iii) Straight threads, having at least 4 engaged threads, to have tight fit and calculated shear strength at least 10 times the test pressure of the cylinder; gaskets required, adequate to prevent leakage.

(3) Closure of a fitting, boss, or pad must be adequate to prevent leakage.

(h) *Pressure testing.* Each cylinder must successfully withstand a pressure test as follows:

(1) *Pressure test.* All cylinders with a wall stress greater than 18,000 psig must be tested by water-jacket or direct expansion method as prescribed in CGA C-1 (IBR, see §171.7 of this subchapter). The testing equipment must be calibrated as prescribed in CGA C-1. All testing equipment and pressure indicating devices must be accurate within the parameters defined in CGA C-1.

(i) Each cylinder must be tested to a minimum of two (2) times service pressure.

(ii) The minimum test pressure must be maintained at least 30 seconds and sufficiently longer to ensure complete expansion. Any internal pressure applied after heat-treatment and prior to the official test may not exceed 90 percent of the test pressure. If, due to failure of the test apparatus or operator error, the test pressure cannot be maintained, the test may be repeated in accordance with CGA C-1, section 5.7.2.

(iii) Permanent volumetric expansion may not exceed 12 percent of the total volumetric expansion at test pressure.

(2) *Lot testing.* (i) Cylinders with a wall stress of 18,000 psig or less may be lot tested. At least one (1) cylinder randomly selected out of each lot of 200 or less must be tested by the water-jacket or direct expansion method as prescribed in CGA C-1. The testing equipment must be calibrated as prescribed in CGA C-1. All testing equipment and pressure indicating devices must be accurate within the parameters defined in CGA C-1. If, due to failure of the test apparatus or operator error, the test pressure cannot be maintained, the test may be repeated in accordance with CGA C-1, section 5.7.2.

(ii) Each selected cylinder must be tested to a minimum of two (2) times service pressure.

(iii) The minimum test pressure must be maintained at least 30 seconds and sufficiently longer to ensure complete expansion. Any internal pressure applied after heat-treatment and prior to the official test may not exceed 90 percent of the test pressure.

(iv) Permanent volumetric expansion may not exceed 12 percent of the total volumetric expansion at test pressure.

(3) *Pressure testing.* (i) For cylinders with a wall stress of 18,000 psig or less, the remaining cylinders of the lot must be pressure tested by the proof pressure, water-jacket, or direct expansion test method as defined in CGA C-1. The minimum test pressure must be maintained for the specific timeframe and the testing equipment must be calibrated as prescribed in CGA C-1. Further, all testing equipment and pressure indicating devices must be accurate within the parameters defined in CGA C-1.

(ii) Each cylinder must be tested to a minimum of two (2) times service pressure and show no defect. If, due to failure of the test apparatus or operator error, the test pressure cannot be maintained, the test may be repeated in accordance with CGA C-1 5.7.2 or 7.1.2, as appropriate. Determination of expansion properties is not required.

(4) *Burst testing.* One (1) finished cylinder selected at random out of each lot of 1000 or less must be hydrostatically tested to four (4) times service pressure without bursting. Inability to meet this requirement must result in rejection of the lot. All testing equipment and pressure indicating devices must be accurate within the parameters defined in CGA C-1.

(i) *Flattening test.* After hydrostatic testing, a flattening test is required on one section of a cylinder, taken at random out of each lot of 200 or less as follows:

(1) If the weld is not at midlength of the cylinder, the test section must be no less in width than 30 times the cylinder wall thickness. The weld must be in the center of the section. Weld reinforcement must be removed by machining or grinding so that the weld is flush with the exterior of the parent metal. There must be no evidence of cracking in the sample when it is flattened between flat plates to no more than 6 times the wall thickness.

(2) If the weld is at midlength of the cylinder, the test may be made as specified in paragraph (i)(1) of this section or must be made between wedge shaped knife edges (60° angle) rounded to a ½ inch radius. There must be no evidence of cracking in the sample when it is flattened to no more than 6 times the wall thickness.

(j) *Mechanical test.* A mechanical test must be conducted to determine yield strength, tensile strength, elongation as a percentage, and reduction of area of material as a percentage as follows:

(1) The test is required on two (2) specimens removed from one cylinder or part thereof as illustrated in appendix A to this subpart taken at random out of each lot of 200 or fewer.

(2) Specimens must conform to the following:

(i) A gauge length of 8 inches with a width not over 1½ inches, a gauge

length of 2 inches with a width not over 1½ inches.

(ii) The specimen, exclusive of grip ends, may not be flattened. Grip ends may be flattened to within 1 inch of each end of the reduced section.

(iii) When size of cylinder does not permit securing straight specimens, the specimens may be taken in any location or direction and may be straightened or flattened cold, by pressure only, not by blows; when specimens are so taken and prepared, the inspector's report must show in connection with record of physical test detailed information in regard to such specimens.

(iv) Heating of a specimen for any purpose is not authorized.

(3) The yield strength in tension must be the stress corresponding to a permanent strain of 0.2 percent of the gauge length. The following conditions apply:

(i) The yield strength must be determined by the "offset" method as prescribed in ASTM E 8 (IBR, see § 171.7 of this subchapter).

(ii) Cross-head speed of the testing machine may not exceed ⅛ inch per minute during yield strength determination.

(k) *Acceptable results for mechanical tests.* An acceptable result of the mechanical test requires at least 7 percent and yield strength not over 80 percent of tensile strength.

