permanently attached to the top of the cylinder.

(6) On the footring permanently attached to the cylinder, provided the water capacity of the cylinder does not exceed 25 pounds.

[Amdt. 178–114, 61 FR 25942, May 23, 1996, as amended at 66 FR 4535, Aug. 28, 2001; 67 FR 16015, Sept. 27, 2002; 67 FR 51653, Aug. 8, 2002; 68 FR 75748, Dec. 31, 2003]

§ 178.53 Specification 4D welded steel cylinders for aircraft use.

(a) *Type, size, and service pressure.* A DOT 4D cylinder is a welded steel sphere (two seamless hemispheres) or circumferentially welded cylinder (two seamless drawn shells) with a water capacity not over 100 pounds and a service pressure of at least 300 but not over 500 psig. Cylinders closed in by spinning process are not authorized.

(b) *Steel.* Open-hearth or electric steel of uniform and weldable quality must be used. Content may not exceed the following: Carbon, 0.25; phosphorus, 0.045; sulphur, 0.050, except that the following steels commercially known as 4130X and Type 304, 316, 321, and 347 stainless steels may be used with proper welding procedure. A heat of steel made under table 1 in this paragraph (b), check chemical analysis of which is slightly out of the specified range, is acceptable, if satisfactory in all other respects, provided the tolerances shown in table 2 in this paragraph (b) are not exceeded, except as approved by the Associate Administrator. The following chemical analyses are authorized:

TABLE 1—4130X STEEL

4130X	Percent
Carbon	0.25/0.35.
Manganese	0.40/0.60.
Phosphorus	0.04 max.
Sulphur	0.05 max
Silicon	0.15/0.35.
Chromium	0.80/1.10.
Molybdenum	0.15/0.25.
Zirconium	None.
Nickel	None.

TABLE 2—AUTHORIZED STAINLESS STEELS

	Stainless steels			
	304 (percent)	316 (percent)	321 (percent)	347 (percent)
Carbon (max)	0.08	0.08	0.08	0.08
Manganese (max)	2.00	2.00	2.00	2.00
Phosphorus (max)	.030	.045	.030	.030
Sulphur (max)	.030	.030	.030	.030
Silicon (max)	.75	1.00	.75	.75
Nickel	8.0/11.0	10.0/14.0	9.0/13.0	9.0/13.0
Chromium	18.0/20.0	16.0/18.0	17.0/20.0	17.0/20.0
Molybdenum	.....	2.0/3.0	.....	.....
Titanium	.....	.....	[1]	.....
Columbium	.....	.....	.....	[2]

[1] Titanium may not be less than 5C and not more than 0.60%.
[2] Columbium may not be less than 10C and not more than 1.0%.

TABLE 3—CHECK ANALYSIS TOLERANCES

Element	Limit or maximum specified (percent)	Tolerance (percent) over the maximum limit or under the minimum limit	
		Under minimum limit	Over maximum limit
Carbon	To 0.15 incl	0.01	0.01
	Over 0.15 to 0.40 incl	.03	.04
Manganese	To 0.60 incl	.03	.03
	Over 1.15 to 2.50 incl	.05	.05
Phosphorus[1]	All ranges	.....	.01
Sulphur	All ranges	.....	.01
Silicon	To 0.30 incl	.02	.03
	Over 0.30 to 1.00 incl	.05	.05
Nickel	Over 5.30 to 10.00 incl	.10	.10
	Over 10.00 to 14.00 incl	.15	.15
Chromium	To 0.90 incl	.03	.03
	Over 0.90 to 2.10 incl	.05	.05
	Over 15.00 to 20.00 incl	.20	.20

TABLE 3—CHECK ANALYSIS TOLERANCES—Continued

Element	Limit or maximum specified (percent)	Tolerance (percent) over the maximum limit or under the minimum limit	
		Under minimum limit	Over maximum limit
Molybdenum	To 0.20 incl	.01	.01
	Over 0.20 to 0.40 incl	.02	.02
	Over 1.75 to 3.0 incl	.10	.10
Titanium	All ranges	.05	.05
Columbium	All ranges	.05	.05

[1] Rephosphorized steels not subject to check analysis for phosphorus.

