Designation: A 618/A 618M – 04

Standard Specification for Hot-Formed Welded and Seamless High-Strength Low-Alloy Structural Tubing[1]

This standard is issued under the fixed designation A 618/A 618M; 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.

This standard has been approved for use by agencies of the Department of Defense.

1. Scope*

1.1 This specification covers grades of hot-formed welded and seamless high-strength low-alloy square, rectangular, round, or special shape structural tubing for welded, riveted, or bolted construction of bridges and buildings and for general structural purposes. When the steel is used in welded construction, the welding procedure shall be suitable for the steel and the intended service.

1.2 Grade II has atmospheric corrosion resistance equivalent to that of carbon steel with copper (0.20 minimum Cu) Grades Ia and Ib have atmospheric corrosion resistance substantially better than that of Grade II (Note 1). When properly exposed to the atmosphere, Grades Ia and Ib can be used bare (unpainted) for many applications. When enhanced corrosion resistance is desired, Grade III, copper limits may be specified.

NOTE 1—For methods of estimating the atmospheric corrosion resistance of low alloy steels see Guide G 101 or actual data.

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 shall be used independently of the other. Combining values from the two systems may result in nonconformance with the standard.

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 Domestic 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 material adequately:

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

3.1.2 Grade (Table 1 and Table 2),

3.1.3 Material (round, square, or rectangular tubing),

3.1.4 Method of manufacture (seamless, buttwelded, or hot-stretch-reduced electric-resistance welded),

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

3.1.6 Length (specific or random, see 8.2),

3.1.7 End condition (see 9.2),

3.1.8 Burr removal (see 9.2),

3.1.9 Certification (see 12.1),

3.1.10 Specification designation (A 618 or A 618M, including yeardate),

3.1.11 End use, and

3.1.12 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.

4.2 Steel may be cast in ingots or may be strand cast. When steels of different grades are sequentially strand cast, identification of the resultant transition material is required. The producer shall remove the transition material by any established procedure that positively separates the grades.

5. Manufacture

5.1 The tubing shall be made by the seamless, furnace-buttwelded (continuous-welded), or hot-stretch-reduced electric-resistance-welded process.

[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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TABLE 1 Chemical Requirements

Element	Composition, %							
	Grade Ia		Grade Ib		Grade II		Grade III	
	Heat	Product	Heat	Product	Heat	Product	Heat	Product
Carbon, max	0.15	0.18	0.20	. . .	0.22	0.26	0.23[A]	0.27[A]
Manganese	1.00 max	1.04 max	1.35 max	1.40 max	0.85–1.25	1.30 max	1.35 max[A]	1.40 max[A]
Phosphorus, max	0.15	0.16	0.025	0.035	0.025	0.035	0.025	0.035
Sulfur, max	0.025	0.045	0.025	0.035	0.025	0.035	0.025	0.035
Silicon, max	. . .	. . .	. . .	. . .	0.30	0.33	0.30	0.35
Copper, min	0.20	0.18	0.20[B]	0.18[B]	0.20	0.18	. . .	. . .
Vanadium, min	. . .	. . .	. . .	. . .	0.02	0.01	0.02[C]	0.01

[A] For each reduction of 0.01 % C below the specified carbon maximum, an increase of 0.05 % manganese above the specified maximum will be permitted up to 1.45 % for the heat analysis and up to 1.50 % for the product analysis.
[B] If chromium and silicon contents are each 0.50 % min, then the copper minimums do not apply.
[C] For Grade III, columbium may be used in conformance with the following limits: 0.005 %, min (heat) and 0.004 %, min (product).

TABLE 2 Tensile Requirements

	Grades Ia, Ib, and II				Grade III	
	Walls ¾ in. [19.0 mm] and Under		Walls over ¾ to 1½ in. [19.0 to 38.0 mm], incl			
Tensile strength, min, ksi [MPa][A]	70	[485]	67	[460]	65	[450]
Yield strength, min, ksi [MPa][A]	50	[345]	46	[315]	50	[345]
Elongation in 2 in. or 50 mm, min, %	22		22		20	
Elongation in 8 in. or 200 mm, min, %	19		18		18	

[A] For Grade II, when the material is normalized, the minimum yield strength and minimum tensile strength required shall be reduced by 5 ksi [35 MPa].

6. Chemical Composition

6.1 When subjected to the heat and product analysis, respectively, the steel shall conform to the requirements prescribed in Table 1.

6.1.1 For Grades Ia and Ib, the choice and use of alloying elements, combined with carbon, manganese, and sulfur within the limits prescribed in Table 1 to give the mechanical properties prescribed in Table 2 and to provide the atmospheric corrosion resistance of 1.2, should be made by the manufacturer and included and reported in the heat analysis for information purposes only to identify the type of steel applied. For Grades Ia and Ib 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 2—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.

6.1.2 When Grade III is required for enhanced corrosion resistance, copper limits may be specified and the minimum content shall be 0.20 % by heat analysis and 0.18 % by product analysis.

