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An American National Standard

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Standard Specification for Seamless Austenitic and Martensitic Stainless Steel Tubing for Liquid Metal-Cooled Reactor Core Components[1]

This standard is issued under the fixed designation A 771/A 771M; 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 covers seamless annealed or cold-worked, austenitic or martensitic stainless steel tubing of 0.100 to 1.0 in. [2.5 to 25 mm] outside diameter with wall thickness of 0.050 in. [1.3 mm] or less for use at high temperature in liquid metal-cooled reactor plants.

1.2 The values stated in either inch-pound units or SI units are to be regarded separately as 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.

1.3 This specification and the applicable material specifications are expressed in both inch-pound and SI units. However, unless the order specifies the applicable "M" specification designation (SI units), the material shall be furnished in inch-pound units.

2. Referenced Documents

2.1 *ASTM Standards:*

A 370 Test Methods and Definitions for Mechanical Testing of Steel Products[2,3]

A 380 Practice for Cleaning, Descaling and Passivation of Stainless Steel Parts, Equipment, and Systems[2]

A 450/A 450M Specification for General Requirements for Carbon, Ferritic Alloy, and Austenitic Alloy Steel Tubes[3]

D 129 Test Method for Sulfur in Petroleum Products (General Bomb Method)[4]

D 808 Test Method for Chlorine in New and Used Petroleum Products (Bomb Method)[4]

E 3 Methods of Preparation of Metallographic Specimens[5]

E 21 Test Methods for Elevated Temperature Tension Tests of Metallic Materials[5]

E 45 Test Methods for Determining the Inclusion Content of Steel[5]

E 165 Test Method for Liquid Penetrant Examination[6]

E 213 Practice for Ultrasonic Examination of Metal Pipe and Tubing[6]

E 384 Test Method for Microhardness of Materials[5]

E 407 Practice for Microetching Metals and Alloys[5]

2.2 *ANSI Standard:*

B46.1 Surface Texture[7]

2.3 *ASNT Standard:*

SNT-TC-1A Recommended Practice for Nondestructive Testing Personnel Qualification and Certification[8]

2.4 *ASME Standard:*

NQA-1 Quality Assurance Program Requirements for Nuclear Facilities[9]

3. Ordering Information

3.1 It is the responsibility of the purchaser to specify all requirements that are necessary for the safe and satisfactory performance of material ordered under this specification. Examples of such requirements include but are not limited to the following:

3.1.1 Quantity (feet, metres, or number of lengths),

3.1.2 Name of material (seamless tubes),

3.1.3 Grade (Table 1),

3.1.4 Annealing and tempering requirements for martensitic grades,

3.1.5 Condition (cold-worked, annealed, or thermomechanical condition),

3.1.6 Dimensions:

3.1.6.1 Diameter and length (tubing dimensions or applicable drawings),

3.1.6.2 Ovality (tolerances on roundness),

3.1.6.3 Wall thickness and eccentricity,

3.1.6.4 Straightness,

3.1.7 Tubing end configuration,

3.1.8 Percent of cold work,

[1] This specification is under the jurisdiction of ASTM Committee A-1 on Steel, Stainless Steel, and Related Alloys and is the direct responsibility of Subcommittee A01.10 on Tubing.

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[2] *Annual Book of ASTM Standards*, Vol 01.03.

[3] *Annual Book of ASTM Standards*, Vol 01.01.

[4] *Annual Book of ASTM Standards*, Vol 05.01.

[5] *Annual Book of ASTM Standards*, Vol 03.01.

[6] *Annual Book of ASTM Standards*, Vol 03.03.

[7] Available from American National Standards Institute, 11 West 42nd St., 13th Floor, New York, NY 10036.

[8] Available from American Society for Nondestructive Testing, 914 Chicago Ave., Evanston, IL 60202.

[9] Available from American Society of Mechanical Engineers, 345 E. 47th St., New York, NY 10017.

TABLE 1 Alloy Composition Limits for Austenitic Stainless Steel Tubing

Grade UNS Designation	TP 316 S31600	. . . S38660	. . . S42100
Element	Weight, %		
Carbon	0.040–0.060	0.030–0.050	0.17–0.23
Manganese	1.00–2.00	1.65–2.35	0.40–0.70
Phosphorus, max	0.040	0.040	0.040
Sulfur, max	0.010	0.010	0.010
Silicon	0.50–0.75	0.50–1.00	0.20–0.30
Nickel	13.0–14.0	14.5–16.5	0.30–0.80
Chromium	17.0–18.0	12.5–14.5	11.0–12.5
Molybdenum	2.00–3.00	1.50–2.50	0.80–1.20
Titanium	. . .	0.10–0.40[A]	. . .
Columbium, max	0.050	0.050	0.050 max
Tantalum, max	0.020	0.020	. . .
Tungsten	. . .	. . .	0.40–0.60
Nitrogen, max	0.010	0.005	. . .
Aluminum, max	0.050	0.050	0.050
Arsenic, max	0.030	0.030	. . .
Boron, max	0.0020	0.0020	. . .
Cobalt, max	0.050	0.050	. . .
Copper, max	0.04	0.04	. . .
Vanadium, max	0.05	0.05	0.25–0.35

[A] Aim for 0.25.