(c) *Identification of material.* Material must be identified by any suitable method except that plates and billets for hotdrawn cylinders must be marked with the heat 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 container appreciably. A reasonably smooth and uniform surface finish is required. Welding procedures and operators must be qualified in accordance with CGA Pamphlet C–3 (IBR, see § 171.7 of this subchapter).

(e) *Wall thickness.* The wall stress at the minimum test pressure may not exceed 24,000 psi, except where steels commercially known as 4130X, types 304, 316, 321, and 347 stainless steels are used, stress at the test pressures may not exceed 37,000 psi. The minimum wall thickness for any container having a capacity of 1,100 cubic inches or less is 0.04 inch. The minimum wall thickness for any container having a capacity in excess of 1,100 cubic inches is 0.095 inch. Calculations must be done by the following:

(1) Calculation for a ''sphere'' must be made by the formula:

$$S = PD / 4tE$$

Where:

S = wall stress in psi;
P = test pressure prescribed for water jacket test, i.e., at least two times service pressure, in psig;
D = outside diameter in inches;
t = minimum wall thickness in inches;
E = 0.85 (provides 85 percent weld efficiency factor which must be applied in the girth weld area and heat affected zones which zone must extend a distance of 6 times wall thickness from center line of weld);
E = 1.0 (for all other areas).

(2) Calculation for a cylinder must be made by the formula:

$$S = [P(1.3D^2 + 0.4d^2)] / (D^2 - d^{T12})$$

Where:

S = wall stress in psi;
P = test pressure prescribed for water jacket test, i.e., at least two times service pressure, in psig;
D = outside diameter in inches;
d = inside diameter in inches.

(f) *Heat treatment.* The completed cylinders must be uniformly and properly heat-treated prior to tests.

(g) *Openings in container.* Openings in cylinders must comply with the following:

(1) Each opening in the container, except those for safety devices, must be provided with a fitting, boss, or pad, securely attached to the container by brazing or by welding or by threads. If threads are used, they must comply with the following:

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

(ii) Taper threads must be of a length not less than that specified for American Standard taper pipe threads.

(iii) Straight threads, having at least 4 engaged threads, must have a tight fit and calculated shear strength of at least 10 times the test pressure of the container. Gaskets, adequate to prevent leakage, are required.

(2) 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. A pressure gauge must permit a reading to an accuracy of 1 percent. An expansion

gauge must permit reading of total expansion to an accuracy of either 1 percent or 0.1 cubic centimeter.

(2) Pressure must be maintained for at least 30 seconds and sufficiently longer to ensure complete expansion. Any internal pressure applied after heat-treatment and 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 cannot be maintained, the test may be repeated at a pressure increased by 10 percent or 100 psig, whichever is the lower.

(3) Permanent volumetric expansion may not exceed 10 percent of the total volumetric expansion at test pressure.

(4) Containers must be tested as follows:

(i) Each container to at least 2 times service pressure; or

(ii) One container out of each lot of 200 or less to at least 3 times service pressure. Others must be examined under pressure of 2 times service pressure and show no defects.

(i) *Flattening test for spheres and cylinders.* Spheres and cylinders must be subjected to a flattening test as follows:

(1) One sphere taken at random out of each lot of 200 or less must be subjected to a flattening test as follows:

(i) The test must be performed after the hydrostatic test.

(ii) The test must be between parallel steel plates on a press with a welded seam at right angles to the plates. Any projecting appurtenances may be cut off (by mechanical means only) prior to crushing.

(2) One cylinder taken at random out of each lot of 200 or less must be subjected to a flattening test, as follows:

(i) The test must be performed after the hydrostatic test.

(ii) The test must be between knife edges, wedge shaped, 60° angle, rounded to ½ inch radius. For lots of 30 or less, physical tests are authorized to be made on a ring at least 8 inches long cut from each cylinder and subjected to the same heat treatment as the finished cylinder.

(j) *Physical test and specimens for spheres and cylinders.* Spheres and cylinders must be subjected to a physical test as follows:

(1) Physical test for spheres are required on 2 specimens cut from a flat representative sample plate of the same heat taken at random from the steel used to produce the sphere. This flat steel from which the 2 specimens are to be cut must receive the same heat-treatment as the spheres themselves. Sample plates must be taken for each lot of 200 or less spheres.

(2) Specimens for spheres must have a gauge length 2 inches with a width not over 1½ inches, or a gauge length at least 24 times the thickness with a width not over 6 times the thickness is authorized when a wall is not over 3⁄16 inch thick.

