



Designation: A 556/A 556M – 96 (Reapproved 2001)

## Standard Specification for Seamless Cold-Drawn Carbon Steel Feedwater Heater Tubes<sup>1</sup>

This standard is issued under the fixed designation A 556/A 556M; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

### 1. Scope

1.1 This specification<sup>2</sup> covers minimum-wall-thickness, seamless cold-drawn carbon steel tubes including bending into the form of U-tubes, if specified, for use in tubular feedwater heaters.

1.2 The tubing sizes covered shall be 5/8 to 1¼-in. [15.9 to 31.8-mm] outside diameter, inclusive, with minimum wall thicknesses equal to or greater than 0.045 in. [1.1 mm].

1.3 Optional supplementary requirements are provided, and when desired, shall be stated in the order.

1.4 The values stated in either inch-pound units or SI units are to be regarded separately as the standard. Within the text, the SI units are shown in brackets. The values stated in each system are not exact equivalents; therefore, each system must be used independently of the other. Combining values from the two systems may result in nonconformance with the specification. The inch-pound units shall apply unless the “M” designation of this specification is specified in the order.

### 2. Referenced Documents

#### 2.1 ASTM Standards:

- A 450/A 450M Specification for General Requirements for Carbon, Ferritic Alloy, and Austenitic Alloy Steel Tubes<sup>3</sup>
- E 30 Test Methods for Chemical Analysis of Steel, Cast Iron, Open-Hearth Iron, and Wrought Iron<sup>4</sup>

### 3. Ordering Information

3.1 Orders for material under this specification should include the following as required to describe the desired material adequately:

- 3.1.1 Quantity (feet, metres, or number of pieces),
- 3.1.2 Name of material (seamless steel tubing),
- 3.1.3 Dimensions (outside diameter and minimum wall thickness),
- 3.1.4 Length (specific or random),
- 3.1.5 Manufacture (cold drawn),
- 3.1.6 Grade (chemical composition),
- 3.1.7 Optional requirements,
- 3.1.8 *Bending Requirements*— If order specifies tubes to be bent, the design of the U-tubes shall accompany the order. Purchaser must specify if stress-relief anneal of the U-bends is required,
- 3.1.9 Test report required (see Certification Section of Specification A 450/A 450M),
- 3.1.10 Specification number, and
- 3.1.11 Special requirements and any supplementary requirements selected.

### 4. General Requirements

4.1 Material furnished to this specification shall conform to the applicable requirements of the current edition of the Specification A 450/A 450M, unless otherwise provided herein.

### 5. Manufacture

5.1 *Manufacture*—Tubes shall be made by the seamless process and shall be cold drawn.

#### 5.2 Heat Treatment:

5.2.1 Cold-drawn tubes shall be heat treated after the final cold-draw pass at a temperature of 1200°F [640°C] or higher to ensure ductility satisfactory for rolling into tube sheets and to meet mechanical properties as specified.

5.2.2 If stress-relief anneal of the U-bends is specified, the anneal shall consist of heating the bent portion within a range of 1100 to 1200°F [585 to 640°C].

### 6. Chemical Composition

6.1 The steel shall conform to one of the requirements as to chemical composition as prescribed in Table 1.

<sup>1</sup> This specification is under the jurisdiction of ASTM Committee A01 on Steel, Stainless Steel, and Related Alloys, and is the direct responsibility of Subcommittee A01.09 on Carbon Steel Tubular Products.

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<sup>2</sup> For ASME Boiler and Pressure Vessel Code applications see related Specification SA-556 in Section II of that Code.

<sup>3</sup> *Annual Book of ASTM Standards*, Vol 01.01.

<sup>4</sup> *Annual Book of ASTM Standards*, Vol 03.05.

**TABLE 1 Chemical Requirements**

Element	Composition, %		
	Grade A2	Grade B2	Grade C2
Carbon, max	0.18	0.27	0.30
Manganese	0.27–0.63	0.29–0.93	0.29–1.06
Phosphorus, max	0.035	0.035	0.035
Sulfur, max	0.035	0.035	0.035
Silicon, min	...	0.10	0.10

6.2 When a grade is ordered under this specification, supplying an alloy grade that specifically requires the addition of any element other than those listed for the ordered grade in Table 1 is not permitted.

**7. Product Analysis**

7.1 When requested in the purchase order, a product analysis shall be made by the manufacturer or supplier from one tube or billet per heat.

