



Designation: A709/A709M – 21

Standard Specification for Structural Steel for Bridges¹

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.

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. Twelve grades are available in five 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]
QST 50 [QST 345]	50 [345]
QST 50S [QST 345S]	50 [345]
50W [345W]	50 [345]
HPS 50W [HPS 345W]	50 [345]
50CR [345CR]	50 [345]
QST 65 [QST450]	65 [450]
QST 70 [QST485]	70 [485]
HPS 70W [HPS 485W]	70 [485]
HPS 100W [HPS 690W]	100 [690]

1.1.1 Grades 36 [250], 50 [345], 50S [345S], 50W [345W], 50CR [345CR], QST 50 [QST 345], QST 50S [QST 345S], QST 65 [QST 450], and QST 70 [QST 485] are also included in Specifications [A36/A36M](#), [A572/A572M](#), [A992/A992M](#), [A588/A588M](#), [A1010/A1010M](#) (UNS S41003), and [A913/A913M](#) respectively. When the requirements of [Table 11](#) or [Table 12](#) or the supplementary requirements of this specification are specified, they exceed the requirements of Specifications [A36/A36M](#), [A572/A572M](#), [A992/A992M](#), [A588/A588M](#), [A1010/A1010M](#) (UNS S41003), and [A913/A913M](#). 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

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		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	...
QST 50 [QST 345]	^G	all	50 [345] min	65 [450] min	...	...	18	21 ^F	...
50S [345S]	^G	all	50–65 [345–450] ^{H,I}	65 [450] ^H min	...	...	18	21	...
QST 50S [QST 345S]	^G	all	50–65 [345–450]	65 [450] 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	...	...	...
QST 65 [QST 450]	^G	all	65 [450] min	80 [550] min	...	...	15	17	...
QST 70 [QST 485]	^G	all	70 [485] min	90 [620] min	...	...	14	16	...
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 and Definitions **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 and Definitions **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 and Definitions **A370**) 1½-in. [40-mm] wide specimen; 50 % minimum applies if measured on the Fig. 4 (Test Methods and Definitions **A370**) ½-in. [12.5-mm] round specimen.

^M Not applicable to Fracture Critical Tension Components (see **Table 12**).

A370 Test Methods and Definitions for Mechanical Testing of Steel Products

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

A913/A913M Specification for High-Strength Low-Alloy Steel Shapes of Structural Quality, Produced by Quenching and Self-Tempering Process (QST)

A992/A992M Specification for Structural Steel Shapes

A1010/A1010M Specification for Higher-Strength Martensitic Stainless Steel Plate, Sheet, and Strip

G101 Guide for Estimating the Atmospheric Corrosion Resistance of Low-Alloy Steels

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 speci- fied	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, ^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

^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 ¾ in. [10 mm] in thickness; a minimum of 0.50 % (0.45 % by product analysis) shall be required for plates ¾ in. [10 mm] and less in thickness, and for all other products. 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

3. Terminology

3.1 Definitions of Terms Specific to This Standard:

3.1.1 *fracture critical member, n*—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, n*—a steel member designed to carry primary design loads, including dead, live, impact, and other loads.

3.1.3 *non-fracture critical member, n*—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, n*—a steel member that is not in tension under any design loading.

**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.

3.1.5 *secondary member, n*—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, n*—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:

**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 Grades QST 50 [QST 345], QST 50S [QST 345S], QST 65
[QST 450], and QST 70 [QST 485] Chemical Requirements
(Heat Analysis)**

NOTE 1—Boron shall not be intentionally added. See Specification **A6/A6M**, Section 7.1.2, for additional guidance regarding boron.

