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Standard Specification for Structural Steel for Bridges[1]

This standard is issued under the fixed designation A709/A709M; 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.

ε[1] NOTE—Table 3 was corrected editorially in June 2018.

1. Scope*

1.1 This specification covers carbon and high-strength low-alloy steel structural shapes, plates, and bars, quenched and tempered alloy steel, and stainless steel for structural plates intended for use in bridges. Eight grades are available in four yield strength levels as follows:

Grade U.S. [SI]	Yield Strength, ksi [MPa]
36 [250]	36 [250]
50 [345]	50 [345]
50S [345S]	50 [345]
50W [345W]	50 [345]
HPS 50W [HPS 345W]	50 [345]
50CR [345CR]	50 [345]
HPS 70W [HPS 485W]	70 [485]
HPS 100W [HPS 690W]	100 [690]

1.1.1 Grades 36 [250], 50 [345], 50S [345S], 50W [345W], and 50CR [345CR] are also included in Specifications A36/A36M, A572/A572M, A992/A992M, A588/A588M, and A1010/A1010M (UNS S41003), respectively. When the requirements of Table 10 or Table 11 or the supplementary requirements of this specification are specified, they exceed the requirements of Specifications A36/A36M, A572/A572M, A992/A992M, A588/A588M, and A1010/A1010M (UNS S41003). Product availability is shown in Table 1.

1.1.2 Grades 50W [345W], 50CR [345CR], HPS 50W [HPS 345W], HPS 70W [HPS 485W], and HPS 100W [HPS 690W] have enhanced atmospheric corrosion resistance (see 13.1.2). Product availability is shown in Table 1.

1.2 Grade HPS 70W [HPS 485W] or HPS 100W [HPS 690W] shall not be substituted for Grades 36 [250], 50 [345], 50S [345S], 50W [345W], or HPS 50W [HPS 345W]. Grade 50W [345W], or HPS 50W [HPS 345W] shall not be substituted for Grades 36 [250], 50 [345] or 50S [345S] without agreement between the purchaser and the supplier.

1.3 When the steel is to be welded, it is presupposed that a welding procedure suitable for the grade of steel and intended use or service will be utilized. See Appendix X3 of Specification A6/A6M for information on weldability.

1.4 For structural products to be used as tension components requiring notch toughness testing, standardized requirements are provided in this standard, and they are based upon American Association of State Highway and Transportation Officials (AASHTO) requirements for both fracture critical and non-fracture critical members.

1.5 Supplementary requirements are available but shall apply only if specified in the purchase order.

1.6 The values stated in either SI units or inch-pound units are to be regarded separately as standard. 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.

1.7 For structural products produced from coil and furnished without heat treatment or with stress relieving only, the additional requirements, including additional testing requirements and the reporting of additional test results, of Specification A6/A6M apply.

1.8 *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.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

A6/A6M Specification for General Requirements for Rolled Structural Steel Bars, Plates, Shapes, and Sheet Piling

A36/A36M Specification for Carbon Structural Steel

A370 Test Methods and Definitions for Mechanical Testing of Steel Products

[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 A01.02 on Structural Steel for Bridges, Buildings, Rolling Stock and Ships.

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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**

TABLE 1 Tensile and Hardness Requirements[A]

NOTE 1—Where ". . ." appears in this table, there is no requirement.

Grade	Plate Thickness, in. [mm]	Structural Shape Flange or Leg Thickness, in. [mm]	Yield Point or Yield Strength,[B] ksi [MPa]	Tensile Strength, ksi [MPa]	Minimum Elongation, %				Reduction of Area[C,D] min, %
					Plates and Bars[C, E]		Shapes[E]		
					8 in. or 200 mm	2 in. or 50 mm	8 in. or 200 mm	2 in. or 50 mm	
36 [250]	to 4 [100], incl	to 3 in. [75 mm], incl	36 [250] min	58–80 [400–550]	20	23	20	21	...
	over 3 in. [75 mm]		36 [250] min	58 [400] min	...	...	20	19	...
50 [345]	to 4 [100], incl	all	50 [345] min	65 [450] min	18	21	18	21[F]	...
50S [345S]	[G]	all	50–65 [345–450][H,I]	65 [450][H] min	...	...	18	21	...
50W [345W] and HPS 50W [HPS 345W]	to 4 [100], incl	all	50 [345] min	70 [485] min	18	21	18	21[J]	...
50CR [345CR]	to 2 [50], incl	[G]	50 [345] min	70 [485] min	18	21	...	...	...
HPS 70W [HPS 485 W]	to 4 [100], incl	[G]	70 [485] min[B]	85–110 [585–760]	...	19[K]	...	...	...
HPS 100W [HPS 690W]	to 2½ [65], incl	[G]	100 [690] min[B]	110–130 [760–895]	...	18[K]	...	...	[L]
	over 2½ to 4 [65 to 100], incl[M]	[G]	90 [620] min[B]	100–130 [690–895]	...	16[K]	...	...	[L]