7.2 If the original test for product analysis fails, retests of two additional tubes or billets shall be made. Both retests for the elements in question shall meet the requirements of this specification; otherwise, all remaining material in the heat or lot (Note 1) shall be rejected or, at the option of the producer, each tube may be individually tested for acceptance. Tubes that do not meet the requirements of this specification shall be rejected.

NOTE 1—For tension and hardness test requirements, the term *lot* applies to all tubes prior to cutting, of the same nominal diameter and wall thickness which are produced from the same heat of steel. When final heat treatment is in a batch-type furnace, a lot shall include only those tubes of the same size and the same heat which are heat treated in the same furnace charge. When the final heat treatment is in a continuous furnace, a lot shall include all tubes of the same size and heat, heat treated in the same furnace at the same temperature, time at heat and furnace speed.

7.3 For referee purposes, Test Methods E 30 shall be used.

**8. Mechanical Properties**

8.1 *Tensile Properties*—The material shall conform to the requirements as to tensile properties prescribed in Table 2, when pulled in full section.

8.2 *Hardness Requirements*—The tubes shall not exceed the Rockwell Hardness shown in Table 3.

**9. Permissible Variations in Dimensions (Fig. 1)**

9.1 Permissible variations from the specified outside diameter shall not exceed  $\pm 0.004$  in. [0.10 mm] for tubing under 1.0-in. [25.4-mm] outside diameter nor  $\pm 0.006$  in. [0.15 mm] for tubing 1.0 in. [25.4 mm] to 1.25 in. [31.7 mm] inclusive. These tolerances do not apply to the bent portion of the U-tubes. At the bent portion of a U-tube for  $R = 2 \times D$  or greater neither the major nor minor diameter of tube shall

**TABLE 2 Tensile Requirements**

	Grade A2	Grade B2	Grade C2
Tensile strength, min, ksi [MPa]	47 [320]	60 [410]	70 [480]
Yield strength, min, ksi [MPa]	26 [180]	37 [260]	40 [280]
Elongation in 2 in. or 50 mm, min, % (longitudinal)	35	30	30

**TABLE 3 Hardness Requirements**

Grade A2	HR B 72
Grade B2	HR B 79
Grade C2	HR B 89

deviate from nominal by more than 10 %. If  $1\frac{1}{2} D$  is specified, tolerances could be greater.

9.2 Permissible variations from the specified minimum wall thickness shall not exceed +20 % or –0. The wall thickness of the tube in U-bent section shall be not less than value determined by:

$$t_f = T(2R) / (2R + D) \tag{1}$$

where:

- $t_f$  = wall thickness after bending, in. [mm],
- $T$  = specified minimum tube wall thickness, in. [mm],
- $R$  = centerline bend radius, in. [mm], and
- $D$  = nominal outside tube diameter, in. [mm].

9.3 In the case of U-tubes, the length of the tube legs as measured from the point of tangency of the bend and the tube leg to the end of the tube leg shall not be less than specified, but may exceed the specified values by the amount given in Table 4. The difference in lengths of the tube legs shall not be greater than  $\frac{1}{8}$  in. [3 mm] unless otherwise specified.

9.4 The end of any tube may depart from square by not more than the amount given in Table 5.

9.5 The leg spacing measured between the points of tangency of the bend to the legs shall not vary from the value  $(2R - \text{specified tube OD})$  by more than  $\frac{1}{16}$  in. [1.5 mm] where  $R$  is the centerline bend radius.

9.6 The bent portion of the U-tube shall be substantially uniform in curvature and not exceed  $\pm \frac{1}{16}$  in. [ $\pm 1.5$  mm] of the normal centerline radius.

**10. Workmanship, Finish, and Appearance**

10.1 Finished tubes shall be free from scale but may have a superficial oxide film on the surfaces. A light oxide scale on the outside and inside surfaces of U-bend shall be allowed for tubes which have been heat treated.

10.2 Finished tubes shall be reasonably straight and have smooth ends free from burrs. Tubes shall have a workmanlike finish and shall be free of surface imperfections that cannot be removed within the allowable wall tolerances. Removal of surface imperfections such as handling marks, straightening marks, light mandrel and die marks, shallow pits, and scale pattern will not be required provided they are within the allowable wall tolerances.

10.3 Finished tubes shall be coated both on the outside and the inside diameter to prevent corrosion in transit. The type of coating applied should be mutually agreed upon and specified in the order.

**11. Mechanical Tests Required**

11.1 *Tension Test*—One tension test shall be made on a specimen for lots of not more than 50 tubes. Tension tests shall be made on specimens from two tubes for lots of more than 50 tubes (Note 1).

11.2 *Flattening Test*—One flattening test shall be made on specimens taken from each end of one finished tube, not the