



Designation: A 501 – 01 (Reapproved 2005)

# Standard Specification for Hot-Formed Welded and Seamless Carbon Steel Structural Tubing<sup>1</sup>

This standard is issued under the fixed designation A 501; 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 ( $\epsilon$ ) 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 black and hot-dipped galvanized hot-formed welded and seamless carbon steel square, round, rectangular, or special shape structural tubing for welded, riveted, or bolted construction of bridges and buildings, and for general structural purposes.

1.2 Square and rectangular tubing is furnished in sizes 1 to 10 in. (25.4 to 254 mm) across flat sides with wall thicknesses 0.095 to 1.000 in. (2.41 to 25.40 mm), dependent upon size; round tubing is furnished in NPS ½ to NPS 24 (see **Note 1**) inclusive, with nominal (average) wall thicknesses 0.109 to 1.000 in. (2.77 to 25.40 mm), dependent upon size. Special shape tubing and tubing with other dimensions is permitted to be furnished, provided that such tubing complies with all other requirements of this specification.

**NOTE 1**—The dimensionless designator NPS (nominal pipe size) has been substituted in this standard for such traditional terms as “nominal diameter,” “size,” and “nominal size.”

1.3 The following precautionary statement pertains only to the test method portion of this specification: *This standard does not purport to address all the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

1.4 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

1.5 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.

<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>

**A 53/A 53M** Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless

**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

**A 941** Terminology Relating to Steel, Stainless Steel, Related Alloys, and Ferroalloys

2.2 *AIAG Standard*:<sup>3</sup>

**B-1** Bar Code Symbology Standard

## 3. Terminology

3.1 *Definitions*—For definitions of terms used in this specification, refer to Terminology **A 941**.

## 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 or number of lengths),

4.1.2 Name of material (hot-formed tubing),

4.1.3 Method of manufacture (seamless or welded) (see Section 6),

4.1.4 Finish (black or galvanized),

4.1.5 Size (outside diameter and calculated nominal wall thickness for round tubing and the outside dimensions and calculated nominal wall thickness for square and rectangular tubing (Section 11),

4.1.6 Length (random, multiple, or specific; see 12.3),

<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 Automotive Industry Action Group, 26200 Lahser Road, Suite 200, Southfield, MI 48034.

- 4.1.7 End condition (see 17.3),
- 4.1.8 Burr removal (see 17.3),
- 4.1.9 Certification (see Section 19),
- 4.1.10 ASTM specification designation and year of issue,
- 4.1.11 End use,
- 4.1.12 Special requirements, and
- 4.1.13 Bar coding (see 20.3).

**5. Process**

5.1 The steel shall be made by one or more of the following processes: open-hearth, 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 one of the following processes: seamless; furnace-butt welding (continuous welding); or electric-resistance welding followed by reheating throughout the cross section and hot forming by a reducing or shaping process, or both.

**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 A 751. 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**

Tensile strength, min, psi (MPa)	58 000 (400)
Yield strength, min, psi (MPa)	36 000 (250)
Elongation in 2 in. (50.8 mm), min, %	23

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

**10. Bend Test**

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

10.2 The bend test specimen shall be taken longitudinally from the tubing, and shall represent the full wall thickness of material. It shall be permissible for the sides of the bend test to have their corners rounded out to a radius of 1/16 in. (1.59 mm) maximum.

10.3 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.

**11. Dimensions**

11.1 *Square Structural Tubing*—The outside dimensions (across the flats), the weight per foot, and the calculated nominal wall thickness of common sizes of square structural tubing included in this specification are listed in Table 4.

11.2 *Rectangular Structural Tubing*—The outside dimensions (across the flats), the weight per foot, and the calculated nominal wall thickness of common sizes of rectangular structural tubing included in this specification are listed in Table 5.

11.3 *Round Structural Tubing*—The NPS and outside diameter dimensions, the weight per foot, and the calculated nominal wall thickness of common sizes of round structural tubing included in this specification are listed in Table 6.

11.4 *Special Shape Structural Tubing*—The dimensions and tolerances of special shape structural tubing are available by inquiry and negotiation with the manufacturer.

