



Designation: A 501–01 (Reapproved 2005) Designation: A501 – 07

Standard Specification for Hot-Formed Welded and Seamless Carbon Steel Structural Tubing¹

This standard is issued under the fixed designation A501; 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 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 ± 0.32 in. (25.4 to 25.4813 mm) across flat sides with wall thicknesses 0.095 to $\pm 0.003.00$ in. (2.41 to 25.4076 mm), dependent upon size; round tubing is furnished in NPS $\frac{1}{2}$ 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~~

1.3 This specification covers the following grades:

1.3.1 Grade A — 36 000 psi (250 MPa) min yield strength.

1.3.2 Grade B — 50 000 psi (345 MPa) min yield strength.

1.4 An optional supplementary requirement is provided for Grade B and, when desired, shall be so stated on the order.

1.5 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~~

~~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.~~

1.6 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.

1.7 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.

2. Referenced Documents

2.1 ASTM Standards:²

A53/A53M Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless

A370 Test Methods and Definitions for Mechanical Testing of Steel Products

A700 Practices for Packaging, Marking, and Loading Methods for Steel Products for Domestic Shipment

A751 Test Methods, Practices, and Terminology for Chemical Analysis of Steel Products

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

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.

2.2 *AIAG Standard:*³

B-1 Bar Code Symbology Standard

3. Terminology

3.1 *Definitions*—For definitions of terms used in this specification, refer to Terminology A 941-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 or number of lengths),

4.1.2 Name of material (hot-formed tubing),

~~4.1.3 Method of manufacture (seamless or welded) (see Section~~

4.1.3 Grade (A or B)

~~4.1.4 Method of manufacture (seamless or welded) (see Section 6),~~

4.1.4~~5~~ Finish (black or galvanized),

4.1.5~~6~~ 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~~7~~ Length (random, multiple, or specific; see 12.3),

~~4.1.7 End condition (see~~

4.1.8 End condition (see 17.3),

~~4.1.8 Burr removal (see~~

4.1.9 Burr removal (see 17.3),

~~4.1.9 Certification (see Section~~

4.1.10 Certification (see Section 19),

4.1.10~~1~~ ASTM specification designation and year of issue,

4.1.11~~2~~ End use,

4.1.12~~3~~ Special requirements, and

4.1.13~~4~~ 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); electric-resistance welding or electric-resistance submerged arc 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.

³ Available from Automotive Industry Action Group, 26200 Lahser Road, Suite 200, Southfield, MI 48034.

³ Available from Automotive Industry Action Group (AIAG), 26200 Lahser Rd., Suite 200, Southfield, MI 48033, <http://www.aiag.org>.

TABLE 1 Chemical Requirements^A

Element	Composition, %			
	Grade A		Grade B	
	Heat analysis	Product analysis	Heat analysis	Product analysis
Carbon, max	0.26	0.30	0.22 ^B	0.26
Manganese, max	1.40 ^B	1.45
Phosphorus, max	0.035	0.045	0.030	0.040
Sulfur, max	0.035	0.045	0.020	0.030
Copper, when copper steel is specified, min	0.20	0.18	0.20	0.18

^AWhere an ellipsis (...) appears in this table, there is no requirement.

^BFor 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.

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 751A751. 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.

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 $\frac{1}{16}$ 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.

10. Charpy V-Notch Impact Test

10.1 The Charpy V-notch impact test applies to Grade B only and wall thickness greater than 0.312 in. (8 mm).

10.1.1 Charpy V-notch tests shall be made in accordance with Test Methods and Definitions A370

10.1.2 One Charpy V-notch impact test shall be made from a length of tubing representing each lot.

10.1.3 The test results of full-size longitudinal specimens shall meet an average value of 20 ft-lb at 0 °F (-18 °C).

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~~Table 3.

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~~Table 4.

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~~Table 5.

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 3, ~~Table 5~~Table 4, and ~~Table 6~~Table 5, 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:*

12.1.1 *Round Structural Tubing*—For round hot-formed structural tubing NPS 2 and over, the outside diameter shall not vary more than ± 1 % from the specified outside diameter. For NPS 1½ and under, the outside diameter shall not vary more than $\frac{1}{64}$ in. (0.40 mm) over or more than $\frac{1}{32}$ 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 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~~Table 6, which includes an allowance for convexity or concavity.

