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Standard Specification for Cold-Formed Welded and Seamless High-Strength, Low-Alloy Structural Tubing with Improved Atmospheric Corrosion Resistance[1]

This standard is issued under the fixed designation A847/A847M; 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 cold-formed welded and seamless high-strength, low-alloy round, square, rectangular, or special tubular shapes for welded, riveted, or bolted construction of bridges and buildings and for general structural purposes where high strength and enhanced atmospheric corrosion resistance are required (Note 1). The atmospheric corrosion resistance of this steel in most environments is substantially better than carbon steel with or without copper addition (Note 2). When properly exposed to the atmosphere, this steel can be used bare (unpainted) for many applications. When this steel is used in welded construction, the welding procedure shall be suitable for the steel and the intended service.

1.2 This tubing is produced in welded sizes with a maximum periphery of 88 in. [2235 mm] and a maximum wall of 1 in. [25.4 mm], and in seamless with a maximum periphery of 32 in. [813 mm] and a maximum wall of 0.500 in. [12.7 mm]. Tubing having other dimensions may be furnished provided such tubing complies with all other requirements of this specification.

NOTE 1—Products manufactured to this specification may not be suitable for those applications where low temperature notch toughness properties may be important, such as dynamically loaded elements in welded structures, unless ordered with toughness tests. See the Supplementary Requirements.

NOTE 2—For methods of estimating the atmospheric corrosion resistance of low alloy steels, see Guide G101 or actual data.

1.3 The values stated in either SI units or inch-pound units are to be regarded separately as standard. Within the text, the SI units are shown in brackets. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in non-conformance with the standard.

1.4 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

A370 Test Methods and Definitions for Mechanical Testing of Steel Products

A700 Guide for Packaging, Marking, and Loading Methods for Steel Products for Shipment

A751 Test Methods and Practices for Chemical Analysis of Steel Products

[1] 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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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

***A Summary of Changes section appears at the end of this standard**

A1058 Test Methods for Mechanical Testing of Steel Products—Metric
G101 Guide for Estimating the Atmospheric Corrosion Resistance of Low-Alloy Steels
2.2 *Steel Tube Institute Standard:*[3]
Methods to Check Dimensional Tolerances on Hollow Structural Sections

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 ASTM specification number,

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

3.1.3 Name of material (cold-formed tubing),

3.1.4 Method of manufacture (welded or seamless),

3.1.5 Size (outside diameter and nominal wall thickness for round tubing and the outside dimensions and nominal wall thickness for square and rectangular tubing),

3.1.6 Length (specific or random, see 10.3),

3.1.7 End condition (see 14.2),

3.1.8 Burr removal (see 14.2),

3.1.9 Certification (see Section 17),

3.1.10 Specific weld location,

3.1.11 End use, and

3.1.12 Special or supplementary requirements.

4. Process

4.1 The steel shall be made by one or both of the following processes: basic oxygen or electric furnace.

5. Manufacture

5.1 The tubing shall be made by a welded or seamless process.

5.2 Welded tubing shall be made from flat-rolled steel by the electric-resistance welding or electric-fusion welding process. The longitudinal butt joint shall be welded across its thickness in such a manner that the structural design strength of the tubing section is assured. The weld shall not be located within the radius of the corners of any square, rectangular, or other tubular shapes unless specified by the purchaser.

5.2.1 Structural tubing welded by the electric-resistance method is normally furnished without removal of inside flash.

5.3 The tubing may be stress relieved or annealed, as is considered necessary by the tubing manufacturer, to conform to the requirements of this specification.

6. Chemical Composition

6.1 The choice and use of alloying elements combined with carbon, manganese, phosphorus, sulphur, and copper shall be within

[3] Available from the Steel Tube Institute (STI), 2516 Waukegan Rd., STE 172, Glenview, IL 60025-1774, https://steeltubeinstitute.org.

the limits prescribed in Section 7 to give the mechanical properties prescribed in Table 1 and to provide the atmospheric corrosion resistance of 1.1. The choice and use of these elements shall be made by the manufacturer and included and reported in the heat analysis to identify the type of steel applied. Elements commonly added include chromium, nickel, silicon, vanadium, titanium, and zirconium. For Specification A847/A847M material, the atmospheric corrosion-resistance index, calculated on the basis of the chemical composition of the steel as described in Guide G101, shall be 6.0 or higher. The amount of nickel, silicon, and chromium present shall be reported due to their use calculating the atmospheric corrosion index.