[A] See specimen orientation and preparation subsection in the Tension Tests section of Specification A6/A6M.
[B] Measured at 0.2 % offset or 0.5 % extension under load as described in Section 13 of Test Methods A370.
[C] Elongation and reduction of area not required to be determined for floor plates.
[D] For plates wider than 24 in. [600 mm], the reduction of area requirement, where applicable, is reduced by five percentage points.
[E] For plates wider than 24 in. [600 mm], the elongation requirement is reduced by two percentage points. See elongation requirement adjustments in the Tension Tests section of Specification A6/A6M.
[F] Elongation in 2 in. or 50 mm: 19 % for shapes with flange thickness over 3 in. [75 mm].
[G] Not applicable.
[H] The yield to tensile ratio shall be 0.87 or less for shapes that are tested from the web location; for all other shapes, the requirement is 0.85.
[I] A maximum yield strength of 70 ksi [480 MPa] is permitted for structural shapes that are required to be tested from the web location.
[J] For wide flange shapes with flange thickness over 3 in. [75 mm], elongation in 2 in. or 50 mm of 18 % minimum applies.
[K] If measured on the Fig. 3 (Test Methods A370) 1½-in. [40–mm] wide specimen, the elongation is determined in a 2-in. or 50-mm gage length that includes the fracture and shows the greatest elongation.
[L] 40 % minimum applies if measured on the Fig 3 (Test Methods A370) 1½-in. [40-mm] wide specimen; 50 % minimum applies if measured on the Fig. 4 (Test Methods A370) ½-in. [12.5-mm] round specimen.
[M] Not applicable to Fracture Critical Tension Components (see Table 11).

TABLE 2 Grade 36 [250] Chemical Requirements (Heat Analysis)

NOTE 1—Where ". . ." appears in this table there is no requirement. The heat analysis for manganese shall be determined and reported as described in the Heat Analysis section of Specification A6/A6M.

Product Thickness, in. [mm]	Shapes[A] All	Plates >15 in. [380 mm] Width[B]				Bars, Plates ≤15 in. [380 mm] Width[B]		
		To ¾ [20], incl	Over ¾ to 1½ [20 to 40], incl	Over 1½ to 2½ [40 to 65], incl	Over 2½ to 4 [65 to 100], incl	To ¾ [20], incl	Over ¾ to 1½ [20 to 40], incl	Over 1½ to 4 [40 to 100], incl
Carbon, max, %	0.26	0.25	0.25	0.26	0.27	0.26	0.27	0.28
Manganese, %	...	...	0.80–1.20	0.80–1.20	0.85–1.20	...	0.60–0.90	0.60–0.90
Phosphorus, max, %	0.04	0.030	0.030	0.030	0.030	0.04	0.04	0.04
Sulfur, max, %	0.05	0.030	0.030	0.030	0.030	0.05	0.05	0.05
Silicon, %	0.40 max	0.40 max	0.40 max	0.15–0.40	0.15–0.40	0.40 max	0.40 max	0.40 max
Copper, min, % when copper steel is specified	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20

[A] Manganese content of 0.85 to 1.35 % and silicon content of 0.15 to 0.40 % is required for shapes with flange thickness over 3 in. [75 mm].
[B] For each reduction of 0.01 % below the specified carbon maximum, an increase of 0.06 % manganese above the specified maximum will be permitted up to a maximum of 1.35 %.