Element	Maximum Content in %		
	Grade QST 50 and QST 50S [QST 345] and [QST 345S]	Grade QST 65 [QST 450]	Grade QST 70Q [QST 485]
Carbon	0.12	0.12	0.12
Manganese	1.60	1.60	1.60
Phosphorus	0.030	0.030	0.030
Sulfur	0.030	0.030	0.030
Silicon	0.40	0.40	0.40
Copper	0.45	0.35	0.45
Nickel	0.25	0.25	0.25
Chromium	0.25	0.25	0.25
Molybdenum	0.07	0.07	0.07
Columbium (niobium) ^A	0.05	0.05	0.05
Vanadium	0.06	0.08	0.09

^A Columbium and niobium are interchangeable names for the same element.

**TABLE 10 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]

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 10).

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.

TABLE 11 Non-Fracture Critical Tension Component Impact Test Requirements

Grade	Thickness, in. [mm]	Minimum Average Energy, ft-lbf [J]		
		Zone 1	Zone 2	Zone 3
36T [250T] ^A	to 4 [100] incl	15 [20] at 70°F [21°C]	15 [20] at 40°F [4°C]	15 [20] at 10°F [-12°C]
50T [345T] ^{A, B}	to 2 [50] incl	15 [20] at 70°F [21°C]	15 [20] at 40°F [4°C]	15 [20] at 10°F [-12°C]
50ST [345ST] ^{A, B}	over 2 to 4 [50 to 100] incl	20 [27] at 70°F [21°C]	20 [27] at 40°F [4°C]	20 [27] at 10°F [-12°C]
50WT [345WT] ^{A, B}				
QST 50T [QST 345T] ^{B, D}	to 2 [50] incl	15 [20] at 70°F [21°C]	15 [20] at 40°F [4°C]	15 [20] at 10°F [-12°C]
QST 50ST [QST 345ST] ^D	over 2 to 4 [50 to 100] incl	20 [27] at 70°F [21°C]	20 [27] at 40°F [4°C]	20 [27] at 10°F [-12°C]
50CRT [345CRT] ^{A, B}	to 2 [50] incl	15 [20] at 70°F [21°C]	15 [20] at 40°F [4°C]	15 [20] at 10°F [-12°C]
HPS 50WT	to 4 [100] incl	20 [27] at 10°F [-12°C]	20 [27] at 10°F [-12°C]	20 [27] at 10°F [-12°C]
[HPS 345WT] ^{A, B}				
QST 65T [QST 450T] ^{B, D}	to 2 [50] incl	20 [27] at 50°F [10°C]	20 [27] at 20°F [-7°C]	20 [27] at -10°F [-23°C]
	over 2 to 4 [50 to 100] incl	25 [34] at 50°F [10°C]	25 [34] at 20°F [-7°C]	25 [34] at -10°F [-23°C]
QST 70T [QST 485T] ^{B, D}	to 2 [50] incl	20 [27] at 50°F [10°C]	20 [27] at 20°F [-7°C]	20 [27] at -10°F [-23°C]
	over 2 to 4 [50 to 100] incl	25 [34] at 50°F [10°C]	25 [34] at 20°F [-7°C]	25 [34] at -10°F [-23°C]
HPS 70WT	to 4 [100] incl	25 [34] at -10°F [-23°C]	25 [34] at -10°F [-23°C]	25 [34] at -10°F [-23°C]
[HPS 485WT] ^{B, D}				
HPS 100WT	to 2½ [65] incl	25 [34] at -30°F [-34°C]	25 [34] at -30°F [-34°C]	25 [34] at -30°F [-34°C]
[HPS 690WT] ^D	over 2½ to 4 [65 to 100] incl	35 [48] at -30°F [-34°C]	35 [48] at -30°F [-34°C]	35 [48] at -30°F [-34°C]

^A The CVN-impact testing shall be at “H” frequency in accordance with Specification **A673/A673M**.

