



Designation: A500/A500M – 23

Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes¹

This standard is issued under the fixed designation A500/A500M; 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 carbon steel round, square, rectangular, or special structural tubular shapes for welded, riveted, or bolted construction of bridges and buildings, and for general structural purposes.

1.2 This tubing is produced in both welded and seamless sizes with a periphery of 88 in. [2235 mm] or less, and a specified wall thickness of 1.000 in. [25.4 mm] or less. Grade D requires heat treatment.

NOTE 1—Products manufactured to this specification may not be suitable for those applications such as dynamically loaded elements in welded structures, etc., where low-temperature notch-toughness properties, which are typically measured by Charpy Impact testing, may be important. There are other ASTM standards that do have CVN requirements and may be more suitable for those applications.

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. The inch-pound units shall apply unless the “M” designation of this specification is specified in the order.

1.4 The text of this specification contains notes and footnotes that provide explanatory material. Such notes and footnotes, excluding those in tables and figures, do not contain any mandatory requirements.

1.5 *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.*

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. 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

A941 Terminology Relating to Steel, Stainless Steel, Related Alloys, and Ferroalloys

2.2 Military Standards:

MIL-STD-129 Marking for Shipment and Storage³

MIL-STD-163 Steel Mill Products, Preparation for Shipment and Storage³

2.3 Federal Standards:

Fed. Std. No. 123 Marking for Shipment³

Fed. Std. No. 183 Continuous Identification Marking of Iron and Steel Products³

2.4 AIAG Standard:

B-1 Bar Code Symbology Standard⁴

2.5 Steel Tube Institute:⁵

Methods to Check Dimensional Tolerances on Hollow Structural Sections

3. Terminology

3.1 *Definitions*—For definitions of terms used in this specification, refer to Terminology A941.

4. Ordering Information

4.1 It shall be the responsibility of the purchaser to specify all requirements that are necessary for the products under this specification. Such requirements to be considered include, but are not limited to, the following:

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.

³ Available from Standardization Documents Order Desk, Bldg. 4 Section D, 700 Robbins Ave., Philadelphia, PA 19111-5094, Attn: NPODS.

⁴ Available from Automotive Industry Action Group (AIAG), 26200 Lahser Rd., Suite 200, Southfield, MI 48033, <http://www.aiag.org>.

⁵ Available from the Steel Tube Institute (STI), 2516 Waukegan Rd., STE 172, Glenview, IL 60025-1774, <https://steeltubeinstitute.org>.

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

- 4.1.1 Quantity (feet [metres] or number of lengths),
- 4.1.2 Name of material (cold-formed tubing),
- 4.1.3 Method of manufacture (seamless or welded),
- 4.1.4 Grade (B, C, or D),
- 4.1.5 Size (outside diameter and wall thickness for round tubing, and outside dimensions and wall thickness for square and rectangular tubing),
- 4.1.6 Copper-containing steel (see **Table 1**), if applicable,
- 4.1.7 Length (random, multiple, specific; see **11.3**),
- 4.1.8 End condition (see **16.3**),
- 4.1.9 Burr removal (see **16.3**),
- 4.1.10 Certification (see **Section 18**),
- 4.1.11 ASTM specification designation and year of issue,
- 4.1.12 End use,
- 4.1.13 Special requirements,
- 4.1.14 Bar coding (see **19.3**), and
- 4.1.15 Destructive Weld Tests required in addition to or in lieu of those listed (see **10.8**).

5. Process

5.1 The steel shall be made by one or more of the following processes: basic-oxygen or electric-furnace.

5.2 When steels of different grades are sequentially strand cast, the steel producer shall identify the resultant transition material and remove it using an established procedure that positively separates the grades.

6. Manufacture

6.1 The tubing shall be made by a seamless or welding process.

6.2 Welded tubing shall be made from flat-rolled steel by the electric-resistance-welding process. The longitudinal butt joint of welded tubing shall be welded across its thickness in such a manner that the structural design strength of the tubing section is assured.

6.3 The weld shall not be located within the radius of the corners of any tubular shapes unless specified by the purchaser.

NOTE 2—Welded tubing is normally furnished without removal of the inside flash.

6.4 Except as required by **6.5**, it shall be permissible for the tubing to be stress relieved or annealed.

6.5 Grade D tubing shall be heat treated at a temperature of at least 1100 °F [590 °C] for one hour per inch [25 mm] of thickness.

7. Heat Analysis

7.1 Each heat analysis shall conform to the requirements specified in **Table 1** for heat analysis.

8. Product Analysis

8.1 The tubing shall be capable of conforming to the requirements specified in **Table 1** 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 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 1** 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 requirements as to tensile properties prescribed in **Table 2**.

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

10.1 The flattening test shall be made on round structural tubing. A flaring 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, flaring test or a wedge crush test shall be made on square and rectangular tubular shapes with a side up to and including 10 in. except when the customer specifies the weld to be located in the corner. Destructive weld tests on tubular

TABLE 1 Chemical Requirements

Element	Composition, %			
	Grades B and D		Grade C	
	Heat Analysis	Product Analysis	Heat Analysis	Product Analysis
Carbon, max ^A	0.26	0.30	0.23	0.27
Manganese, max ^A	1.35	1.40	1.35	1.40
Phosphorus, max	0.035	0.045	0.035	0.045
Sulfur, max	0.035	0.045	0.035	0.045
Copper, min ^B	0.20	0.18	0.20	0.18

^A For each reduction of 0.01 percentage point below the specified maximum for carbon, an increase of 0.06 percentage point above the specified maximum for manganese is permitted, up to a maximum of 1.50 % by heat analysis and 1.60 % by product analysis.

