

to indicate that the cylinder and the outer packaging are capable of passing, as demonstrated by design testing, the Thermal Resistance Test specified in appendix D to part 178 of this subchapter.

(6) A cylinder of compressed oxygen that has been furnished by an aircraft operator to a passenger in accordance with 14 CFR § 121.574, § 125.219, or § 135.91 is excepted from the outer packaging requirements of paragraph (f)(3) of this section.

[67 FR 51646, Aug. 8, 2002, as amended at 67 FR 61289, Sept. 30, 2002; 68 FR 75745, Dec. 31, 2003; 71 FR 33883, June 12, 2006; 71 FR 51127, Aug. 29, 2006; 72 FR 55098, Sept. 28, 2007; 76 FR 56317, Sept. 13, 2011; 80 FR 1161, Jan. 8, 2015; 80 FR 72927, Nov. 23, 2015; 81 FR 3676, Jan. 21, 2016; 85 FR 75714, Nov. 25, 2020; 85 FR 85416, Dec. 28, 2020]

§ 173.302a Additional requirements for shipment of nonliquefied (permanent) compressed gases in specification cylinders.

(a) *Detailed filling requirements.* Nonliquefied compressed gases (except gas in solution) for which filling requirements are not specifically prescribed in § 173.304a must be shipped subject to the requirements in this section and §§ 173.301, 173.301a, 173.302, and 173.305 in specification cylinders, as follows:

(1) DOT 3, 3A, 3AA, 3AL, 3B, 3E, 4B, 4BA, 4BW, and 4E cylinders.

(2) DOT 3HT cylinders. These cylinders are authorized for aircraft use only and only for nonflammable gases. They have a maximum service life of 24 years from the date of manufacture. The cylinders must be equipped with frangible disc type pressure relief devices that meet the requirements of § 173.301(f). Each frangible disc must have a rated bursting pressure not exceeding 90 percent of the minimum required test pressure of the cylinder. Discs with fusible metal backing are not permitted. Specification 3HT cylinders may be offered for transportation only when packaged in accordance with § 173.301(a)(9).

(3) DOT 39 cylinders. When the cylinder is filled with a Division 2.1 flammable gas, the internal volume of the cylinder may not exceed 1.23 L (75 in³). For chemical under pressure (see § 172.102 of this subchapter (special provision 362)), the internal volume may

not exceed the size limits of the specification as provided in § 178.65(a)(1) of this subchapter.

(4) DOT 3AX, 3AAX, and 3T cylinders are authorized for Division 2.1 and 2.2 materials and for carbon monoxide. DOT 3T cylinders are not authorized for hydrogen. When used in methane service, the methane must be a nonliquefied gas with a minimum purity of 98.0 percent methane and commercially free of corroding components.

(5) Aluminum cylinders manufactured in conformance with specifications DOT 39, 3AL and 4E are authorized for oxygen only under the conditions specified in § 173.302(b).

(6) DOT 4E cylinders- DOT 4E cylinders with a maximum capacity of 43L (11 gal) must have a minimum rating of 240 psig and be filled to no more than 200 psig at 21 °C (70 °F).

(b) *Special filling limits for DOT 3A, 3AX, 3AA, 3AAX, and 3T cylinders.* A DOT 3A, 3AX, 3AA, 3AAX, and 3T cylinder may be filled with a compressed gas, other than a liquefied, dissolved, Division 2.1, or Division 2.3 gas, to a pressure 10 percent in excess of its marked service pressure, provided:

(1) The cylinder is equipped with a frangible disc pressure relief device (without fusible metal backing) having a bursting pressure not exceeding the minimum prescribed test pressure.

(2) The cylinder's elastic expansion was determined at the time of the last test or retest by the water jacket method.