^B If the yield point of the structural product exceeds the specified minimum value by 15 ksi [105MPa] or more, the testing temperature for the minimum average energy required shall be reduced by 15°F [8°C] for each increment or fraction of 10 ksi [70 MPa] above the 15 ksi [105 MPa] exceedance of the specified minimum value. The yield point is the value given in the test report. See examples in Table Footnote C.^C

^C If the yield point or yield strength for a 50 ksi [345 MPa] minimum yield strength steel is more than 65 ksi [450 MPa] but not more than 75 ksi [520 MPa], the test temperature reduction is 15°F [8°C]. If the yield point is more than 75 ksi [520 MPa] but not more than 85 ksi [585 MPa], the test temperature reduction is 30°F [17°C].

If the yield point or yield strength for a 65 ksi [450 MPa] minimum yield strength steel is more than 80 ksi [550 MPa] but not more than 90 ksi [620 MPa], the test temperature reduction is 15°F [8°C]. If the yield point is more than 90 ksi [620 MPa] but not more than 100 ksi [690 MPa], the test temperature reduction is 30°F [17°C].

If the yield point or yield strength for a 70 ksi [485 MPa] minimum yield strength steel is more than 85 ksi [585 MPa] but not more than 95 ksi [655 MPa], the test temperature reduction is 15°F [8°C]. If the yield point is more than 95 ksi [655 MPa] but not more than 105 ksi [725 MPa], the test temperature reduction is 30°F [17°C].

^D The CVN-impact testing shall be at “P” frequency in accordance with Specification **A673/A673M**.

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 **A6/A6M**.

6. Materials and Manufacture

6.1 For all Grades, the steel shall be killed.

6.2 For Grades 50W [345W], QST 65 [QST 450], QST 70 [QST 485], HPS 50W [HPS 345W], and HPS 70W [HPS 485W], the steel shall be made to fine grain practice.

6.3 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.

6.4 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.

6.5 For Grade HPS 100W [HPS 690W], the requirements for fine austenitic grain size in Specification **A6/A6M** shall be met.

6.6 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.

6.7 Grade 50CR [345CR] shall be furnished normalized and tempered or quenched and tempered.

6.8 For fracture critical base material only, weld repair of the base metal by the material manufacturer or supplier is not permitted.

TABLE 12 Fracture Critical Tension Component Impact Test Requirements

Grade	Thickness, in. [mm]	Minimum Test Value Energy, ^A ft-lbf [J]	Minimum Average Energy, ^A ft-lbf [J]		
			Zone 1	Zone 2	Zone 3
36F [250F]	to 4 [100], incl	20 [27]	25 [34] at 70°F [21°C]	25 [34] at 40°F [4°C]	25 [34] at 10°F [-12°C]
50F [345F] ^B 50SF [345SF] ^B 50WF [345WF] ^B	to 2 [50], incl over 2 to 4 [50 to 100], incl	20 [27] 24 [33]	25 [34] at 70°F [21°C] 30 [41] at 70°F [21°C]	25 [34] at 40°F [4°C] 30 [41] at 40°F [4°C]	25 [34] at 10°F [-12°C] 30 [41] at 10°F [-12°C]
QST 50F [QST 345F] ^B QST 50SF [QST 345SF]	to 2 [50] incl over 2 to 4 [50 to 100] incl	20 [27] 24 [33]	25 [34] at 70°F [21°C] 30 [41] at 70°F [21°C]	25 [34] at 40°F [4°C] 30 [41] at 40°F [4°C]	25 [34] at 10°F [-12°C] 30 [41] at 10°F [-12°C]
50CRF [345CRF] ^B	to 2 [50], incl	20 [27]	25 [34] at 70°F [21°C]	25 [34] at 40°F [4°C]	25 [34] at 10°F [-12°C]
HPS 50WF [HPS 345WF] ^B	to 4 [100], incl	24 [33]	30 [41] at 10°F [-12°C]	30 [41] at 10°F [-12°C]	30 [41] at 10°F [-12°C]
QST 65F [QST 450F] ^B	to 2 [50] incl over 2 to 4 [50 to 100] incl	24 [33] 28 [38]	30 [41] at 50°F [10°C] 35 [48] at 50°F [10°C]	30 [41] at 20°F [-7°C] 35 [48] at 20°F [-7°C]	30 [41] at -10°F [-23°C] 35 [48] at -10°F [-23°C]
QST 70F [QST 485F] ^B	to 2 [50] incl over 2 to 3 [50 to 76] incl	24 [33] 28 [38]	30 [41] at 50°F [10°C] 35 [48] at 50°F [10°C]	30 [41] at 20°F [-7°C] 35 [48] at 20°F [-7°C]	30 [41] at -10°F [-23°C] 35 [48] at -10°F [-23°C]
HPS 70WF [HPS 485WF] ^B	to 4 [100], incl	28 [38]	35 [48] at -10°F [-23°C]	35 [48] at -10°F [-23°C]	35 [48] at -10°F [-23°C]
HPS 100WF [HPS 690WF]	to 2½ [65], incl over 2½ to 4 [65 to 100], incl	28 [38] ^D	35 [48] at -30°F [-34°C] Not permitted	35 [48] at -30°F [-34°C] Not permitted	35 [48] at -30°F [-34°C] Not permitted