11.5 *Other Sizes*—The dimensional tolerances for hot-formed welded and seamless structural tubing manufactured in accordance with the requirements of this specification, but with ordered dimensions other than those listed in Table 4, Table 5, and Table 6, shall be consistent with those given in this specification for similar sizes and type of product.

**12. Permissible Variations in Dimensions of Square, Round, Rectangular, and Special Shape Structural Tubing**

12.1 *Outside Dimensions:*

**TABLE 3 Bend Test Requirements**

Thickness of Material, in. (mm)	Ratio of Bend Diameter to Specimen Thickness
3/4 (19.0) and under	1/2
Over 3/4 to 1 (19.0 to 25.4), incl	1

**TABLE 1 Chemical Requirements**

Element	Composition, %	
	Heat analysis	Product analysis
Carbon, max	0.26	0.30
Phosphorus, max	0.035	0.045
Sulfur, max	0.035	0.045
Copper, when copper steel is specified, min	0.20	0.18



TABLE 4 Dimensions of Common Sizes of Square Structural Tubing

Size Given in Outside Dimensions Across Flat Sides, in. (mm)	Weight per Unit Length, lb/ft (kg/m)	Calculated Nominal Wall Thickness, in. (mm)
1 by 1 (25.4 by 25.4)	1.09 (1.62)	0.095 (2.41)
	1.41 (2.10)	0.133 (3.38)
2 by 2 (50.8 by 50.8)	2.69 (4.00)	0.110 (2.79)
	3.04 (4.52)	0.125 (3.18)
	3.65 (5.44)	0.154 (3.91)
	4.31 (6.41)	0.188 (4.78)
2½ by 2½ (63.5 by 63.5)	4.32 (6.43)	0.141 (3.58)
	5.59 (8.32)	0.188 (4.78)
	7.10 (10.56)	0.250 (6.35)
3 by 3 (76.2 by 76.2)	5.78 (8.60)	0.156 (3.96)
	6.86 (10.21)	0.188 (4.78)
	8.80 (13.09)	0.250 (6.35)
3½ by 3½ (88.9 by 88.9)	6.88 (10.24)	0.156 (3.96)
	8.14 (12.11)	0.188 (4.78)
	10.50 (15.62)	0.250 (6.35)
	12.69 (18.88)	0.312 (7.92)
4 by 4 (101.6 by 101.6)	9.31 (13.85)	0.188 (4.78)
	12.02 (17.89)	0.250 (6.35)
	14.52 (21.61)	0.312 (7.92)
	16.84 (25.06)	0.375 (9.52)
	20.88 (31.07)	0.500 (12.70)
5 by 5 (127.0 by 127.0)	11.86 (17.65)	0.188 (4.78)
	15.42 (22.94)	0.250 (6.35)
	18.77 (27.93)	0.312 (7.92)
	21.94 (32.65)	0.375 (9.52)
	27.68 (41.19)	0.500 (12.70)
6 by 6 (152.4 by 152.4)	14.41 (21.44)	0.188 (4.78)
	18.82 (28.00)	0.250 (6.35)
	23.02 (34.25)	0.312 (7.92)
	27.04 (40.28)	0.375 (9.52)
	34.48 (51.31)	0.500 (12.70)
7 by 7 (177.8 by 177.8)	16.85 (25.07)	0.188 (4.78)
	22.04 (32.80)	0.250 (6.35)
	26.99 (39.16)	0.312 (7.92)
	31.73 (47.21)	0.375 (9.52)
	40.55 (60.34)	0.500 (12.70)
8 by 8 (203.2 by 203.2)	25.44 (37.85)	0.250 (6.35)
	31.24 (46.49)	0.312 (7.92)
	36.83 (54.80)	0.375 (9.52)
	47.35 (70.46)	0.500 (12.70)
	56.98 (84.79)	0.625 (15.88)
	65.73 (97.81)	0.750 (19.05)
10 by 10 (254.0 by 254.0)	32.23 (47.96)	0.250 (6.35)
	39.74 (59.13)	0.312 (7.92)
	47.03 (69.98)	0.375 (9.52)
	60.95 (90.69)	0.500 (12.70)
	73.98 (110.08)	0.625 (15.88)
	86.13 (128.16)	0.750 (19.05)
	107.79 (160.39)	1.000 (25.40)

12.1.1 *Round Structural Tubing*—For round hot-formed structural tubing NPS 2 and over, the outside diameter shall not vary more than  $\pm 1\%$  from the specified outside diameter. For NPS 1½ and under, the outside diameter shall not vary more than ¼ in. (0.40 mm) over or more than ½ in. (0.79 mm) under the specified outside diameter.

