Designation: A 709/A 709M – 04a$^{\epsilon 1}$

Standard Specification for Structural Steel for Bridges[1]

This standard is issued under the fixed designation A 709/A 709M; 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 1, Table S1.2, and Table S1.3 were corrected editorially in March 2005.

1. Scope*

1.1 This specification covers carbon and high-strength low-alloy steel structural shapes, plates, and bars and quenched and tempered alloy steel for structural plates intended for use in bridges. Nine 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]
HPS 70W [HPS 485W]	70 [485]
100 [690]	100 [690]
100W [690W]	100 [690]
HPS 100W [HPS 690W]	100 [690]

1.1.1 Grades 36 [250], 50 [345], 50S [345S], 50W [345W], 100 [690], and 100W [690W] are also included in Specifications A 36A 36/A 36M/A 36M, A 572/A 572MA 572/A 572M, A 992/A 992MA 992/A 992M, A 588/A 588M, and A 514/A 514M, respectively. When the supplementary requirements of this specification are specified, they exceed the requirements of Specifications A 36A 36/A 36M/A 36M, A 572/A 572MA 572/A 572M, A 992/A 992MA 992/A 992M, A 588/A 588MA 588/A 588M, and A 514/A 514MA 514/A 514M.

1.1.2 Grades 50W [345W], HPS 50W [HPS 345], HPS 70W [HPS 485W], 100W [690W], and HPS 100W [HPS 690W] have enhanced atmospheric corrosion resistance (see 11.1.2). Product availability is shown in Table 1.

1.2 Grade HPS 70W [HPS 485W], 100 [690], 100W [690W], 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 A 6A 6/A 6M/A 6M for information on weldability.

1.4 Supplementary requirements are available but shall apply only when specified by the purchaser at the time of ordering.

1.5 The values stated in either inch-pound units or SI units are to be regarded as standard. Within the text, the SI units are shown in brackets. The values stated in each system are not exact equivalents; therefore, each system must be used independently of the other. Combining values from the two systems may result in nonconformance with this specification.

1.6 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 A 6A 6/A 6M/A 6M apply.

2. Referenced Documents

2.1 *ASTM Standards:*[2]

A 6/A 6M Specification for General Requirements for Rolled Structural Steel Bars, Plates, Shapes, and Sheet Piling

A 36/A 36M Specification for Carbon Structural Steel

A 370 Test Methods and Definitions for Mechanical Testing of Steel Products

A 435/A 435M Specification for Straight-Beam Ultrasonic Examination of Steel Plates

A 514/A 514M Specification for High-Yield-Strength, Quenched and Tempered Alloy Steel Plate, Suitable for Welding

A 572/A 572M Specification for High-Strength Low-Alloy Columbium-Vanadium Structural Steel

A 588/A 588M Specification for High-Strength Low-Alloy Structural Steel with 50 ksi [345 MPa] Minimum Yield Point to 4 in. [100 mm] Thick

A 673/A 673M Specification for Sampling Procedure for Impact Testing of Structural Steel

A 992/A 992M Specification for Structural Steel Shapes

[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.

Current edition approved Sept. 1, 2004. Published September 2004. Originally approved in 1974. Last previous edition approved in 2004 as A 709/A 709M– 04.

[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, %	Brinell Hardness Number
					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[F]	...	...
		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]	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[I]	...	...
HPS 70W [HPS 485 W]	to 4 [100], incl	[G]	70 [485] min[B]	85–110 [585–760]	. . .	19[J] †	. . .	. . .	. . .	...
100 [690] , 100W [690W], and HPS 100W [HPS 690W]	to 2½ [65], incl	[G]	100 [690] min[B]	110–130 [760–895]	...	18[J]	...	...	[K]	235–293[L]
100 [690] and 100W [690 W]	over 2½ to 4 [65 to 100]	[G]	90 [620] min[B]	100–130 [690–895]	...	16[J]	...	...	[K]	...

† Footnote added editorially in March 2005.

[A] See specimen orientation and preparation subsection in the Tension Tests section of Specification A 6/A 6 M.
[B] Measured at 0.2 % offset or 0.5 % extension under load as described in Section 13 of Test Methods A 370.
[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 A 6/A 6M.
[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 0.85 or less.
[I] For wide flange shapes with flange thickness over 3 in. [75 mm], elongation in 2 in. or 50 mm. of 18 % minimum applies.
[J] If measured on the Fig. 3 (Test Methods A 370) 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.
[K] 40 % minimum applies if measured on the Fig 3 (Test Methods A 370) 1 ½ –in. [40-mm] wide specimen; 50 % minimum applies if measured on the Fig. 4 (Test Methods A 370) ½ –in. [12.5-mm] round specimen.
[L] Applies only to Grades 100 [690] and 100W [690W] plates that are ⅜ in. [10 mm] or less in thickness and are not tension tested (See 8.1).