NOTE 3—The user is cautioned that the Guide G101 predictive equation for calculation of an atmospheric corrosion-resistance index has been verified only for the composition limits stated in that guide.

7. Heat Analysis

7.1 Each heat analysis shall conform to the requirements given in Table 2 for heat analysis.

8. Product Analysis

8.1 The tubing shall be capable of conforming to the requirements given in Table 2 for product analysis.

8.2 If product analyses are made, they shall be made using test specimens taken from two lengths of tubing from each lot of 500 lengths, or a fraction thereof, or two pieces of flat-rolled stock from each lot of a corresponding quantity of flat-rolled stock. Methods and practices relating to chemical analysis shall be in accordance with Test Methods, Practices, and Terminology A751. Such product analyses shall conform to the requirements specified in Table 2 for product analysis.

8.3 If both product analyses representing a lot fail to conform to the specified requirements, the lot shall be rejected.

8.4 If only one product analysis representing a lot fails to conform to the specified requirements, product analyses shall be made using two additional test specimens taken from the lot. Both additional product analyses shall conform to the specified requirements or the lot shall be rejected.

9. Tensile Requirements

9.1 The material, as represented by the test specimen, shall conform to the tensile property requirements prescribed in Table 1.

10. Permissible Variations and Dimensions

10.1 *Outside Dimensions:*

10.1.1 *Round Structural Tubing*—The outside diameter shall not vary from the specified outside diameter by more than ± 0.5 %, rounded to the nearest 0.005 in. [0.1 mm], for specified outside diameters 1.900 in. [48.3 mm] and smaller; ± 0.75 %, rounded to the nearest 0.005 in., for specified outside diameters 2 in. [50 mm] and larger. The outside diameter measurements shall be made at positions at least 2 in. [50 mm] from either end of the tubing.

10.1.2 *Square and Rectangular Structural Tubing*—The specified dimensions, measured across the flats at a position at least 2 in. [50 mm] from either end of the tubing and including an allowance for convexity or concavity, shall not exceed the plus and minus tolerances shown in Table 3.

10.2 *Wall Thickness*—The minimum wall thickness at any point of measurement on the tubing shall be not more than 10 % less than the specified wall thickness. The maximum wall thickness, excluding the weld seam of welded tubing, shall be not more than 10 % greater than the specified wall thickness. The wall thickness on square and rectangular tubing is to be measured at the center of the flat.

TABLE 1 Tensile Requirements

Tensile strength, min, psi [MPa]	70 000 [485]
Yield strength, min, psi [MPa]	50 000 [345]
Elongation in 2 in. or [50 mm] min, %	19[A]

[A] Applies to specified wall thicknesses 0.120 in. [3.0 mm] and over. For lighter wall thicknesses, elongation shall be by agreement with the manufacturer.

TABLE 2 Chemical Requirements

Elements	Heat Analysis	Product Analysis
Carbon, max	0.20	0.24
Manganese, max	1.35	1.40
Phosphorus, max	0.04	0.04
Sulphur, max	0.035	0.045
Copper, min	0.20^{A}	0.18^{A}
Nickel	. . .^{B}	. . .^{B}
Silicon	. . .^{B}	. . .^{B}
Chromium	. . .^{B}	. . .^{B}

^{A} If chromium and silicon contents are each 0.50 minimum, then the copper minimums do not apply.
^{B}The amount of nickel, silicon, and chromium present must be reported, but there are no minimum requirements.

TABLE 3 Outside Dimension Tolerances for Square and Rectangular Tubing

Largest outside dimension across flats, in. [mm]	Tolerance, ± in. [mm]^{A}
2½ [63.5] and under	0.020 [0.5]
Over 2½ [63.5] to 3½ [88.9], incl	0.025 [0.6]
Over 3½ [88.9] to 5½ [139.7], incl	0.030 [0.7]
Over 5½ [139.7]	1 %

^{A} Tolerances include allowance for convexity or concavity. For rectangular sections, the tolerance calculated for the larger flat dimension shall also apply to the smaller flat dimension. This tolerance may be increased 50 % when applied to the smaller dimension if the ratio of the external sides is in the range of 1.5 to 3, inclusive; the tolerance may be increased 100 % when the ratio exceeds 3.

10.3 *Length*—Structural tubing is normally produced in random mill lengths 5 ft [1.5 m] and over, in multiple lengths, and in specified mill lengths (see Section 3). When specified mill lengths are ordered, the length tolerance shall be in accordance with Table 4.

10.4 *Straightness*—The permissible variation for straightness of structural tubing shall be ⅛ in. times the number of feet [10.4 mm times the number of metres] of total length divided by 5.