12.1.2 *Square, Rectangular, and Special Shape Structural Tubing*—The outside dimensions, measured across the flats at

TABLE 5 Dimensions of Common Sizes of Rectangular Structural Tubing

Size Given in Outside Dimensions Across Flat Sides, in. (mm)	Weight per Unit Length, lb/ft (kg/m)	Calculated Nominal Wall Thickness, in. (mm)
3 by 2 (76.2 by 50.8)	4.32 (6.43)	0.141 (3.58)
	5.59 (8.32)	0.188 (4.78)
	7.10 (10.56)	0.250 (6.35)
4 by 2 (101.6 by 50.8)	5.78 (8.60)	0.156 (3.96)
	6.86 (10.21)	0.188 (4.78)
	8.80 (13.09)	0.250 (6.35)
4 by 3 (101.6 by 76.2)	6.88 (10.24)	0.156 (3.96)
	8.14 (12.11)	0.188 (4.78)
	10.50 (15.62)	0.250 (6.35)
	12.69 (18.88)	0.312 (7.92)
5 by 3 (127.0 by 76.2)	9.31 (13.85)	0.188 (4.78)
	12.02 (17.89)	0.250 (6.35)
	14.52 (21.61)	0.312 (7.92)
	16.84 (25.06)	0.375 (9.52)
6 by 3 (152.4 by 76.2)	10.58 (15.74)	0.188 (4.78)
	13.72 (20.42)	0.250 (6.35)
	16.65 (24.78)	0.312 (7.92)
	19.39 (28.85)	0.375 (9.52)
6 by 4 (152.4 by 101.6)	11.86 (17.65)	0.188 (4.78)
	15.42 (22.94)	0.250 (6.35)
	18.77 (27.93)	0.312 (7.92)
	21.94 (32.65)	0.375 (9.52)
	27.68 (41.19)	0.500 (12.70)
7 by 5 (177.8 by 127.0)	14.41 (21.44)	0.188 (4.78)
	18.82 (28.00)	0.250 (6.35)
	23.02 (34.25)	0.312 (7.92)
	27.04 (40.28)	0.375 (9.52)
	34.48 (51.31)	0.500 (12.70)
8 by 4 (203.2 by 101.6)	14.41 (21.44)	0.188 (4.78)
	18.82 (28.00)	0.250 (6.35)
	23.02 (34.25)	0.312 (7.92)
	27.04 (40.28)	0.375 (9.52)
	34.48 (51.31)	0.500 (12.70)
8 by 6 (203.2 by 152.4)	16.85 (25.07)	0.188 (4.78)
	22.04 (32.80)	0.250 (6.35)
	26.99 (39.16)	0.312 (7.92)
	31.73 (47.21)	0.375 (9.52)
	40.55 (60.34)	0.500 (12.70)
10 by 6 (254.0 by 152.4)	25.44 (37.85)	0.250 (6.35)
	31.24 (46.49)	0.312 (7.92)
	36.83 (54.80)	0.375 (9.52)
	47.35 (70.46)	0.500 (12.70)

positions at least 2 in. (50.8 mm) from the ends of the tubing, shall not vary from the specified outside dimensions by more than the applicable amount given in Table 7, which includes an allowance for convexity or concavity.

12.2 *Weight*—The weight of the structural tubing shall be not more than 3.5 % under its theoretical weight, as calculated using its length and the applicable weight per unit length given in Table 4, Table 5, or Table 6.

12.3 *Length*—Structural tubing is commonly produced in random 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 specific lengths. When specific lengths are ordered, the permissible variations in length shall be as given in Table 8.