TABLE 2 Tensile Requirements

	Grade A	Grade B
Tensile strength, min, psi (MPa)	58 000 (400)	70 000 (483)
Yield strength, min, psi (MPa)	36 000 (250)	50 000 (345)
Elongation in 2 in. (50.8 mm), min, %	23	23

TABLE 3 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)
	38.33 (57.03)	0.38 (9.65)
	47.35 (70.46)	0.500 (12.70)
	49.16 (73.15)	0.50 (12.70)
	56.98 (84.79)	0.625 (15.88)
	60.20 (89.57)	0.63 (16.00)
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)
	48.68 (72.43)	0.38 (9.65)
	60.95 (90.69)	0.500 (12.70)
	62.78 (93.41)	0.50 (12.70)
	73.98 (110.08)	0.625 (15.88)
	77.35 (115.10)	0.63 (16.00)
	86.13 (128.16)	0.750 (19.05)
	90.19 (134.19)	0.75 (19.05)
	107.79 (160.39)	1.000 (25.40)
12 by 12 (304.8 by 304.8)	76.39 (113.66)	0.50 (12.70)
	94.51 (140.62)	0.63 (16.00)
	110.61 (164.58)	0.75 (19.05)

TABLE 3 *Continued*

Size Given in Outside Dimensions Across Flat Sides, in. (mm)	Weight per Unit Length, lb/ft (kg/m)	Calculated Nominal Wall Thickness, in. (mm)	
<u>14 by 14</u> <u>(355.6 by 355.6)</u>	90.01 (133.92)	0.50 (12.70)	
	111.66 (166.14)	0.63 (16.00)	
	131.04 (194.97)	0.75 (19.05)	
	140.49 (209.03)	0.81 (20.57)	
	145.40 (216.35)	0.87 (22.00)	
	162.18 (241.31)	0.98 (25.00)	
<u>16 by 16</u> <u>(406.4 by 406.4)</u>	103.62 (154.18)	0.50 (12.70)	
	128.81 (191.66)	0.63 (16.00)	
	162.52 (241.81)	0.81 (20.57)	
	168.99 (251.44)	0.87 (22.00)	
	188.98 (281.19)	0.98 (25.00)	
	208.24 (309.84)	1.10 (28.00)	
<u>18 by 18</u> <u>(457.2 by 457.2)</u>	267.09 (397.40)	1.26 (32.00)	
	294.62 (438.36)	1.42 (36.00)	
	320.84 (477.38)	1.57 (40.00)	
<u>20 by 20</u> <u>(508.0 by 508.0)</u>	130.85 (194.70)	0.50 (12.70)	
	163.12 (242.70)	0.63 (16.00)	
	192.31 (286.13)	0.75 (19.05)	
	206.66 (307.49)	0.81 (20.57)	
	214.68 (319.42)	0.87 (22.00)	
	240.67 (358.10)	0.98 (25.00)	
	265.88 (395.60)	1.10 (28.00)	
	298.26 (443.78)	1.26 (32.00)	
	329.25 (489.88)	1.42 (36.00)	
	358.83 (533.90)	1.57 (40.00)	
	393.84 (585.99)	1.77 (45.00)	
	426.66 (634.83)	1.97 (50.00)	
	<u>22 by 22</u> <u>(558.8 by 558.8)</u>	177.48 (264.08)	0.63 (16.00)
		208.27 (309.88)	0.75 (19.00)
238.27 (354.51)		0.87 (22.00)	
267.48 (397.98)		0.98 (25.00)	
295.90 (440.26)		1.10 (28.00)	
332.57 (494.83)		1.26 (32.00)	
367.84 (547.31)		1.42 (36.00)	
401.71 (597.70)		1.57 (40.00)	
442.08 (657.77)		1.77 (45.00)	
480.27 (714.58)		1.97 (50.00)	
516.26 (768.14)		2.17 (55.00)	
<u>24 by 24</u> <u>(609.6 by 609.6)</u>	194.64 (289.60)	0.63 (16.00)	
	228.64 (340.19)	0.75 (19.00)	
	261.85 (389.61)	0.87 (22.00)	
	294.28 (437.85)	0.98 (25.00)	
	325.92 (484.93)	1.10 (28.00)	
	366.87 (545.87)	1.26 (32.00)	
	406.43 (604.73)	1.42 (36.00)	
	444.59 (661.51)	1.57 (40.00)	
	490.32 (729.55)	1.77 (45.00)	
	533.87 (794.34)	1.97 (50.00)	
	575.22 (855.87)	2.17 (55.00)	
	614.39 (914.15)	2.36 (60.00)	
	<u>26 by 26</u> <u>(660.4 by 660.4)</u>	211.79 (315.12)	0.63 (16.00)
249.01 (370.50)		0.75 (19.00)	
285.44 (424.70)		0.87 (22.00)	
321.08 (477.73)		0.98 (25.00)	
355.93 (529.59)		1.10 (28.00)	
401.18 (596.92)		1.26 (32.00)	
445.03 (662.16)		1.42 (36.00)	
487.48 (725.31)		1.57 (40.00)	
538.57 (801.33)		1.77 (45.00)	
587.47 (874.10)		1.97 (50.00)	
634.19 (943.61)		2.17 (55.00)	
678.72 (1009.86)		2.36 (60.00)	
<u>28 by 28</u> <u>(711.2 by 711.2)</u>		228.94 (340.64)	0.63 (16.00)
	269.38 (400.80)	0.75 (19.00)	
	309.02 (459.79)	0.87 (22.00)	