(3) Physical test for cylinders is required on 2 specimens cut from 1 cylinder taken at random out of each lot of 200 or less. For lots of 30 or less, physical tests are authorized to be made on a ring at least 8 inches long cut from each cylinder and subjected to the same heat treatment as the finished cylinder.

(4) Specimens for cylinders must conform to the following:

(i) A gauge length of 8 inches with a width not over 1½ inches, or a gauge length of 2 inches with a width not over 1½ inches, or a gauge length at least 24 times the thickness with a width not over 6 times the thickness is authorized when a cylinder wall is not over 3⁄16 inch thick.

(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. Heating of the specimen for any purpose is not authorized.

(5) 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 either the ''offset'' method or the ''extension under load'' method as prescribed in ASTM E 8 (IBR, see §171.7 of this subchapter).

(ii) In using the ''extension under load'' method, the total strain (or ''extension under load'') corresponding to the stress at which the 0.2 percent permanent strain occurs may be determined with sufficient accuracy by calculating the elastic extension of the

gauge length under appropriate load and adding thereto 0.2 percent of the gauge length. Elastic extension calculations must be based on an elastic modulus of 30,000,000. In the event of controversy, the entire stress-strain diagram must be plotted and the yield strength determined from the 0.2 percent offset.

(iii) For the purpose of strain measurement, the initial strain must be set while the specimen is under a stress of 12,000 psi and the strain indicator reading being set at the calculated corresponding strain.

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

(k) *Acceptable results for physical and flattening tests.* Either of the following is an acceptable result:

(1) An elongation of at least 40 percent for a 2 inch gauge length or at least 20 percent in other cases and yield strength not over 73 percent of tensile strength. In this instance, the flattening test is not required.

(2) An elongation of at least 20 percent for a 2 inch gauge length or 10 percent in other cases. Flattening is required to 50 percent of the original outside diameter without cracking.

(l) *Rejected cylinders.* Reheat-treatment is authorized for rejected cylinders. Subsequent thereto, containers must pass all prescribed tests to be acceptable. Repair of welded seams by welding prior to reheat-treatment is authorized.

(m) *Marking.* Marking on each container by stamping plainly and permanently are only authorized where the metal is at least 0.09 inch thick, or on a metal nameplate permanently secured to the container by means other than soft solder, or by means that would not reduce the wall thickness.

[Amdt. 178–114, 61 FR 25942, May 23, 1996, as amended at 66 FR 45386, 45388, Aug. 28, 2001; 67 FR 51653, Aug. 8, 2002; 68 FR 75748, Dec. 31, 2003]

§ 178.55 Specification 4B240ET welded or brazed cylinders.

(a) *Type, spinning process, size and service pressure.* A DOT 4B240ET cylinder is a brazed type cylinder made from electric resistance welded tubing. The maximum water capacity of this cylinder is 12 pounds or 333 cubic inches and the service must be 240 psig. The maximum outside diameter of the shell must be five inches and maximum length of the shell is 21 inches. Cylinders closed in by a spinning process are authorized.

(b) *Steel.* Open-hearth, basic oxygen, or electric steel of uniform quality must be used. Plain carbon steel content may not exceed the following: Carbon, 0.25; phosphorus, 0.045; sulfur, 0.050. The addition of other elements for alloying effect is prohibited.

(c) *Identification of material.* Material must be identified by any suitable method.

(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. Heads may be attached to shells by lap brazing or may be formed integrally. The thickness of the bottom of cylinders welded or formed by spinning is, under no condition, to be less than two times the minimum wall thickness of the cylindrical shell. Such bottom thicknesses must be measured within an area bounded by a line representing the points of contact between the cylinder and the floor when the cylinder is in a vertical position. Seams must conform to the following:

(1) Circumferential seams must be by brazing only. Heads must be attached to shells by the lap brazing method and must overlap not less than four times the wall thickness. Brazing material must have a melting point of not less than 1000 °F. Heads must have a driving fit with the shell unless the shell is crimped, swedged, or curled over the skirt or flange of the head and be thoroughly brazed until complete penetration of the joint by the brazing material is secured. Brazed joints may be repaired by brazing.

(2) Longitudinal seams in shell must be by electric resistance welded joints only. No repairs to longitudinal joints is permitted.