



Designation: A500/A500M – 13

# Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes<sup>1</sup>

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 shape structural tubing 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 0.875 in. [22 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 may be important.

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.*

<sup>1</sup> 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:<sup>2</sup>

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, Practices, and Terminology 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 Storage<sup>3</sup>

MIL-STD-163 Steel Mill Products, Preparation for Shipment and Storage<sup>3</sup>

### 2.3 Federal Standards:

Fed. Std. No. 123 Marking for Shipment<sup>3</sup>

Fed. Std. No. 183 Continuous Identification Marking of Iron and Steel Products<sup>3</sup>

### 2.4 AIAG Standard:

B-1 Bar Code Symbology Standard<sup>4</sup>

## 3. Terminology

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

## 4. Ordering Information

4.1 Orders for material under this specification shall contain information concerning as many of the following items as are required to describe the desired material adequately:

4.1.1 Quantity (feet [metres] or number of lengths),

4.1.2 Name of material (cold-formed tubing),

<sup>2</sup> 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.

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

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

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



- 4.1.3 Method of manufacture (seamless or welded),
- 4.1.4 Grade (A, 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, and
- 4.1.14 Bar coding (see 19.3).

## 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 shaped tube 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.

TABLE 1 Chemical Requirements

| Element                     | Composition, %     |                  |               |                  |
|-----------------------------|--------------------|------------------|---------------|------------------|
|                             | Grades A, B, and D |                  | Grade C       |                  |
|                             | Heat Analysis      | Product Analysis | Heat Analysis | Product Analysis |
| Carbon, max <sup>A</sup>    | 0.26               | 0.30             | 0.23          | 0.27             |
| Manganese, max <sup>A</sup> | 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 <sup>B</sup>    | 0.20               | 0.18             | 0.20          | 0.18             |

<sup>A</sup> 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.

<sup>B</sup> If copper-containing steel is specified in the purchase order.

## 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.

TABLE 2 Tensile Requirements

| Round Structural Tubing                          |                 |                 |                 |                 |
|--------------------------------------------------|-----------------|-----------------|-----------------|-----------------|
|                                                  | Grade A         | Grade B         | Grade C         | Grade D         |
| Tensile strength, min, psi [MPa]                 | 45 000<br>[310] | 58 000<br>[400] | 62 000<br>[425] | 58 000<br>[400] |
| Yield strength, min, psi [MPa]                   | 33 000<br>[230] | 42 000<br>[290] | 46 000<br>[315] | 36 000<br>[250] |
| Elongation in 2 in. [50 mm], min, % <sup>D</sup> | 25 <sup>A</sup> | 23 <sup>B</sup> | 21 <sup>C</sup> | 23 <sup>B</sup> |
| Shaped Structural Tubing                         |                 |                 |                 |                 |
|                                                  | Grade A         | Grade B         | Grade C         | Grade D         |
| Tensile strength, min, psi [MPa]                 | 45 000<br>[310] | 58 000<br>[400] | 62 000<br>[425] | 58 000<br>[400] |
| Yield strength, min, psi [MPa]                   | 39 000<br>[270] | 46 000<br>[315] | 50 000<br>[345] | 36 000<br>[250] |
| Elongation in 2 in. [50 mm], min, % <sup>D</sup> | 25 <sup>A</sup> | 23 <sup>B</sup> | 21 <sup>C</sup> | 23 <sup>B</sup> |

<sup>A</sup>Applies 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 calculated by the formula: percent elongation in 2 in. [50 mm] =  $56t + 17.5$ , rounded to the nearest percent. For A500M use the following formula:  $2.2t + 17.5$ , rounded to the nearest percent.

<sup>B</sup>Applies 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.

<sup>C</sup>Applies 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.

<sup>D</sup> The minimum elongation values specified apply only to tests performed prior to shipment of the tubing.