(3) Either the average wall stress or the maximum wall stress does not exceed the wall stress limitation shown in the following table:

Type of steel	Average wall stress limitation	Maximum wall stress limitation
I. Plain carbon steels over 0.35 carbon and medium manganese steels	53,000	58,000
II. Steels of analysis and heat treatment specified in spec. 3AA	67,000	73,000
III. Steels of analysis and heat treatment specified in spec. DOT-3T	87,000	94,000
IV. Plain carbon steels less than 0.35 carbon made prior to 1920	45,000	48,000

(i)(A) The average wall stress must be computed from the elastic expansion data using the following formula:

$$S = 1.7EE / KV - 0.4P$$

Where:

S = wall stress, pounds per square inch;

EE = elastic expansion (total less permanent) in cubic centimeters;

K = factor $\times 10^{-7}$ experimentally determined for the particular type of cylinder being tested or derived in accordance with CGA C-5 (IBR, see § 171.7 of this subchapter);

V = internal volume in cubic centimeter (1 cubic inch = 16.387 cubic centimeters);

P = test pressure, pounds per square inch.

(B) The formula in paragraph (b)(3)(i)(A) of this section is derived from the formula in paragraph (b)(3)(ii) of this section and the following:

$$EE = (PKVD^2) / (D^2 - d^2)$$

(ii) The maximum wall stress must be computed from the formula:

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

Where:

S = wall stress, pounds per square inch;

P = test pressure, pounds per square inch;

D = outside diameter, inches;

d = D-2t, where t = minimum wall thickness determined by a suitable method.

(iii) Compliance with average wall stress limitation may be determined by computing the elastic expansion rejection limit in accordance with CGA C-5, by reference to data tabulated in CGA C-5, or by the manufacturer's marked elastic expansion rejection limit (REE) on the cylinder.

(4) An external and internal visual examination made at the time of test or retest shows the cylinder to be free from excessive corrosion, pitting, or dangerous defects.

(5) A plus sign (+) is added following the test date marking on the cylinder to indicate compliance with paragraphs (b) (2), (b)(3), and (b)(4) of this section.

(c) *Special filling limits for DOT 3A, 3AX, 3AA, and 3AAX cylinders containing Division 2.1 gases.* Except for transportation by aircraft, a DOT specification 3A, 3AX, 3AA, and 3AAX cylinder may be filled with hydrogen and mixtures of hydrogen with helium, argon or nitrogen, to a pressure 10% in excess of its marked service pressure subject to the following conditions:

(1) The cylinder must conform to the requirements of paragraph (b)(2) and (b)(3) of this section;

(2) The cylinder was manufactured after December 31, 1945;

(3) DOT specification 3A and 3AX cylinders are limited to those having an intermediate manganese composition.

(i) Cylinders manufactured with intermediate manganese steel must have been normalized, not quenched and tempered. Quench and temper treatment of intermediate steel is not authorized.

(ii) Cylinders manufactured with chrome moly steel must have been quenched and tempered, not normalized. Use of normalized chrome moly steel cylinders is not permitted.

(4) Cylinders must be equipped with pressure relief devices as follows:

(i) Cylinders less than 1.7 m (65 inches) in length must be equipped with fusible metal backed frangible disc devices;

(ii) Cylinders 1.7 m (65 inches) or greater in length and 24.5 cm (9.63 inches) in diameter or larger must be equipped with fusible metal backed frangible disc devices or frangible disc devices, except as provided in paragraph (c)(4)(iii) of this section. Cylinders with a diameter of 0.56 m (22 inches) or larger must be equipped with frangible disc devices except as provided in paragraph (c)(4)(iii) of this section.

(iii) Cylinders greater than 3.66 m (144 inches) in length that are horizontally mounted on a motor vehicle, in an ISO framework, or other framework of equivalent structural integrity are not required to be equipped with pressure relief devices. If such devices are installed, they must be selected in accordance with § 173.301(f).

(d) *Carbon monoxide.* Carbon monoxide must be offered in a DOT 3, 3A, 3AX, 3AA, 3AAX, 3AL, 3E, or 3T cylinder having a minimum service pressure of 1800 psig. The pressure in a steel cylinder may not exceed 1000 psig at 21 °C (70 °F), except that if the gas is dry and sulfur free, the cylinder may be filled to 5% of the cylinder's service pressure or 2000 psig, whichever is less. A DOT 3AL cylinder may be filled to its marked service pressure. A DOT 3AL cylinder is authorized only when transported by motor vehicle, rail car, or cargo-only aircraft.