^A The CVN-impact testing shall be at "P" frequency in accordance with Specification **A673/A673M** except for plates, for which the sampling shall be as follows:

- (1) As-rolled (including control-rolled and TMCP) plates shall be sampled at each end of each plate-as-rolled.
- (2) Normalized plates shall be sampled at one end of each plate, as heat treated.
- (3) Quenched and tempered plates shall be sampled at each end of each plate, as heat treated.

^B If the yield point of the structural product exceeds the specified minimum value by 15 ksi [105MPa] or more, the testing temperature for the minimum average energy required shall be reduced by 15°F [8°C] for each increment or fraction of 10 ksi [70 MPa] above the 15 ksi [105 MPa] exceedance of the specified minimum value. The yield point is the value given in the test report. See examples in Table Footnote C.^C

^C If the yield point or yield strength for a 50 ksi [345 MPa] minimum yield strength steel is more than 65 ksi [450 MPa] but not more than 75 ksi [520 MPa], the test temperature reduction is 15°F [8°C]. If the yield point is more than 75 ksi [520 MPa] but not more than 85 ksi [585 MPa], the test temperature reduction is 30°F [17°C]. If the yield point or yield strength for a 65 ksi [450 MPa] minimum yield strength steel is more than 80 ksi [550 MPa] but not more than 90 ksi [620 MPa], the test temperature reduction is 15°F [8°C]. If the yield point is more than 90 ksi [620 MPa] but not more than 100 ksi [690 MPa], the test temperature reduction is 30°F [17°C].

If the yield point or yield strength for a 70 ksi [485 MPa] minimum yield strength steel is more than 85 ksi [585 MPa] but not more than 95 ksi [655 MPa], the test temperature reduction is 15°F [8°C]. If the yield point is more than 95 ksi [655 MPa] but not more than 105 ksi [725 MPa], the test temperature reduction is 30°F [17°C].

^D Not applicable.

6.9 For grades QST 50 [QST 345], QST 50S [QST 345S], QST 65 [QST 450], and QST 70 [QST 485], the shapes are produced by the quenching and self-tempering process (QST). Following rapid quenching to achieve a surface temperature below the martensite start temperature, Ms, the shapes shall be allowed to auto-temper to a self-tempering temperature (STT) that shall be 1100°F [595°C] minimum and 1300°F [705°C] maximum. The STT shall be reported on the mill test report. Due to the inherent characteristics of the QST process, the shapes shall not be formed nor post weld heat treated at temperatures exceeding 1100°F [600°C].

7. Heat Treatment

7.1 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.

7.2 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.

