Designation: A 847/A 847M – 05

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 A 847/A 847M; 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 shaped structural tubing 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 64 in. [1626 mm] and a maximum wall of 0.625 in. [15.9 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.

1.3 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 is to be used independently of the other, without combining values in any way.

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, etc.

NOTE 2—For methods of estimating the atmospheric corrosion resistance of low alloy steels see Guide G 101 or actual data.

2. Referenced Documents

2.1 *ASTM Standards:* [2]

A 370 Test Methods and Definitions for Mechanical Testing of Steel Products

A 700 Practices for Packaging, Marking, and Loading Methods for Steel Products for Shipment

A 751 Test Methods, Practices, and Terminology for Chemical Analysis of Steel Products

G 101 Guide For Estimating the Atmospheric Corrosion Resistance of Low-Alloy Steels

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),

[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.**

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3.1.10 End use, and
3.1.11 Special requirements.

4. Process

4.1 The steel shall be made by one or more of the following processes: open hearth, 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.

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 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 A 847 material, the atmospheric corrosion-resistance index, calculated on the basis of the chemical composition of the steel as described in Guide G 101, shall be 6.0 or higher.

NOTE 3—The user is cautioned that the Guide G 101 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 comforming 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 A 751. 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.

TABLE 1 Tensile Requirements for Round and Shaped Tubing

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	0.15	[A]
Sulphur, max	0.05	0.06
Copper, min	0.20[B]	0.18[B]

[A] Because of the degree to which phosphorus segregates, product analysis for this element is not technologically appropriate for rephosphorized steels unless misapplication is clearly indicated.

[B] If chromium and silicon contents are each 0.50 minimum, then the copper minimums do not apply.

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.

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.

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The wall thickness on square and rectangular tubing is to be measured at the center of the flat.

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.

11. Special Shaped Structural Tubing

11.1 The dimensions and tolerances of special shaped structural tubing are available by inquiry and negotiation with the manufacturer.

12. Flattening Test

12.1 The flattening test shall be made on round structural tubing. A flattening test is not required for shaped structural tubing.

12.2 For welded round structural tubing, a specimen at least 4 in. [100 mm] in length shall be flattened cold between parallel plates in three steps, with the weld located at 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 shall occur before the distance between the plates is less than two thirds of the original outside diameter of the tubing. As a second step, the flattening shall be continued. During the second step, which is a test for ductility exclusive of the weld, no cracks or breaks on the inside or outside surfaces, except as provided for in 12.4, shall occur before the distance between the plates is less than one half of the original outside diameter of the tubing, but not less than five times the wall thickness of the tubing. During the third step, which is a test for soundness, continue the flattening until the specimen breaks or the opposite walls of the tubing 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 of 2⅜ in. [60.3 mm] specified outside diameter and larger, a section not less than 2½ in. [60 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 12.4, shall occur before 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 = nominal wall thickness of tubing, in. [mm], and
D = actual outside diameter of tubing, in. [mm].

12.3.1 During the second step, which is a test for soundness, continue the flattening until the specimen breaks or the opposite walls of the tubing 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 14.

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

13. Test Methods

13.1 The tension specimens required by this specification shall conform to those described in the latest issue of Methods and Definitions A 370, Supplementary Requirements II.

13.2 The tension test specimens shall be taken longitudinally from a section of the finished tubing at a location at least 90° from the weld in the case of welded tubing, and shall not be flattened between gage marks. If desired, the tension tests may be made on the full section of the tubing; otherwise, a

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

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longitudinal strip-test specimen as prescribed in Test Methods and Definitions A 370, Supplementary Requirements II, shall be used. The specimens shall have all burrs removed and shall not contain surface imperfections which would interfere with proper determination of the tensile properties of the metal.

13.3 The yield strength corresponding to a permanent offset of 0.2 % of the gage length of the specimen, or to a total extension of 0.5 % of the gage length under load, shall be determined.

14. Workmanship, Finish, and Appearance

14.1 All tubing shall be free from defects and shall have a workmanlike finish.

14.1.1 Surface imperfections shall be classed as defects when their depth reduces the remaining wall thickness to less than 90 % of the specified nominal wall thickness.

14.1.2 Surface imperfections such as handling marks, light die or roll marks, or shallow pits are not considered defects, provided the imperfections are removable within the minimum wall permitted. The removal of such surface imperfections is not required. Welded tubing shall be free of protruding metal on the outside surface of the weld seam.