(e) *Diborane and diborane mixtures.* Diborane and diborane mixed with

compatible compressed gas must be offered in a DOT 3AL1800 or 3AA1800 cylinder. The maximum filling density of the diborane may not exceed 7 percent. Diborane mixed with compatible compressed gas may not have a pressure exceeding the service pressure of the cylinder if complete decomposition of the diborane occurs. Cylinder valve assemblies must be protected in accordance with § 173.301(h).

(f) *Fluorine*. Fluorine must be shipped in specification 3A1000, 3AA1000, or 3BN400 cylinders without pressure relief devices and equipped with valve protection cap. The cylinder may not be charged to over 400 psig at 21 °C (70 °F) and may not contain over 2.7 kg (6 lbs) of gas.

[67 FR 51646, Aug. 8, 2002, as amended at 68 FR 75745, Dec. 31, 2003; 70 FR 34075, June 13, 2005; 71 FR 54395, Sept. 14, 2006; 72 FR 4455, Jan. 31, 2007; 72 FR 55098, Sept. 28, 2007; 78 FR 1091, Jan. 7, 2013; 81 FR 3676, Jan. 21, 2016; 85 FR 85416, Dec. 28, 2020]

§ 173.302b Additional requirements for shipment of non-liquefied (permanent) compressed gases in UN pressure receptacles.

(a) *General*. A cylinder filled with a non-liquefied gas must be offered for transportation in UN pressure receptacles subject to the requirements in this section and § 173.302. In addition, the requirements in §§ 173.301 and 173.301b must be met.

(b) *UN pressure receptacles filling limits*. A UN pressure receptacle is authorized for the transportation of non-liquefied compressed gases as specified in this section. Except where filling limits are specifically prescribed in this section, the working pressure of a UN pressure receptacle may not exceed $\frac{2}{3}$ of the test pressure of the receptacle. Alternatively, the filling limits specified for non-liquefied gases in Table 1 of P200 of the UN Recommendations (IBR, see § 171.7 of this subchapter) are authorized. In no case may the internal pressure at 65 °C (149 °F) exceed the test pressure.

(c) *Fluorine, compressed, UN 1045 and Oxygen difluoride, compressed, UN 2190*. Fluorine, compressed and Oxygen difluoride, compressed must be packaged in a UN pressure receptacle with a minimum test pressure of 200 bar and a maximum working pressure not to ex-

ceed 30 bar. A UN pressure receptacle made of aluminum alloy is not authorized. The maximum quantity of gas authorized in each UN pressure receptacle is 5 kg.

(d) *Diborane and diborane mixtures, UN 1911*. Diborane and diborane mixtures must be packaged in a UN pressure receptacle with a minimum test pressure of 250 bar and a maximum filling ratio dependent on the test pressure not to exceed 0.07. Filling should be further limited so that if complete decomposition of diborane occurs, the pressure of diborane or diborane mixtures will not exceed the working pressure of the cylinder. The use of UN tubes and MEGCs is not authorized.

(e) *Carbon monoxide, compressed UN 1016*. Carbon monoxide, compressed is authorized in UN pressure receptacles. The settled pressure in a steel pressure receptacle containing carbon monoxide may not exceed $\frac{1}{3}$ of the pressure receptacle's test pressure at 65 °C (149 °F) except, if the gas is dry and sulfur-free, the settled pressure may not exceed $\frac{1}{2}$ of the marked test pressure.

[71 FR 33883, June 12, 2006]

§ 173.302c Additional requirements for the shipment of adsorbed gases in UN pressure receptacles.

(a) A cylinder filled with an adsorbed gas must be offered for transportation in UN pressure receptacles subject to the requirements in this section and § 173.302, as well as, §§ 173.301 and 173.301b.

(b) The pressure of each filled cylinder must be less than 101.3 kPa at 20 °C (68 °F) and must not exceed 300 kPa at 50 °C (122 °F).

(c) The minimum test pressure of the cylinder must be 21 bar.

(d) The minimum burst pressure of the cylinder must be 94.5 bar.

(e) The internal pressure at 65 °C (149 °F) of the filled cylinder must not exceed the test pressure of the cylinder.

(f) The adsorbent material must be compatible with the cylinder and must not form harmful or dangerous compounds with the gas to be adsorbed. The gas in combination with the adsorbent material must not affect or weaken the cylinder or cause a dangerous reaction (*e.g.*, a catalyzing reaction).