(l) *Weld tests.* Welds of the cylinder are required to pass the following tests successfully:

(1) *Reduced section tensile test.* A specimen must be removed from the cylinder used for the mechanical tests specified in paragraph (j) of this section. The specimen must be taken from across the seam; edges must be parallel for a distance of approximately 2 inches on either side of the weld. The specimen must be fractured in tension. The actual breaking stress must be a minimum of 30,000 psi. The apparent breaking stress calculated on the minimum design wall thickness must be a minimum of two (2) times the stress calculated under paragraph (f)(2) of this section. If the specimen fails to meet the requirements, the lot must be rejected except that specimens may be taken from two (2) additional cylinders

from the same lot as the previously tested specimens. If either of the latter specimens fails to meet requirements, the entire lot represented must be rejected.

(2) *Guided bend test.* A bend test specimen must be removed from the cylinder used for the mechanical test specified in paragraph (j) of this section. The specimen must be taken across the circumferential seam, must be a minimum of 1½ inches wide, edges must be parallel and rounded with a file, and back-up strip, if used, must be removed by machining. The specimen must be tested as follows:

(i) *Standard guided bend test.* The specimen must be bent to refusal in the guided bend test jig as illustrated in CGA C-3 (IBR, see § 171.7 of this subchapter). The root of the weld (inside surface of the cylinder) must be located away from the ram of the jig. The specimen must not show a crack or other open defect exceeding ⅛ inch in any direction upon completion of the test. Should this specimen fail to meet the requirements, one additional specimen must be taken from two additional cylinders from the same lot and tested. If either of the latter specimens fails to meet requirements, the entire lot represented must be rejected.

(ii) *Alternate guided bend test.* This test may be used as an alternate to the guided bend test. The test specimen must be in conformance with The Aluminum Association's "Welding Aluminum: Theory and Practice, Fourth Edition, 2002" (IBR, see § 171.7 of this subchapter). If the specimen fails to meet the requirements, one additional specimen must be taken from two additional cylinders or welded test plates from the same lot and tested. If any of these latter two specimens fails to meet the requirements, the entire lot must be rejected.

(m) *Rejected cylinders.* Repair of welded seams is authorized. Acceptable cylinders must pass all prescribed tests.

(n) *Markings.* (1) Markings must be as required in § 178.35 and in addition must be stamped plainly and permanently in one of the following locations on the cylinder:

(i) On the neck, neckring, valve boss, valve protection sleeve, or similar part

permanently attached to the top of the cylinder.

(ii) On the footring permanently attached to the cylinder, provided the water capacity of the cylinder does not exceed 30 pounds.

(2) Embossing the cylinder head or side wall is not permitted.

(o) *Inspector's report.* In addition to the information required by § 178.35, the record of chemical analyses must also include applicable information on iron, titanium, zinc, and magnesium used in the construction of the cylinder.

[Amdt. 178-114, 61 FR 25942, May 23, 1996, as amended at 62 FR 51561, Oct. 1, 1997; 66 FR 45386, Aug. 28, 2001; 67 FR 51654, Aug. 8, 2002; 68 FR 75748, Dec. 31, 2003; 69 FR 54046, Sept. 7, 2004; 74 FR 16143, Apr. 9, 2009; 85 FR 85431, Dec. 27, 2020]

§ 178.69 Responsibilities and requirements for manufacturers of UN pressure receptacles.

(a) Each manufacturer of a UN pressure receptacle marked with "USA" as a country of approval must comply with the requirements in this section. The manufacturer must maintain a quality system, obtain an approval for each initial pressure receptacle design type, and ensure that all production of UN pressure receptacles meets the applicable requirements.

(1) *Quality system.* The manufacturer of a UN pressure receptacle must have its quality system approved by the Associate Administrator. The quality system will initially be assessed through an audit by the Associate Administrator or his or her representative to determine whether it meets the requirements of this section. The Associate Administrator will notify the manufacturer in writing of the results of the audit. The notification will contain the conclusions of the audit and any corrective action required. The Associate Administrator may perform periodic audits to ensure that the manufacturer operates in accordance with the quality system. Reports of periodic audits will be provided to the manufacturer. The manufacturer must bear the cost of audits.

(2) *Quality system documentation.* The manufacturer must be able to demonstrate a documented quality system. Management must review the adequacy

of the quality system to assure that it is effective and conforms to the requirements in § 178.70. The quality system records must be in English and must include detailed descriptions of the following:

(i) The organizational structure and responsibilities of personnel with regard to design and product quality;

(ii) The design control and design verification techniques, processes, and procedures used when designing the pressure receptacles;

(iii) The relevant procedures for pressure receptacle manufacturing, quality control, quality assurance, and process operation instructions;

(iv) Inspection and testing methodologies, measuring and testing equipment, and calibration data;

(v) The process for meeting customer requirements;

(vi) The process for document control and document revision;

(vii) The system for controlling non-conforming material and records, including procedures for identification, segregation, and disposition;

(viii) Production, processing and fabrication, including purchased components, in-process and final materials; and

(ix) Training programs for relevant personnel.

(3) *Maintenance of quality system.* The manufacturer must maintain the quality system as approved by the Associate Administrator. The manufacturer shall notify the Associate Administrator of any intended changes to the approved quality system prior to making the change. The Associate Administrator will evaluate the proposed change to determine whether the amended quality system will satisfy the requirements. The Associate Administrator will notify the manufacturer of the findings.

(b) *Design type approvals.* The manufacturer must have each pressure receptacle design type reviewed by an IIA and approved by the Associate Administrator in accordance with § 178.70. A cylinder is considered to be of a new design, compared with an existing approved design, as stated in the applicable ISO design, construction and testing standard.