14.1.3 Defects having a depth not in excess of 33⅓ % of the wall thickness may be repaired by welding, subject to the following conditions:

14.1.3.1 The defect shall be completely removed by chipping or grinding to sound metal.

14.1.3.2 The repair weld shall be made using a low hydrogen process.

14.1.3.3 The projecting weld metal shall be removed to produce a workmanlike finish.

14.2 The ends of structural tubing, unless otherwise specified, shall be finished square cut and the burr held to a minimum. The burr can be removed on the outside diameter, inside diameter, or both, as a supplementary requirement. When burrs are to be removed, it shall be specified on the purchase order.

15. Number of Tests

15.1 One tension test, as specified in Section 13, shall be made from a length of tubing representing each lot.

15.2 The flattening test, as specified in Section 12, shall be made on one length of round tubing from each lot.

15.3 The term "lot" applies to all tubes of the same nominal size and wall thickness which are produced from the same heat of steel.

16. Retests

16.1 If the results of the mechanical tests of any lot do not conform to all requirements of Sections 9 and 12, retests may be made on additional tubing of double the original number from the same lot. Each lot shall conform to the requirements specified or the tubing represented by the test is subject to rejection.

16.2 In case of failure on retest to meet the requirements of Sections 9 and 12, the manufacturer may elect to retreat, rework, or otherwise eliminate the condition responsible for failure. Thereafter, the material remaining from the lot originally represented may be tested and shall comply with all requirements of this specification.

17. Certification

17.1 If specified in the purchase order or contract, the manufacturer shall furnish to purchaser a certificate of compliance stating that the product was manufactured, sampled, tested, and inspected in accordance with this specification and any other requirements designated in the purchase order or contract, and was found to meet all such requirements. Certificates of compliance shall include the specification number and year of issue.

17.2 If specified in the purchase or contract, the manufacturer shall furnish to the purchaser test reports for the product shipped that contain the heat analyses and the results of the tension tests required by this specification and the purchase order or contract. Test reports shall include the specification number and year of issue.

17.3 A signature or notarization is not required on certificates of compliance or test reports; however, the documents shall clearly identify the organization submitting them. Notwithstanding the absence of a signature, the organization submitting the document is responsible for its content.

17.4 A certificate of compliance or test report printed from, or used in electronic form from, an electronic data interchange (EDI) shall be regarded as having the same validity as a counterpart printed in the certifying organization's facility. The content of the EDI transmitted document shall conform to any existing EDI agreement between the purchaser and the manufacturer.

18. Inspection

18.1 All tubing shall be subject to inspection at the place of manufacture to ensure conformance to the requirements of this specification.

19. Rejection

19.1 Each length of tubing received from the manufacturer may be inspected by the purchaser and, if it does not meet the requirements of this specification based on the inspection and test method sections, the length may be rejected and the manufacturer shall be notified. Disposition of rejected tubing shall be a matter of agreement between the manufacturer and the purchaser.

19.2 Tubing found in fabrication or in installation to be unsuitable for the intended use, under the scope and requirements of this specification, may be set aside and the manufacturer notified. Such tubing shall be subject to mutual investigation as to the nature and severity of the deficiency and the forming or installation, or both, conditions involved. Disposition shall be a matter for agreement.

20. Marking

20.1 Except as noted in 20.2, each length of structural tubing shall be legibly marked to show the following information: manufacturer's name, brand, or trademark and the specification number.

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20.2 For structural tubing having a largest dimension of 4 in. [100 mm] or less, the information listed in 20.1 may be marked on a tag securely attached to the bundle.

20.3 *Bar Coding*—In addition to the requirements in 20.1 and 20.2, bar coding is acceptable as a supplemental identification method. The purchaser may specify in the order a specific bar coding system to be used.

21. Packing, Marking, and Loading

21.1 When specified in the order or contract, packing, marking, and loading shall be in accordance with the procedures of Practices A 700.

SUMMARY OF CHANGES

Committee A01 has identified the location of selected changes to this specification since the last issue, A 847 – 99a(2003), that may impact the use of this specification. (Approved October 1, 2005)

(*1*) Revised applicable paragraphs of Sections 1, 10, 12, and 20, as well as Table 1, Table 3, Table 4, and Table 5, to include rationalized SI units, creating a combined standard.

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