A572/A572M Specification for High-Strength Low-Alloy Columbium-Vanadium Structural Steel
A588/A588M Specification for High-Strength Low-Alloy Structural Steel, up to 50 ksi [345 MPa] Minimum Yield Point, with Atmospheric Corrosion Resistance
A673/A673M Specification for Sampling Procedure for Impact Testing of Structural Steel
A992/A992M Specification for Structural Steel Shapes
A1010/A1010M Specification for Higher-Strength Martensitic Stainless Steel Plate, Sheet, and Strip

TABLE 3 Grade 50 [345] Chemical Requirements[A] (Heat Analysis)

Maximum Diameter, Thickness, or Distance Between Parallel Faces, in. [mm]	Carbon, max, %	Manganese,[B] max, %	Phosphorus,[C] max, %	Sulfur,[C] max, %†	Silicon[D]		Columbium (Niobium),[E] Vanadium, and Nitrogen
					Plates to 1½-in. [40-mm] Thick, Shapes with flange or leg thickness to 3 in. [75 mm] inclusive, Sheet Piling, Bars, Zees, and Rolled Tees, max, %	Plates Over 1½-in. [40-mm] Thick and Shapes with flange thickness over 3 in. [75 mm], %	
4 [100]	0.23	1.35	0.030	0.030	0.40	0.15–0.40	See Table 4

†Editorially corrected.

[A] Copper when specified shall have a minimum content of 0.20 % by heat analysis (0.18 % by product analysis).
[B] Manganese, minimum by heat analysis of 0.80 % (0.75 % by product analysis) shall be required for all plates over ⅜ in. [10 mm] in thickness; a minimum of 0.50 % (0.45 % by product analysis) shall be required for plates ⅜ in. [10 mm] and less in thickness, and for all other products. The manganese to carbon ratio shall not be less than 2 to 1. For each reduction of 0.01 percentage point below the specified carbon maximum, an increase of 0.06 percentage point manganese above the specified maximum is permitted, up to a maximum of 1.60 %.
[C] A maximum phosphorus content of 0.04 % and a maximum sulfur content of 0.05 % are permitted for the following materials:
- Structural shapes
- Bars
- Plates with widths up to and including 15 in. [380 mm]

[D] Silicon content in excess of 0.40 % by heat analysis must be negotiated.
[E] Columbium and niobium are interchangeable names for the same element.

TABLE 4 Grade 50 [345] Alloy Content

Type[A]	Elements	Heat Analysis, %
1	Columbium (niobium)[B]	0.005–0.05[C]
2	Vanadium	0.01–0.15[D]
3	Columbium (niobium)[B]	0.005–0.05[C]
	Vanadium	0.01–0.15[D]
	Columbium (niobium)[B] plus vanadium	0.02–0.15[E]

[A] Alloy content shall be in accordance with Type 1, 2, or 3 and the contents of the applicable elements shall be reported on the test report.
[B] Columbium and niobium are interchangeable names for the same element.
[C] Product analysis limits = 0.004 to 0.06 %.
[D] Product analysis limits = 0.005 to 0.17 %.
[E] Product analysis limits = 0.01 to 0.16 %.

TABLE 5 Grade 50CR [345CR] Chemical Requirements (Heat Analysis)

NOTE 1—Where ". . ." appears in this table there is no requirement.

Element	Composition, %
Carbon	0.030 max
Manganese	1.50 max
Phosphorus	0.040 max
Sulfur	0.010 max
Silicon	1.00 max
Nickel	1.50 max
Chromium	10.5 – 12.5
Molybdenum	. . .
Nitrogen	0.030 max

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TABLE 6 Grade 50W [345 W] Chemical Requirements (Heat Analysis)

NOTE 1—Types A and B are equivalent to Specification A588/A588M, Grades A and B, respectively.

Element	Composition, %[A]	
	Type A	Type B
Carbon[B]	0.19 max	0.20 max
Manganese[B]	0.80–1.25	0.75–1.35
Phosphorus[C]	0.030 max	0.030 max
Sulfur[C]	0.030 max	0.030 max
Silicon	0.30–0.65	0.15–0.50
Nickel	0.40 max	0.50 max
Chromium	0.40–0.65	0.40–0.70
Copper	0.25–0.40	0.20–0.40
Vanadium	0.02–0.10	0.01–0.10

[A] Weldability data for these types have been qualified by FHWA for use in bridge construction.
[B] 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 %.
[C] A maximum phosphorus content of 0.04 % and a maximum sulfur content of 0.05 % are permitted for the following materials:
· Structural shapes
· Bars
· Plates with widths up to and including 15 in. [380 mm]

TABLE 7 Grades HPS 50W [HPS 345W] and HPS 70W [HPS 485 W], and HPS 100W [HPS 690W] Chemical Requirements (Heat Analysis)

NOTE 1—Where ". . ." appears in this table, there is no requirement.