**TABLE 4 Length Tolerances for Specific Lengths of Structural Tubing**

|                                                    | 22 ft [6.5 m]<br>and Under |          | Over 22<br>ft [6.5 m] |          |
|----------------------------------------------------|----------------------------|----------|-----------------------|----------|
|                                                    | Over                       | Under    | Over                  | Under    |
| Length tolerance for specific<br>lengths, in. [mm] | ½<br>[13]                  | ¼<br>[6] | ¾<br>[19]             | ¼<br>[6] |

**TABLE 5 Permissible Variations in Twist for Square and Rectangular Structural Tubing**

| Specified Outside Large<br>Flat Dimension, in. [mm] | Maximum Permissible<br>Variations in Twist<br>per 3 ft of Length<br>[Twist per Metre of Length] |       |
|-----------------------------------------------------|-------------------------------------------------------------------------------------------------|-------|
|                                                     | in.                                                                                             | [mm]  |
| 1½ [40] and under                                   | 0.050                                                                                           | [1.3] |
| Over 1½ to 2½ [40 to 65], incl                      | 0.062                                                                                           | [1.6] |
| Over 2½ to 4 [65 to 100], incl                      | 0.075                                                                                           | [1.9] |
| Over 4 to 6 [100 to 150], incl                      | 0.087                                                                                           | [2.2] |
| Over 6 to 8 [150 to 200], incl                      | 0.100                                                                                           | [2.5] |
| Over 8 [200]                                        | 0.112                                                                                           | [2.8] |

Twist shall be determined by holding one end of the tubing down on a flat surface plate, measuring the height that each corner on the bottom side of the tubing extends above the surface plate near the opposite ends of the tubing, and calculating the twist (the difference in heights of such corners), except that for heavier sections it shall be permissible to use a suitable measuring device to determine twist. Twist measurements shall not be taken within 2 in. [5 cm] of the ends of the tubing.

## 12. Special Shape Structural Tubing

12.1 The availability, dimensions, and tolerances of special shape structural tubing shall be subject to inquiry and negotiation with the manufacturer.

## 13. Number of Tests

13.1 One tension test as specified in Section 15 shall be made from a length of tubing representing each lot.

13.2 The flattening test, as specified in Section 10, shall be made on one length of round tubing from each lot.

13.3 The term “lot” shall apply to all tubes of the same specified size that are produced from the same heat of steel.

## 14. Retests

14.1 If the results of the mechanical tests representing any lot fail to conform to the applicable requirements specified in Sections 9 and 10, the lot shall be rejected or retested using additional tubing of double the original number from the lot. The lot shall be acceptable if the results of all such retests representing the lot conform to the specified requirements.

14.2 If one or both of the retests specified in 14.1 fail to conform to the applicable requirements specified in Sections 9 and 10, the lot shall be rejected or, subsequent to the manufacturer heat treating, reworking, or otherwise eliminating the

condition responsible for the failure, the lot shall be treated as a new lot and tested accordingly.

## 15. Test Methods

15.1 Tension test specimens shall conform to the applicable requirements of Test Methods and Definitions A370, Annex A2.

15.2 Tension test specimens shall be full-size longitudinal test specimens or longitudinal strip test specimens. For welded tubing, any longitudinal strip test specimens shall be taken from a location at least 90° from the weld and shall be prepared without flattening in the gage length. Longitudinal strip test specimens shall have all burrs removed. Tension test specimens shall not contain surface imperfections that would interfere with proper determination of the tensile properties.

15.3 The yield strength corresponding to an offset of 0.2 % of the gage length or to a total extension under load of 0.5 % of the gage length shall be determined.

## 16. Inspection

16.1 All tubing shall be inspected at the place of manufacture to ensure conformance to the requirements of this specification.

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

16.2.1 Surface imperfections shall be classed as defects when their depth reduces the remaining wall thickness to less than 90 % of the specified wall thickness. It shall be permissible for defects having a depth not in excess of 33⅓ % of the specified wall thickness to be repaired by welding, subject to the following conditions:

16.2.1.1 The defect shall be completely removed by chipping or grinding to sound metal,

16.2.1.2 The repair weld shall be made using a low-hydrogen welding process, and

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

16.2.2 Surface imperfections such as handling marks, light die or roll marks, or shallow pits are not considered defects provided that the imperfections are removable within the specified limits on wall thickness. 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.

16.3 Unless otherwise specified in the purchase order, structural tubing shall be furnished with square cut ends, with the burr held to a minimum. When so specified in the purchase order, the burr shall be removed on the outside diameter, inside diameter, or both.

## 17. Rejection

17.1 It shall be permissible for the purchaser to inspect tubing received from the manufacturer and reject any tubing that does not meet the requirements of this specification, based upon the inspection and test methods outlined herein. The purchaser shall notify the manufacturer of any tubing that has