

(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 $\frac{1}{8}$ inch per minute during yield strength determination.

(l) *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 and yield strength not over 73 percent of tensile strength. Flattening is required, without cracking, to 6 times the wall thickness.

(m) *Leakage test.* All spun cylinders and plugged cylinders must be tested for leakage by gas or air pressure after the bottom has been cleaned and is free from all moisture, subject to the following conditions and limitations:

(1) Pressure, approximately the same as but no less than service pressure, must be applied to one side of the finished bottom over an area of at least $\frac{1}{16}$ of the total area of the bottom but not less than $\frac{3}{4}$ inch in diameter, including the closure, for at least one minute, during which time the other side of the bottom exposed to pressure must be covered with water and closely examined for indications of leakage. Except as provided in paragraph (n) of

this section, a cylinder must be rejected if there is any leaking.

(2) A spun cylinder is one in which an end closure in the finished cylinder has been welded by the spinning process.

(3) A plugged cylinder is one in which a permanent closure in the bottom of a finished cylinder has been effected by a plug.

(4) As a safety precaution, if the manufacturer elects to make this test before the hydrostatic test, he should design his apparatus so that the pressure is applied to the smallest area practicable, around the point of closure, and so as to use the smallest possible volume of air or gas.

(n) *Rejected cylinders.* Reheat treatment of rejected cylinders is authorized. Subsequent thereto, cylinders must pass all prescribed tests to be acceptable. Repair by welding or spinning is not authorized. Spun cylinders rejected under the provisions of paragraph (m) of this section may be removed from the spun cylinder category by drilling to remove defective material, tapping and plugging.

(o) *Marking.* Markings may be stamped into the sidewalls of cylinders having a service pressure of 150 psig if all of the following conditions are met:

(1) Wall stress at test pressure may not exceed 24,000 psi.

(2) Minimum wall thickness must be not less than 0.090 inch.

(3) Depth of stamping must be no greater than 15 percent of the minimum wall thickness, but may not exceed 0.015 inch.

(4) Maximum outside diameter of cylinder may not exceed 5 inches.

(5) Carbon content of cylinder may not exceed 0.25 percent. If the carbon content exceeds 0.25 percent, the complete cylinder must be normalized after stamping.

(6) Stamping must be adjacent to the top head.

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§ 178.39 Specification 3BN seamless nickel cylinders.

(a) *Type, size and service pressure.* A DOT 3BN cylinder is a seamless nickel

cylinder with a water capacity (nominal) not over 125 pounds water capacity (nominal) and a service pressure at least 150 to not over 500 psig.

(b) *Nickel*. The percentage of nickel plus cobalt must be at least 99.0 percent.

(c) *Identification of material*. The material must be identified by any suitable method except that plates and billets for hot-drawn 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 cylinder appreciably. A reasonably smooth and uniform surface finish is required. Cylinders closed in by spinning process are not authorized.

(e) *Welding or brazing*. Welding or brazing for any purpose whatsoever is prohibited except that welding is authorized for the attachment of neckrings and footrings which are non-pressure parts, and only to the tops and bottoms of cylinders. Neckrings and footrings must be of weldable material, the carbon content of which may not exceed 0.25 percent. Nickel welding rod must be used.

(f) *Wall thickness*. The wall stress may not exceed 15,000 psi. A minimum wall thickness of 0.100 inch is required for any cylinder over 5 inches in outside diameter. Wall stress calculation must be made by using 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 or 450 psig whichever is the greater;

D = outside diameter in inches;

d = inside diameter in inches.

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

(h) *Openings in cylinders and connections (valves, fuse plugs, etc.) for those openings*. Threads conforming to the following are required on openings:

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

(2) Taper threads, when used, to be of length not less than as specified for American Standard taper pipe threads.

(3) Straight threads having at least 6 engaged threads are authorized. Straight threads must have a tight fit and a calculated shear strength of at least 10 times the test pressure of the cylinder. Gaskets, adequate to prevent leakage, are required.

(i) *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 reading of total expansion to an accuracy either of 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 total volumetric expansion at test pressure.

(4) Each cylinder must be tested to at least 2 times service pressure.

(j) *Flattening test*. A flattening test must be performed on one cylinder taken at random out of each lot of 200 or less, by placing the cylinder between wedge shaped knife edges having a 60° included angle, rounded to ½-inch radius. The longitudinal axis of the cylinder must be at a 90-degree angle to knife edges during the test. For lots of 30 or less, flattening tests are authorized to be made on a ring at least 8 inches long cut from each cylinder and subjected to same heat treatment as the finished cylinder.

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

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(1) The test 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 same heat treatment as the finished cylinder.

(2) Specimens must conform to the following:

(i) A gauge length of 8 inches with a width of not over 1½ inches, a gauge length of 2 inches with a width of not over 1½ inches, or a gauge length of at least 24 times the thickness with a width not over 6 times 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 one 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 tests 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 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 must be set at the calculated corresponding strain.

(iv) Cross-head speed of the testing machine may not exceed 1/8 inch per minute during yield strength determination.

(l) *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 point not over 50 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 and a yield point not over 50 percent of tensile strength. Flattening is required, without cracking, to 6 times the wall thickness.

(m) *Rejected cylinders.* Reheat treatment is authorized for rejected cylinders. Subsequent thereto, cylinders must pass all prescribed tests to be acceptable. Repair by welding is not authorized.

[Amdt. 178-114, 61 FR 25942, May 23, 1996, as amended by 66 FR 45185, 45386, 45388, Aug. 28, 2001; 67 FR 51652, Aug. 8, 2002; 68 FR 75748, Dec. 31, 2003]

§ 178.42 Specification 3E seamless steel cylinders.

(a) *Type, size, and service pressure.* A DOT 3E cylinder is a seamless steel cylinder with an outside diameter not greater than 2 inches nominal, a length less than 2 feet and a service pressure of 1,800 psig.

(b) *Steel.* Open-hearth or electric steel of uniform quality must be used. Content percent may not exceed the following: Carbon, 0.55; phosphorus, 0.045; sulphur, 0.050.

(c) *Identification of steel.* Materials must be identified by any suitable method.

(d) *Manufacture.* Cylinders must be manufactured by best appliances and methods. No defect is permitted that is likely to weaken the finished cylinder appreciably. A reasonably smooth and