Element	Composition, %	
	Grades HPS 50W [HPS 345W], HPS 70W [HPS 485W]	Grade HPS 100W [HPS 690W]
Carbon	0.11 max	0.08 max
Manganese		
2.5 in. [65 mm] and under	1.10–1.35	0.95–1.50
Over 2.5 in. [65 mm]	1.10–1.50	0.95–1.50
Phosphorus	0.020 max	0.015 max
Sulfur[A]	0.006 max	0.006 max
Silicon	0.30–0.50	0.15–0.35
Copper	0.25–0.40	0.90–1.20
Nickel	0.25–0.40	0.65–0.90
Chromium	0.45–0.70	0.40–0.65
Molybdenum	0.02–0.08	0.40–0.65
Vanadium	0.04–0.08	0.04–0.08
Columbium (niobium)[B]	. . .	0.01–0.03
Aluminum	0.010–0.040	0.020–0.050
Nitrogen	0.015 max	0.015 max

[A] The steel shall be calcium treated for sulfide shape control.
[B] Columbium and niobium are interchangeable names for the same element.

TABLE 8 Grade 50S [345S] Chemical Requirements (Heat Analysis)

Element	Composition, %
Carbon, max	0.23
Manganese	0.50 to 1.60[A]
Silicon, max	0.40
Vanadium, max	0.15[B]
Columbium (niobium),[C] max	0.05[B]
Phosphorus, max	0.035
Sulfur, max	0.045
Copper, max	0.60
Nickel, max	0.45
Chromium, max	0.35
Molybdenum, max	0.15

[A] Provided that the ratio of manganese to sulfur is not less than 20 to 1, the minimum limit for manganese for shapes with flange or leg thickness not exceeding 1 in. [25 mm] shall be 0.30 %.
[B] The sum of columbium (niobium) and vanadium shall not exceed 0.15 %.
[C] Columbium and niobium are interchangeable names for the same element.

TABLE 9 Relationship Between Impact Testing Temperature Zones and Minimum Service Temperature

Zone	Minimum Service Temperature, °F [°C]
1	0 [–18]
2	below 0 to –30 [–18 to –34]
3	below –30 to –60 [–34 to –51]

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *fracture critical member*—a main load-carrying tension member or tension component of a bending member whose failure would be expected to cause collapse of a structure or bridge without multiple, redundant load paths.

3.1.2 *main load-carrying member*—a steel member designed to carry primary design loads, including dead, live, impact, and other loads.

3.1.3 *non-fracture critical member*—a main load-carrying member whose failure would not be expected to cause collapse of a structure or bridge with multiple, redundant load paths.

3.1.4 *non-tension component*—a steel member that is not in tension under any design loading.

3.1.5 *secondary member*—a steel member used for aligning and bracing of main load-carrying members, or for attaching utilities, signs, or other items to them, but not to directly support primary design loads

3.1.6 *tension component*—a part or element of a fracture critical or non-fracture critical member that is in tension under various design loadings.

4. Ordering Requirements

4.1 In addition to the items listed in the ordering information section of Specification A6/A6M, the following items should be considered if applicable:

4.1.1 Type of component (tension or non-tension, fracture critical or non-fracture critical) (see Section 10).

4.2 Impact testing temperature zone (see Table 9).

5. General Requirements for Delivery

5.1 Structural products furnished under this specification shall conform to the requirements of the current edition of Specification A6/A6M, for the specific structural product ordered, unless a conflict exists in which case this specification shall prevail.

5.2 Coils are excluded from qualification to this specification until they are processed into a finished structural product. Structural products produced from coil means structural products that have been cut to individual lengths from a coil. The processor directly controls, or is responsible for, the operations involved in the processing of a coil into a finished structural product. Such operations include decoiling, leveling or straightening, hot-forming or cold-forming (if applicable),