7.3 For Grade 50CR [345CR], the heat treatment shall be performed by the manufacturer and shall consist of heating the steel to a temperature in the range of 1600 to 1700°F [870 to 925°C], cooling in air or quenching in water, and tempering between 1200 to 1400°F [650 to 760°C] for a time to be determined by the manufacturer. The heat-treating temperatures shall be reported on the test certificates.

8. Chemical Requirements

8.1 The heat analysis shall conform to the requirements for the specified grade, as given in **Tables 2-9**.

8.2 For Grade 50S [345S], in addition to the elements listed in **Table 8**, 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 %.

8.3 For Grade 50S [345S], the maximum permissible carbon equivalent value shall be 0.47 % for structural shapes with flange thickness over 2 in. [50 mm], 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:

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

8.4 For Grades QST 50 [QST 345], QST 50S [QST 345S], QST 65 [QST 450], and QST 70 [QST 485], the following Carbon Equivalent Limits apply (calculated using the CE formula in 8.3):

Maximum Carbon Equivalent Limits

Grade QST 50 [QST 345]:	0.38 %
Grade QST 50S [QST 345S]:	0.38 %
Grade QST 65 [QST 450]:	0.43 %
Grade QST 70 [QST 485]:	0.45 %

9. Tensile Requirements

9.1 The material as represented by test specimens, except as specified in 9.2, shall conform to the requirements for tensile properties given in Table 1.

9.2 For Grade 36 [250], shapes less than 1 in.² [645 mm²] 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.

10. Impact Testing Requirements

10.1 *Non-Fracture-Critical, T, Tension Components*—Structural products ordered for use as tension components of non-fracture-critical members shall be impact tested in accordance with Specification A673/A673M and as given in Table 11. The test results shall meet the requirements given in Table 11.

10.2 *Fracture-Critical, F, Tension Components*—Structural products ordered for use as tension components of fracture-critical members shall be impact tested in accordance with Specification A673/A673M and as given in Table 12. The test results shall meet the requirements given in Table 12.

10.3 Steel grades ordered for use without suffix T or F as listed in 10.1 and 10.2 do not require impact testing and shall be used as non-tension components or secondary members only.

11. Test Specimens and Number of Tension Tests

11.1 For Grades 36 [250], 50 [345], 50W [345W], QST 50 [QST 345], QST 50S [QST 345S], QST 65 [QST 450], and QST 70 [QST 485] and non-quenched and tempered Grades 50CR [345CR], 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 A6/A6M.

11.2 The following requirements, which are in addition to those of Specification A6/A6M, shall apply only to Grade HPS 100W [HPS 690W] and quenched and tempered Grades 50CR [345CR], HPS 50W [HPS 345W], and HPS 70W [HPS 485W].

11.2.1 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.

11.2.2 After final heat treatment of the plates, one tension test specimen shall be taken from a corner of each plate as heat treated.

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

12. Retests

12.1 Grades 36 [250], 50 [345], 50S [345S], 50W [345W], QST 50 [QST 345], QST 50S [QST 345S], QST 65 [QST 450], and QST 70 [QST 485] and non-quenched and tempered 50CR [345CR], HPS 50W [HPS 345W] and HPS 70W [HPS 485W] shall be retested in accordance with Specification A6/A6M.

12.2 The manufacturer may reheat treat quenched and tempered plates that fail to meet the mechanical property requirements of this specification. All mechanical property tests shall be repeated when the material is resubmitted for inspection.

13. Atmospheric Corrosion Resistance

13.1 Steels meeting this specification provide three levels of atmospheric corrosion resistance:

13.1.1 Steel grades without suffix provide a level of atmospheric corrosion resistance typical of carbon or alloy steel without copper.