6.2 *Heat Analysis*—An analysis of each heat of open-hearth, basic-oxygen, or electric-furnace steel shall be made by the manufacturer. This analysis shall be made from a test ingot taken during the pouring of the heat. The chemical composition thus determined shall conform to the requirements specified in Table 1 for heat analysis.

6.3 *Product Analysis*:

6.3.1 An analysis may be made by the purchaser from finished tubing manufactured in accordance with this specification, or an analysis may be made from flat-rolled stock from which the welded tubing is manufactured. When product analyses are made, two sample lengths from a lot of each 500 lengths, or fraction thereof, shall be selected. The specimens for chemical analysis shall be taken from the sample lengths in accordance with the applicable procedures of Test Methods, Practices, and Terminology A 751. The chemical composition thus determined shall conform to the requirements specified in Table 1 for product analysis.

6.3.2 In the event the chemical composition of one of the sample lengths does not conform to the requirements shown in Table 1 for product analysis, an analysis of two additional lengths selected from the same lot shall be made, each of which shall conform to the requirements shown in Table 1 for product analysis, or the lot is subject to rejection.

7. Mechanical Requirements

7.1 *Tensile Properties*:

7.1.1 The material, as represented by the test specimen, shall conform to the requirements prescribed in Table 2.

7.1.2 Elongation may be determined on a gage length of either 2 in. [50 mm] or 8 in. [200 mm] at the manufacturer's option.

7.1.3 For material under 5⁄16 in. [8.0 mm] in thickness, a deduction from the percentage elongation of 1.25 percentage points in 8 in. [200 mm] specified in Table 2 shall be made for each decrease of 1⁄32 in. [0.8 mm] of the specified thickness under 5⁄16 in. [8.0 mm].

7.2 *Bend Test*—The bend test specimen shall stand being bent cold through 180° without cracking on the outside of the bent portion, to an inside diameter which shall have a relation to the thickness of the specimen as prescribed in Table 3.

7.3 *Number of Tests*—Two tension and two bend tests, as specified in 7.4.2, and 7.4.3, shall be made from tubing representing each heat. However, if tubing from one heat differs in the ordered nominal wall thickness, one tension test and one bend test shall be made from both the heaviest and lightest wall thicknesses processed.

TABLE 3 Bend Test Requirements

Thickness of Material, in. [mm]	Ratio of Bend Diameter to Specimen Thickness
¾ [19.0] and under	1
Over ¾ to 1 [19.0 to 25.0], incl	1½
Over 1 [25.0]	2

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7.4 *Test Specimens*:

7.4.1 The test specimens required by this specification shall conform to those described in the latest issue of Test Methods and Definitions A 370.

7.4.2 The tension test specimen 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 test may be made on the full section of the tubing; otherwise, a longitudinal strip test specimen shall be used as prescribed in Test Methods and Definitions A 370, Annex A2. The specimens shall have all burrs removed and shall not contain surface imperfections that would interfere with the proper determination of the tensile properties of the metal.

7.4.3 The bend test specimen shall be taken longitudinally from the tubing, and shall represent the full wall thickness of material. The sides of the bend test specimen may have the corners rounded to a maximum radius of 1/16 in. [1.6 mm].

7.5 *Test Methods*:

7.5.1 The yield strength shall be determined in accordance with one of the alternatives described in Test Methods and Definitions A 370.

7.5.2 The bend test shall be made on square or rectangular tubing manufactured in accordance with this specification.

7.6 *Retests:*

7.6.1 If the results of the mechanical tests representing any heat do not conform to a requirement, as specified in 7.1 and 7.2, retests may be made on additional tubing of double the original number from the same heat, each of which shall conform to the requirement specified, or the tubing represented by the test is subject to rejection.

7.6.2 In case of failure on retest to meet the requirements of 7.1 and 7.2, the manufacturer may elect to retreat, rework, or otherwise eliminate the condition responsible for failure to meet the specified requirements. Thereafter, the material remaining from the respective heat originally represented may be tested, and shall comply with all requirements of this specification.

8. Dimensions and Permissible Variations

8.1 The dimensions of square, rectangular, round, and special shape structural tubing to be ordered under this specification shall be subject to prior negotiation with the manufacturer. The dimensions agreed upon shall be indicated in the purchase order.

8.2 *Permissible Variations*:

8.2.1 *Outside Dimensions*:

8.2.1.1 For round tubing 2 in. [50 mm] and over in nominal diameter, the outside diameter shall not vary more than ±1 % from the specified outside diameter. For sizes 1½ in. [38 mm] and under, the outside diameter shall not vary more than 1/64 in. [0.4 mm] over and more than 1/32 in. [0.8 mm] under the specified outside diameter.

8.2.1.2 The specified dimensions, measured across the flats at positions at least 2 in. [50 mm] from either end of square and rectangular tubing and including an allowance for convexity and concavity, shall not exceed the plus and minus tolerance shown in Table 4.