^B If copper-containing steel is specified in the purchase order.

TABLE 2 Tensile Requirements

	Round, Square, Rectangular, and Special Tubular Shapes		
	Grade B	Grade C	Grade D
Tensile strength, min, psi [MPa]	58 000 [400]	62 000 [425]	58 000 [400]
Yield strength, min, psi [MPa]	46 000 [315]	50 000 [345]	36 000 [250]
Elongation in 2 in. [50 mm], min, % ^C	23 ^A	21 ^B	23 ^A

^AApplies to specified wall thicknesses (t) equal to or greater than 0.180 in. [4.57 mm]. For lighter specified wall thicknesses, the minimum elongation values shall be calculated by the formula: percent elongation in 2 in. [50 mm] = $61t + 12$, rounded to the nearest percent. For A500M use the following formula: $2.4t + 12$, rounded to the nearest percent.

^BApplies to specified wall thicknesses (t) equal to or greater than 0.120 in. [3.05 mm]. For lighter specified wall thicknesses, the minimum elongation values shall be by agreement with the manufacturer.

^C The minimum elongation values specified apply only to tests performed prior to shipment of the tubing.

shapes that are not round, square or rectangular are to be agreed upon in advance between the producer and purchaser.

10.2 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 10.5, 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.

10.3 For seamless round structural tubing 2 3/8 in. [60 mm] specified outside diameter and larger, a specimen not less than 2 1/2 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 10.5, shall occur until the distance between the plates is less than the value of “H” calculated by the following equation:

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

where:

- H = distance between flattening plates, in. [mm],
- e = deformation per unit length (constant for a given grade of steel, 0.07 for Grade B, and 0.06 for Grade C),
- t = specified wall thickness of tubing, in. [mm], and
- D = specified outside diameter of tubing, in. [mm].

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.

10.4 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.

10.5 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.

10.6 *Flaring Test*—A section of tube shall stand being flared with a tool having a 60° included angle until the weld area has been expanded a minimum of 15 % of the inside dimension for rounds and squares without any cracking in the weld area. For rectangles, the side containing the weld area and the side opposite the weld area shall be expanded a minimum of 15 % based on the average of the smallest and largest inside dimensions without any cracking in the weld area. The cone

tool shall not have a weld relief groove. Cracking in the corners of square, rectangular, or other tubular shapes after flaring is not grounds for rejection.

10.7 *Wedge Crush Test*—A test specimen at least 4 in. [100 mm] in length shall be placed under the hydraulic press ram with the weld directly underneath the tapered ram wedge. The tapered ram wedge shall be tapered at 30° and rounded at the contact point to a 1/2 in. radius. No cracks or breaks on the inside or outside surfaces of the test specimen shall be present until the tube has collapsed to at least one half its specified dimension.

10.8 Other destructive weld tests may be requested in lieu of or in addition to the tests listed. The purchaser should contact the producer to determine their availability.

11. Permissible Variations in Dimensions

11.1 Outside Dimensions:

11.1.1 *Round Structural Tubing*—The outside diameter shall not vary more than ±0.5 %, rounded to the nearest 0.005 in. [0.1 mm], from the specified outside diameter for specified outside diameters 1.900 in. [48 mm] and smaller, and ± 0.75 %, rounded to the nearest 0.005 in. [0.1 mm], from the specified outside diameter for specified outside diameters 2.00 in. [5 cm] and larger. The outside diameter measurements shall be made at positions at least 2 in. [5 cm] from the ends of the tubing.

11.1.2 *Square and Rectangular Structural Tubing*—The outside dimensions, measured across the flats at positions at least 2 in. [5 cm] from the ends of the tubing, shall not vary from the specified outside dimensions by more than the applicable amount given in Table 3, which includes an allowance for convexity or concavity.

11.2 *Wall Thickness*—The minimum wall thickness excluding the weld seam of welded tubing if supplied with the inside flash not being removed shall be not more than 10 % less than the specified wall thickness. If the welded tubing is supplied with the inside flash removed, then the weld seam shall be included in the wall thickness measurement and shall be not

TABLE 3 Permissible Variations in Outside Flat Dimensions for Square and Rectangular Structural Tubing

Specified Outside Large Flat Dimension, in. [mm]	Permissible Variations Over and Under Specified Outside Flat Dimensions, ^A in. [mm]
1/2 [65] or under	0.020 [0.5]
Over 1/2 to 3/2 [65 to 90], incl	0.025 [0.6]
Over 3/2 to 5/2 [90 to 140], incl	0.030 [0.8]
Over 5/2 [140]	0.01 times large flat dimension

^A The permissible variations include allowances for convexity and concavity. For rectangular tubing having a ratio of outside large to small flat dimension less than 1.5, and for square tubing, the permissible variations in small flat dimension shall be identical to the permissible variations in large flat dimension. For rectangular tubing having a ratio of outside large to small flat dimension in the range of 1.5 to 3.0 inclusive, the permissible variations in small flat dimension shall be 1.5 times the permissible variations in large flat dimension. For rectangular tubing having a ratio of outside large to small flat dimension greater than 3.0, the permissible variations in small flat dimension shall be 2.0 times the permissible variations in large flat dimension.