13.1.2 The steel for Grades 50W [345W], HPS 50W [HPS 345W], and HPS 70W [HPS 485W] shall have an atmospheric corrosion resistance index of 6.0 or higher, calculated from the heat analysis in accordance with Guide G101, Predictive Method Based on the Data of Larabee and Coburn (see Note 3). When properly exposed to the atmosphere, these steels can be used bare (unpainted) for many applications. The steel for Grade HPS 100W [HPS 690W] provides an improved level of atmospheric corrosion resistance over alloy steel without copper.

13.1.3 The steel for Grade 50CR [345CR] may be used bare (unpainted) in some applications where traditional weathering steel does not perform successfully.

NOTE 3—For methods of estimating the atmospheric corrosion resistance of low-alloy steels, see Guide G101. The user is cautioned that the Guide G101 predictive equation (Predictive Method Based on the Data of Larabee and Coburn) for calculation of an atmospheric corrosion resistance index has only been verified for the composition limits stated in that guide.

14. Marking

14.1 In addition to the marking requirements of Specification A6/A6M, the structural product shall be marked as follows:

14.1.1 For Grade 50W [345W], the composition type shall be included.

14.1.2 For structural products that conform to the requirements of 10.1, the letter *T* and the applicable zone number (1, 2, or 3) shall follow the grade designation.

14.1.3 For structural products that conform to the requirements of 10.2, the letter *F* and the applicable zone number (1, 2, or 3) shall follow the grade designation.

15. Keywords

15.1 alloy; atmospheric corrosion resistance; bars; bridges; carbon; fracture-critical; high-strength; low-alloy; non-fracture critical; plates; quenched; shapes; steel; structural steel; tempered

SUPPLEMENTARY REQUIREMENTS

Supplementary requirements shall not apply unless specified in the purchase order or contract. Standardized supplementary requirements for use at the option of the purchaser are listed in Specification **A6/A6M**. Those that are considered suitable for use with this specification are listed by title:

S8. Ultrasonic Examination

S5.1 Refer to S8 of Specification **A6/A6M**.

S32. Single Heat Bundles

S32.1 Bundles containing shapes or bars shall be from a single heat of steel.

S60. Frequency of Tension Tests

S60.1 Tension testing that is additional to the tension testing required by Specification **A6/A6M** shall be made, as follows:

S60.1.1 *Plate*—One tension test shall be made using a test specimen taken from each as-rolled or as-heat treated plate.

S60.1.2 *Structural Shapes*—One tension test shall be made using a test specimen taken from each 5 tons [5 Mg] of material produced on the same mill of the same nominal size, excluding length, from each heat of steel. For single pieces that weigh more than 5 tons [5 Mg] individually, each piece shall be

tested. If shapes are heat treated, one test shall be made on specimens taken from each heat of the same nominal size, excluding length, in each furnace lot.

S60.1.3 *Bars*—One tension test shall be made using a test specimen taken from each 5 tons [5 Mg] of the same heat and same diameter or thickness if the material is furnished as-rolled or is heat treated in a continuous-type furnace. For material heat treated in other than a continuous-type furnace, one test shall be taken from each heat of the same bar diameter or thickness for each furnace charge.

S92. Atmospheric Corrosion Resistance

S92.1 When specified, the material manufacturer shall supply to the purchaser evidence of atmospheric corrosion resistance satisfactory to the purchaser.

S92.2 Refer to S23 of Specification **A6/A6M** (applicable only to Grades 36 [250] and 50 [345]).

ADDITIONAL SUPPLEMENTARY REQUIREMENTS

Standardized supplementary requirements for use at the option of the purchaser are listed in Specification **A6/A6M** as follows:

S18. Maximum Tensile Strength (Grades 50 [345], 50S [345S], 50W [345W], and HPS 50W [HPS 345W])

SUMMARY OF CHANGES

Committee A01 has identified the location of selected changes to this standard since the last issue (A709/A709M – 18) that may impact the use of this standard. (Approved Nov. 1, 2021.)

(1) Revised **Table 3**, Table Footnote B, to remove the language “The manganese to carbon ratio shall not be less than 2 to 1.”

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