3.1.9 Number of tension tests and tensile properties at other cold-work levels,

3.1.10 Packaging,

3.1.11 Surface roughness,

3.1.12 Grain size,

3.1.13 Identification,

3.1.14 Surface condition, and

3.1.15 Sampling levels.

4. General Requirements for Delivery

4.1 Material supplied under this specification shall conform to the applicable requirements of Specification A 450/ A 450M unless otherwise specified herein.

5. Manufacture

5.1 *Melting*—The steel shall be made by a double-vacuum melting process. Unless an alternative melting process has been approved in writing by the purchaser, the process shall consist of a vacuum induction melt followed by a consumable electrode vacuum-arc remelt. Additions of rare earths during melting are prohibited unless approved by the purchaser.

5.2 *Tubemaking*—Tubing shall be made by a seamless process. Tubemaking processes shall have been previously qualified as acceptable. Free sinking to final size is prohibited. There shall be no drawing "chatter" and straightener "ripples" and other process variables that affect nondestructive examination. Surface-finishing processes, such as belt polishing and other mechanical conditioning of the finished tubing, are prohibited. Any in-process conditioning procedures shall be approved prior to use. Chemical pickling of tubing (in-process and finished) is not permitted unless approved by the purchaser prior to use.

5.3 *Special Handling*—Handling methods shall minimize tube-to-tube contact during processing, cleaning, annealing, and storage, and shall be consistent with the preservation of a mar-free surface finish. Special handling procedures shall be provided to maintain the identity of tubing at all times. The manufacturer shall submit his proposed handling methods to the purchaser for approval prior to use.

5.4 *Heat Treating*:

5.4.1 *Austenitic Grades*—All annealing operations shall be performed by use of the continuous bright-hydrogen annealing process unless otherwise specified by the purchaser. The dew point of the gas at the hydrogen inlet shall be less than −80°F [−62°C], and the dew point of the hydrogen at exit shall not exceed −40°F [−40°C]. The temperature and time shall be selected to ensure carbide solution. The temperature of the final anneal shall be demonstrated by thermocouple readings during furnace profile measurements with the thermocouple on the inside of tubes ½ in. [13 mm] or larger and on the outside of smaller tubes. Cooling shall be at a rate rapid enough to avoid visible carbide precipitation as described in 10.5 unless a specific thermomechanical treatment is specified in Section 3.

5.4.2 *Martensitic Grades*—Martensitic grades shall be annealed and tempered as specified in the order.

5.5 *Condition*—Tubing shall be furnished in the annealed, cold-worked, or thermomechanical condition as specified in Section 3.

5.6 *Cold Work*—Cold-worked tubing shall be plug drawn subsequent to the final bright anneal. Percent cold work shall be as specified in Section 3 and shall be based upon the reduction in transverse area or change in weight per unit length. Cold-worked tubing shall be cold-drawn to finished size and delivered without further heat treatment.

5.6.1 *Cold-Work Determination*—Calculate percent cold work determined by reduction in transverse area at each end and center of selected tubes as follows:

$$CW = \frac{A_1 - A_2}{A_1} \times 100 \quad (1)$$

where:

CW = percent cold work,

A_1 = tubing cross-sectional area prior to final cold draw, and

A_2 = tubing cross-sectional area after final cold draw.

Cross-sectional area shall be based upon average diameter at each location.

5.6.2 Calculate percent cold work determined by change in weight per unit length as follows:

$$CW = \frac{W_1 - W_2}{W_1} \times 100 \quad (2)$$

where:

CW = percent cold work,

W_1 = weight per unit length of tubing prior to final cold draw, and

W_2 = weight per unit length of tubing after final cold draw.

5.6.3 The cold-draw procedure and method for measuring percent cold work shall be submitted to the purchaser for review and approval prior to use.

5.7 *Lot Size*—Tube lots shall be limited to a maximum of 5000 ft [1500 m] of the same nominal size, produced from the same heat, fabricated by the same reduction sequence, cold-reduced in the same manner, and annealed in the same