10.5 *Squareness of Sides*—For square and rectangular structural tubing, adjacent sides may deviate from 90° by a tolerance of ± 2° maximum.

10.6 *Radius of Corners*—For square or rectangular structural tubing, the radius of any outside corner of the section shall not exceed three times the specified wall thickness.

10.7 *Twist*—The tolerances for twist, or variation with respect to axial alignment of the section, for square and rectangular structural tubing shall be as shown in Table 5. Twist is measured by holding down on a flat surface plate one end of a square or rectangular tube, with the bottom side of the tube parallel to the surface plate and either (*1*) noting the difference in height above the surface plate of the two corners at the opposite end of the bottom side of the tube, or (*2*) by measuring this difference on the heavier sections by a suitable measuring device. The difference in the height of the corners shall not exceed the values of Table 5. Twist measurements are not to be taken within 2 in. [50 mm] of either end of the product.

TABLE 4 Specified Mill Length

	Tolerances for Structural Tubing			
	22 ft [6.7 m] and under		Over 22 ft [6.7 m]	
	Over	Under	Over	Under
Length tolerance for specified mill length, in. [mm]	½ [12.7]	¼ [6.4]	¾ [19.0]	¼ [6.4]

TABLE 5 Twist Tolerances for Square and Rectangular Structural Tubing

Specified dimension of longest side, in. [mm]	Maximum twist in the first 3 ft [1 m] and in each additional 3 ft	
	in.	mm
1½ [38.1] and under	0.050	1.4
Over 1½ [38.1] to 2½ [63.5], incl	0.062	1.7
Over 2½ [63.5] to 4 [101.6], incl	0.075	2.1
Over 4 [101.6] to 6 [152.4], incl	0.087	2.4
Over 6 [152.4] to 8 [203.2], incl	0.100	2.8
Over 8 [203.2]	0.112	3.1

11. Special Tubular Shapes

11.1 The dimensions and tolerances of special tubular shapes are available by inquiry and negotiation with the manufacturer.

12. Flattening Test, Flaring Test, and Wedge Crush Test

12.1 The flattening test shall be made on round structural tubing. A flaring test or a wedge crush test on round tubing up to and including 10 in. in diameter can be made if stated in the purchase order. Either a flattening test, a flaring test, or a wedge crush test shall be made on square, rectangular, or other tubular shapes with a maximum side up to and including 10 in. except when the customer specifies the weld to be located in the corner.

12.2 For welded structural tubing, a test specimen at least 4 in. [100 mm] in length shall be flattened cold between parallel plates in three steps, with the weld located 90° from the line of direction of force. During the first step, which is a test for ductility of the weld, no cracks or breaks on the inside or outside surfaces of the test specimen shall be present until the distance between the plates is less than two-thirds of the specified outside diameter of the tubing. For the second step, no cracks or breaks on the inside or outside parent metal surfaces of the test specimen, except as provided for in 12.5, shall be present until the distance between the plates is less than one-half of the specified outside diameter of the tubing. During the third step, which is a test for soundness, the flattening shall be continued until the test specimen breaks or the opposite walls of the test specimen meet. Evidence of laminated or unsound material or of incomplete weld that is revealed during the entire flattening test shall be cause for rejection.

12.3 For seamless round structural tubing 2⅜ in. [60 mm] specified outside diameter and larger, a specimen not less than 2½ in. [65 mm] in length shall be flattened cold between parallel plates in two steps. During the first step, which is a test for ductility, no cracks or breaks on the inside or outside surfaces, except as provided for in 12.5, shall occur until the distance between the plates is less than the value of "H" calculated by the following equation:

$$H = (1+e)t/(e+t/D)$$

where:

H = distance between flattening plates, in. [mm],
e = deformation per unit length, 0.06,
t = specified wall thickness of tubing, in. [mm], and
D = specified outside diameter of tubing, in. [mm].

12.3.1 During the second step, which is a test for soundness, the flattening shall be continued until the specimen breaks or the opposite walls of the specimen meet. Evidence of laminated or unsound material that is revealed during the entire flattening test shall be cause for rejection.

12.4 Surface imperfections not found in the test specimen before flattening, but revealed during the first step of the flattening test, shall be judged in accordance with Section 15.

12.5 When low D-to-t ratio tubulars are tested, because the strain imposed due to geometry is unreasonably high on the inside surface at the 6 and 12 o'clock locations, cracks at these locations shall not be cause for rejection if the D-to-t ratio is less than 10.