TABLE 3 *Continued*

Size Given in Outside Dimensions Across Flat Sides, in. (mm)	Weight per Unit Length, lb/ft (kg/m)	Calculated Nominal Wall Thickness, in. (mm)
	347.88 (517.61)	0.98 (25.00)
	385.95 (574.25)	1.10 (28.00)
	435.49 (647.96)	1.26 (32.00)
	483.62 (719.58)	1.42 (36.00)
	530.36 (789.12)	1.57 (40.00)
	586.81 (873.11)	1.77 (45.00)
	641.07 (953.85)	1.97 (50.00)
	693.15 (1031.34)	2.17 (55.00)
	743.04 (1105.57)	2.36 (60.00)
30 by 30	246.10 (366.17)	0.63 (16.00)
<u>762.0 by 762.0</u>	289.75 (431.11)	0.75 (19.00)
	332.61 (494.88)	0.87 (22.00)
	374.68 (557.49)	0.98 (25.00)
	415.97 (618.92)	1.10 (28.00)
	469.79 (699.00)	1.26 (32.00)
	522.22 (777.00)	1.42 (36.00)
	573.24 (852.92)	1.57 (40.00)
	635.05 (944.89)	1.77 (45.00)
	694.68 (1033.61)	1.97 (50.00)
	752.12 (1119.07)	2.17 (55.00)
	807.36 (1201.28)	2.36 (60.00)

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 3, ~~Table 5~~ Table 4, or ~~Table 6~~ Table 5.

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~~ Table 7.

12.4 *Straightness*—The permissible variation for straightness of structural tubing shall be 1/8 in. times the number of feet (10.4 mm times the number of metres) of total length divided by five.

12.5 *Squareness of Sides*—For perpendicular and rectangular tubing, adjacent sides shall be square (90°), with a permissible variation of ±2°.

12.6 *Radius of Corners*—For square and rectangular structural tubing, the radius of each outside corner of the section shall not exceed three times the calculated nominal wall thickness.

12.7 *Twist*—For square, rectangular, and special shape structural tubing, the permissible variations in twist shall be as given in ~~Table 9~~ Table 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 end of the tubing, and calculating the twist (the difference in the measured 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. (50.8 mm) of the ends of the tubing.

13. Number of Tests

13.1 One tension test as specified in 15.2 shall be made from a length of tubing representing each lot.

~~13.2 The bend test as specified in Section 10 shall be made on one length of square or rectangular tubing representing 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.~~

13.2 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 Method

15.1 Tension test specimens shall conform to the applicable requirements of Test Methods and Definitions ~~A-370~~ 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