E 112 Test Methods for Determining Average Grain Size
G 101 Guide for Estimating the Atmospheric Corrosion Resistance of Low-Alloy Steels

3. General Requirements for Delivery

3.1 Structural products furnished under this specification shall conform to the requirements of the current edition of Specification A 6A 6/A 6M/A 6M, for the specific structural product ordered, unless a conflict exists in which case this specification shall prevail.

3.2 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), cutting to length, testing, inspection, conditioning, heat treatment (if applicable), packaging, marking, loading for shipment, and certification.

NOTE 1—For structural products produced from coil and furnished without heat treatment or with stress relieving only, two test results are to be reported for each qualifying coil. Additional requirements regarding structural products produced from coil are described in Specification A 6A 6/A 6M/A 6M.

4. Materials and Manufacture

4.1 For Grades 36 [250] and 50 [345], the steel shall be semi-killed or killed.

4.2 For Grades 50W [345W], HPS 50W [HPS 345W], and HPS 70W [HPS 485W], the steel shall be made to fine grain practice.

4.3 For Grade 50S [345S], the steel shall be killed and such shall be affirmed in the test report by a statement of *killed steel*, a value of 0.10 % or more for the silicon content, or a value of 0.015 % or more for the total aluminum content.

4.4 For Grade 50S [345S], the steelmaking practice used shall be one that produces steel having a nitrogen content not greater than 0.015 % and includes the addition of one or more nitrogen-binding elements, or one that produces steel having a nitrogen content of not greater than 0.012 % (with or without the addition of nitrogen-binding elements). The nitrogen content need not be reported, regardless of which steelmaking practice was used.

4.5 For grades HPS 50W [HPS 345W], HPS 70W [HPS 485W], and HPS 100W [HPS 690W], the steel shall be made

using a low-hydrogen practice, such as vacuum degassing during steel making; controlled soaking of the ingots, slabs; controlled slow cooling of the ingots, slabs, or plates, or a combination thereof.

4.6 For Grades 100 [690], 100W [690W],and HPS 100W [HPS 690W], the requirements for fine austenitic grain size in Specification A 6A 6/A 6M/A 6M shall be met.

4.7 Grades HPS 50W [HPS 345W] and HPS 70W [HPS 485W] shall be furnished in one of the following conditions: as-rolled, control-rolled, thermo-mechanical control processed (TMCP) with or without accelerated cooling, or quenched and tempered.

5. Heat Treatment

5.1 For quenched and tempered Grades HPS 50W [HPS 345W] and HPS 70W [HPS 485W], the heat treatment shall be performed by the manufacturer and shall consist of heating the steel to not less than 1650 °F [900 °C], quenching it in water or oil, and tempering it at not less than 1100 °F [590 °C]. The heat-treating temperatures shall be reported on the test certificates.

5.2 For Grades 100 [690] and 100W [690W], the heat treatment shall be performed by the manufacturer and shall consist of heating the steel to not less than 1650 °F [900 °C], quenching it in water or oil, and tempering it at not less than 1150 °F [620 °C]. The heat-treating temperatures shall be reported on the test certificates.

5.3 For Grade HPS 100W [HPS 690W], the heat treatment shall be performed by the manufacturer and shall consist of heating the steel to a temperature in the range from 1600 to 1700°F [870 to 925°C], quenching it in water, and tempering it at not less than 1050°F [565°C] for a time to be determined by the manufacturer. The heat-treating temperatures shall be reported on the test certificates.

6. Chemical Requirements

6.1 The heat analysis shall conform to the requirements for the specified grade given in Tables 2-7.

6.2 For Grade 50S [345S], in addition to the elements listed in Table 7, test reports shall include, for information, the chemical analysis for tin. Where the amount of tin is less than 0.02 %, it shall be permissible for the analysis to be reported as < 0.02 %.

6.3 For Grade 50S [345S], the maximum permissible carbon equivalent value shall be 0.47 % for structural shapes in Groups 4 and 5, and 0.45 % for other structural shapes. The carbon equivalent shall be based on heat analysis. The required chemical analysis as well as the carbon equivalent shall be reported. The carbon equivalent shall be calculated using the following formula:

$$CE = C + \frac{Mn}{6} + \frac{(Cr + Mo + V)}{5} + \frac{(Ni + Cu)}{15} \quad (1)$$

7. Tensile Requirements

7.1 The material as represented by test specimens, except as specified in 7.2, shall conform to the requirements for tensile properties given in Table 1.