TABLE 4 Outside Dimension Tolerances for Square, Rectangular, and Special Shape Structural Tubing

Largest Outside Dimension Across Flats, in. [mm]	Tolerance ± in. [mm]
2½ [64] and under	0.020 [0.5]
Over 2½ to 3½ [64 to 89], incl	0.025 [0.6]
Over 3½ to 5½ [89 to 140], incl	0.030 [0.8]
Over 5½ [140]	1 %

8.2.2 *Mass*—The mass of structural tubing shall not be less than the specified value by more than 3.5 %. The mass tolerance shall be determined from individual lengths or for round tubing sizes 4½ in. [114 mm] in outside diameter and under and square and rectangular tubing having a periphery of 14 in. [356 mm] and under shall be determined from masses of the customary lifts produced by the mill. On round tubing sizes over 4½ in. [114 mm] in outside diameter and square and rectangular tubing having a periphery in excess of 14 in. [356 mm] the mass tolerance is applicable to the individual length.

8.2.3 *Length*—Structural tubing is commonly produced in random mill lengths of 16 to 22 ft [4.9 to 6.7 m] or 32 to 44 ft [9.8 to 13.4 m], in multiple lengths, and in definite cut lengths (Section 3). When cut lengths are specified for structural tubing, the length tolerances shall be in accordance with Table 5.

8.2.4 *Straightness*—The permissible variation for straightness of structural tubing shall be 1/8 in. times the number of feet of total length divided by 5 [2 mm times length in metres).

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

8.2.6 *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.

8.2.7 *Twist*:

8.2.7.1 The tolerance for twist, or variation with respect to axial alignment of the section for square, rectangular, or special shape structural tubing, shall be as prescribed in Table 6.

8.2.7.2 Twist is measured by holding down one end of a square or rectangular tube on a flat surface plate with the bottom side of the tube parallel to the surface plate, and noting the height that either corner at the opposite end of the bottom side of the tube extends above the surface plate. The difference in the height of the corners shall not exceed the values in Table 6.

9. Workmanship, Finish, and Appearance

9.1 The structural tubing shall be free of defects and shall have a commercially smooth finish.

9.1.1 Surface imperfections shall be classed as defects when their depth exceeds 15 % of the specified wall thickness and when the imperfections materially affected the appearance of

TABLE 5 Cut Length Tolerances for Structural Tubing

	22 ft [6.7 m] and Under		Over 22 to 44 ft [6.7 to 13.4 m], incl	
	Over	Under	Over	Under
Length tolerance for specified cut lengths, in. [mm]	½ [13]	¼ [6]	¾ [19]	¼ [6]

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TABLE 6 Twist Tolerances for Square, Rectangular, or Special Shape Structural Tubing

Specified Dimension of Longest Outside Side, in. [mm]	Maximum Twist per 3 ft of Length, in.	Maximum Twist per Metre of Length, mm
1½ [38] and under	0.050	1.4
Over 1½ to 2½ [38 to 64], incl	0.062	1.7
Over 2½ to 4 [64 to 102], incl	0.075	2.1
Over 4 to 6 [102 to 152], incl	0.087	2.4
Over 6 to 8 [152 to 203], incl	0.100	2.8
Over 8 [203]	0.112	3.1

the structural member, or when their length (measured in a transverse direction) and depth would materially reduce the total cross-sectional area at any location.

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

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

9.1.2.2 The repair weld shall be made using suitable coated electrodes.

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

9.2 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 the burrs are to be removed, it shall be specified in the purchase order.

10. Inspection

10.1 All tubing shall be subject to an inspection at the place of manufacture to assure conformance with the requirements of this specification.

11. Rejection

11.1 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 as outlined in the specification, 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.

11.2 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.

12. Certification

12.1 Upon request of the purchaser in the contract or order, a manufacturer's certification that the material was manufactured and tested in accordance with this specification (including year of issue) together with a report of the chemical and tensile tests shall be furnished.

13. Packaging, Package Marking, and Loading

13.1 Except as noted in 13.2, each length of structural tubing shall be legibly marked by rolling, die stamping, ink printing, or paint stenciling to show the following information: manufacturer's name, brand, or trademark; size and wall thickness; steel grade; and the specification number (year of issue not required).

13.2 For structural tubing 1½ in. [38 mm] and under in nominal size or the greatest cross sectional dimension less than 2 in. [50 mm], the information listed in 10.1 may be marked on a tag securely attached to each bundle.

13.3 When specified in the order, contract, etc., packaging, marking, and loading shall be in accordance with the procedures of Practices A 700.

13.4 *Bar Coding*—In addition to the requirements in 13.1, 13.2, and 13.3, bar coding is acceptable as a supplemental identification method. The purchaser may specify in the order a specific bar coding system to be used.

14. Keywords

14.1 high-strength low-alloy steel; seamless steel tube; steel tube; structural steel tubing; welded steel tubing

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SUMMARY OF CHANGES

Committee A01 has identified the location of selected changes to this standard that have been incorporated since the last issue (A 618–01) that may impact the use of this standard.

(1) Rationalized SI units have been added throughout the text and tables to create a combined standard.

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