§ 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

(g) Flattening test. One cylinder must be taken from the beginning of production of each lot (as defined in paragraph (f)(3) of this section) and subjected to a flattening test as follows:

(1) The flattening test must be made on a cylinder that has been tested at test pressure.

(2) A ring taken from a cylinder may be flattened as an alternative to a test on a complete cylinder. The test ring may not include the heat affected zone or any weld. However, for a sphere, the test ring may include the circumferential weld if it is located at a 45 degree angle to the ring, ±5 degrees.

(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 forbids 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:


(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.

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cylinder wall thickness. Cylinders or shells closed in by spinning process and cylinders with longitudinal seams are not authorized.

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

<table>
<thead>
<tr>
<th>Designation</th>
<th>Chemical analysis—limits in percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iron plus silicon</td>
<td>0.45 maximum</td>
</tr>
<tr>
<td>Copper</td>
<td>0.10 maximum</td>
</tr>
<tr>
<td>Manganese</td>
<td>0.10 maximum</td>
</tr>
<tr>
<td>Magnesium</td>
<td>3.10/3.90</td>
</tr>
<tr>
<td>Chromium</td>
<td>0.15/0.35</td>
</tr>
<tr>
<td>Titanium</td>
<td>0.20 maximum</td>
</tr>
<tr>
<td>Others, each</td>
<td>0.05 maximum</td>
</tr>
<tr>
<td>Others, total</td>
<td>0.15 maximum</td>
</tr>
<tr>
<td>Aluminum</td>
<td>remainder</td>
</tr>
</tbody>
</table>

1 Analysis must regularly be made only for the elements specifically mentioned in this 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.

(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 neckings or flanges, footings, handles, bosses and 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:

   \[ S = \frac{P(1.3D^2 + 0.4d^2)}{(D^2 - d^2)} \]

   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) Hydrostatic test. Each cylinder must successfully withstand a hydrostatic test, as follows:

1. The test must be by water jacket, or other suitable method, operated so as to obtain accurate data. The pressure gauge must permit reading to an accuracy of 1 percent. The expansion gauge must permit a reading of the total expansion to an accuracy of either 1 percent or 0.1 cubic centimeter.

2. Pressure of 2 times service pressure must be maintained for at least 30 seconds and sufficiently longer to insure complete expansion. Any internal pressure applied previous to the official test may not exceed 90 percent of the
test pressure. If, due to failure of the
test apparatus, the test pressure can-
not be maintained, the test may be re-
peated at a pressure increased by 10
percent over the pressure otherwise
specified.

(3) Permanent volumetric expansion
may not exceed 12 percent of total vol-
umetric expansion at test pressure.

(4) Cylinders having a calculated wall
stress of 18,000 psi or less at test pres-
sure may be tested as follows:

(i) At least one cylinder selected at
random out of each lot of 200 or less
must be tested in accordance with
paragraphs (h)(1), (h)(2), and (h)(3) of
this section.

(ii) All cylinders not tested as pro-
vided in paragraph (h)(4)(i) of this sec-
tion must be examined under pressure
of at least 2 times service pressure and
show no defect.

(5) One finished cylinder selected at
random out of each lot of 1,000 or less
must be hydrostatically tested to 4
times the service pressure without
bursting. Inability to meet this re-
quirement must result in rejection of
the lot.

(i) Flattening test. After hydrostatic
testing, a flattening test is required on
one section of a cylinder, taken at ran-
don in each lot of 200 or less as fol-
lows:

(1) If the weld is not at midlength of
the cylinder, the test section must be
no less in width than 30 times the cy-
linder wall thickness. The weld must be
in the center of the section. Weld rein-
forcement must be removed by machin-
ing 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 be-
tween flat plates to no more than 6
times the wall thickness.

(2) Guided bend test. A bend test speci-
men must be cut from the cylinder
used for the physical test specified in
paragraph (j) of this section. Specimen
must be taken across the seam, must
be a minimum of 1 1/2 inches wide, edges
must be parallel and rounded with a
file, and back-up strip, if used, must be
removed by machining. The specimen
shall be tested as follows:

(i) The specimen must be bent to re-
fusion in the guided bend test jig as il-
lustrated in paragraph 6.10 of 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 1/8 inch in any direction upon
completion of the test. Should this
specimen fail to meet the require-
ments, specimens may be taken from
each of 2 additional cylinders from the
same lot and tested. If either of the lat-
ter specimens fails to meet require-
ments, the entire lot represented must
be rejected.

(ii) Alternatively, the specimen may
be tested in a guided bend test jig as il-
lustrated in Figure 12.1 of The Alu-
minum Association's 2002 publication,
"Welding Aluminum: Theory and Prac-
tice." The root of the weld (inside sur-
face of the cylinder) must be located
away from the mandrel of the jig. No
specimen must show a crack or other
open defect exceeding 1/8 inch in any di-
rection upon completion of the test.
Should this specimen fail to meet the
requirements, specimens may be taken
from each of 2 additional cylinders
from the same lot and tested. If either
of the latter specimens fails to meet
requirements, the entire lot rep-
resented must be rejected.

(j) Physical test. A physical test must
be conducted to determine yield
strength, tensile strength, elongation,
and reduction of area of material as
follows:

(1) The test is required on 2 speci-
mens cut from one cylinder or part
thereof taken at random out of each
lot of 200 or less.

(2) Specimens must conform to the
following:

(i) A gauge length of 8 inches with a
width not over 1 1/2 inches, a gauge
length of 2 inches with a width not
over 1 1/2 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 lo-
cation 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 1/8 inch per minute during yield strength determination.

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

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

(1) Reduced section tensile test. A specimen must be cut from the cylinder used for the physical 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 apparent breaking stress calculated on the minimum wall thickness must be at least equal to 2 times the stress calculated under paragraph (f)(2) of this section, and in addition must have an actual breaking stress of at least 30,000 psi. Should this specimen fail to meet the requirements, specimens may be taken from 2 additional cylinders from the same lot and tested. If either of the latter specimens fail to meet requirements, the entire lot represented must be rejected.

(2) Guided bend test. A bend test specimen must be cut from the cylinder used for the physical tests specified in paragraph (j) of this section. Specimen must be taken across the seam, must be 1 1/2 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 bent to refusal in the guided bend test jig illustrated in paragraph 6.10 of CGA Pamphlet 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. No specimen must show a crack or other open defect exceeding 1/8 inch in any direction upon completion of the test. Should this specimen fail to meet the requirements, specimens may be taken from each of 2 additional cylinders from the same lot and tested. If either of the latter specimens fail to meet requirements, the entire lot represented must be rejected.

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

(n) 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.


§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