7.2 For Grade 36 [250] shapes less than 1 in. ^{2}[645 mm^2] in cross section and bars, other than flats, less than ½ in. [12.5 mm] in thickness or diameter need not be subjected to tension tests by the manufacturer.

8. Brinell Hardness Requirements for Grades 100 [690] and 100W [690W]

8.1 For plates ⅜ in. [10 mm] and under in thickness, a Brinell hardness test may be used instead of tension testing each plate, in which case a tension test specimen shall be taken from a corner of each of two plates per lot. A lot shall consist of plates from the same heat and thickness, same prior condition and scheduled heat treatment and shall not exceed 15 tons [15 Mg] in weight. A Brinell hardness test shall be made on each plate not tension tested and shall meet the requirements given in Table 1.

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 A 6/A 6M.

Product Thickness, in. (mm)	Shapes^A All	Plates^B				Bars^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 [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	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Sulfur, max, %	0.05	0.05	0.05	0.05	0.05	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 %.

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, max, %	Sulfur, max, %	Silicon[C]		Columbium, 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, %[D]	Plates Over 1½ –in. [40-mm] Thick and Shapes with flange thickness over 3 in. [75 mm], %	
4 [100]	0.23	1.35	0.04	0.05	0.40	0.15–0.40	[E]

[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. A maximum of manganese of 1.50 % is permissible, with an associated reduction of the carbon maximum by 0.03 percentage point.
[C]Silicon content in excess of 0.40 % by heat analysis must be negotiated.
[D]Bars over 1 ½ in. [40 mm] in diameter, thickness, or distance between parallel faces, shall be made by a killed steel practice.
[E]Alloy content shall be in accordance with Type 1, 2, 3, or 5 and the contents of the applicable elements shall be reported on the test report.

Type	Elements	Heat Analysis, %
1	Columbium[A]	0.005–0.05[B]
2	Vanadium	0.01–0.15
3	Columbium[A]	0.005–0.05[B]
	Vanadium	0.01–0.15
	Columbium plus vanadium	0.02–0.15[C]
5	Titanium	0.006–0.04
	Nitrogen	0.003–0.015
	Vanadium	0.06 max

[A] Columbium shall be restricted to Grade 50 [345] plate, bar, zee, and rolled tee thickness of ¾ in. [20 mm] max, and to shapes with flange or leg thickness to 1½ in. [40 mm] inclusive unless killed steel if furnished. Killed steel shall be confirmed by a statement of killed steel on the test report, or by a report of the presence of a sufficient quantity of a strong deoxidizing element, such as silicon at 0.10 % or higher, or aluminum at 0.015 % or higher.
[B] Product analysis limits = 0.004 to 0.06 %.
[C] Product analysis limits = 0.01 to 0.16 %

TABLE 4 Grade 50W [345 W] Chemical Requirements (Heat Analysis)

NOTE 1—Types A, B, and C are equivalent to Specification A 588/A 588M Grades A, B, and C, respectively.

Element	Composition, %[A]		
	Type A	Type B	Type C
Carbon[B]	0.19 max	0.20 max	0.15 max
Manganese[B]	0.80–1.25	0.75–1.35	0.80–1.35
Phosphorus	0.04 max	0.04 max	0.04 max
Sulfur	0.05 max	0.05 max	0.05 max
Silicon	0.30–0.65	0.15–0.50	0.15–0.40
Nickel	0.40 max	0.50 max	0.25–0.50
Chromium	0.40–0.65	0.40–0.70	0.30–0.50
Copper	0.25–0.40	0.20–0.40	0.20–0.50
Vanadium	0.02–0.10	0.01–0.10	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 %.

9. Test Specimens and Number of Tension Tests

9.1 For Grades 36 [250], 50 [345], and 50W [345W], and non-quenched and tempered Grades HPS 50W [HPS 345W] and HPS 70W [HPS 485W], location and condition, number of tests, and preparation of test specimens shall meet the requirements of Specification A 6A 6/A 6M/A 6M.

9.2 The following requirements, which are in addition to those of Specification A 6A 6/A 6M/A 6M, shall apply only to Grades 100 [690], 100W [690W], and HPS 100W [HPS 690W], and quenched and tempered Grades HPS 50W [HPS 345W] and HPS 70W [HPS 485 W].

9.2.1 When possible, all test specimens shall be cut from the plate in its heat-treated condition. If it is necessary to prepare test specimens from separate pieces, all of these pieces shall be full thickness, and shall be similarly and simultaneously heat treated with the material. All such separate pieces shall be of such size that the prepared test specimens are free of any variation in properties due to edge effects.

9.2.2 After final heat treatment of the plates, one tension test specimen shall be taken from a corner of each plate as heat treated (except as specified in 8.1).

NOTE 2—The term "plate" identifies the "plate as heat treated."