



Designation: A709/A709M – 18

# Standard Specification for Structural Steel for Bridges<sup>1</sup>

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 ( $\epsilon$ ) 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:<sup>2</sup>

- [A6/A6M Specification for General Requirements for Rolled Structural Steel Bars, Plates, Shapes, and Sheet Piling](#)
- [A36/A36M Specification for Carbon Structural Steel](#)

<sup>1</sup> This specification is under the jurisdiction of ASTM Committee A01 on Steel, Stainless Steel and Related Alloys and is the direct responsibility of Subcommittee A01.02 on Structural Steel for Bridges, Buildings, Rolling Stock and Ships.

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<sup>2</sup> For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

\*A Summary of Changes section appears at the end of this standard

**TABLE 1 Tensile and Hardness Requirements<sup>A</sup>**

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, <sup>B</sup> ksi [MPa] | Tensile Strength, ksi [MPa]     | Minimum Elongation, %        |                 |                     |                 | Reduction of Area <sup>C,D</sup> min, % |
|-----------------------------------|---|--|---|---------------------------------|------------------------------|-----------------|---------------------|-----------------|---|
|                                   |   |  |   |                                 | Plates and Bars <sup>C</sup> |                 | Shapes <sup>E</sup> |                 |   |
|                                   |   |  |   |                                 | 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 over 3 in. [75 mm]          | 36 [250] min<br>36 [250] min                          | 58–80 [400–550]<br>58 [400] min | 20<br>...                    | 23<br>...       | 20<br>20            | 21<br>19        | ...<br>...                              |
| 50 [345]                          | to 4 [100], incl                            | all  | 50 [345] min  | 65 [450] min                    | 18                           | 21              | 18                  | 21 <sup>F</sup> | ...                                     |
| QST 50 [QST 345]                  | <sup>G</sup>                                | all  | 50 [345] min  | 65 [450] min                    | ...                          | ...             | 18                  | 21 <sup>F</sup> | ...                                     |
| 50S [345S]                        | <sup>G</sup>                                | all  | 50–65 [345–450] <sup>H,I</sup>                        | 65 [450] <sup>H</sup> min       | ...                          | ...             | 18                  | 21              | ...                                     |
| QST 50S [QST 345S]                | <sup>G</sup>                                | 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 <sup>J</sup> | ...                                     |
| 50CR [345CR]                      | to 2 [50], incl                             | <sup>G</sup>                                       | 50 [345] min  | 70 [485] min                    | 18                           | 21              | ...                 | ...             | ...                                     |
| QST 65 [QST 450]                  | <sup>G</sup>                                | all  | 65 [450] min  | 80 [550] min                    | ...                          | ...             | 15                  | 17              | ...                                     |
| QST 70 [QST 485]                  | <sup>G</sup>                                | all  | 70 [485] min  | 90 [620] min                    | ...                          | ...             | 14                  | 16              | ...                                     |
| HPS 70W [HPS 485 W]               | to 4 [100], incl                            | <sup>G</sup>                                       | 70 [485] min <sup>B</sup>                             | 85–110 [585–760]                | ...                          | 19 <sup>K</sup> | ...                 | ...             | ...                                     |
| HPS 100W [HPS 690W]               | to 2½ [65], incl                            | <sup>G</sup>                                       | 100 [690] min <sup>B</sup>                            | 110–130 [760–895]               | ...                          | 18 <sup>K</sup> | ...                 | ...             | L                                       |
|                                   | over 2½ to 4 [65 to 100], incl <sup>M</sup> | <sup>G</sup>                                       | 90 [620] min <sup>B</sup>                             | 100–130 [690–895]               | ...                          | 16 <sup>K</sup> | ...                 | ...             | L                                       |

<sup>A</sup> See specimen orientation and preparation subsection in the Tension Tests section of Specification A6/A6M.

<sup>B</sup> Measured at 0.2 % offset or 0.5 % extension under load as described in Section 13 of Test Methods A370.

<sup>C</sup> Elongation and reduction of area not required to be determined for floor plates.

<sup>D</sup> For plates wider than 24 in. [600 mm], the reduction of area requirement, where applicable, is reduced by five percentage points.

<sup>E</sup> 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.

<sup>F</sup> Elongation in 2 in. or 50 mm: 19 % for shapes with flange thickness over 3 in. [75 mm].

<sup>G</sup> Not applicable.

<sup>H</sup> 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.

<sup>I</sup> A maximum yield strength of 70 ksi [480 MPa] is permitted for structural shapes that are required to be tested from the web location.

<sup>J</sup> For wide flange shapes with flange thickness over 3 in. [75 mm], elongation in 2 in. or 50 mm of 18 % minimum applies.

<sup>K</sup> 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.

<sup>L</sup> 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.

<sup>M</sup> 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 <sup>A</sup> All | Plates >15 in. [380 mm] Width <sup>B</sup> |                               |                                |                                | Bars, Plates ≤15 in. [380 mm] Width <sup>B</sup> |                               |                                |
|---|-------------------------|--|-------------------------------|--------------------------------|--------------------------------|--|-------------------------------|--------------------------------|
|   |                         | 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                           |

<sup>A</sup> 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].

<sup>B</sup> 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<sup>A</sup> (Heat Analysis)**

| Maximum Diameter, Thickness, or Distance Between Parallel Faces, in. [mm] | Carbon, max, % | Manganese, <sup>B</sup> max, % | Phosphorus, <sup>C</sup> max, % | Sulfur, <sup>C</sup> max, % | Silicon <sup>D</sup>  |   | Columbium (Niobium), <sup>E</sup> 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  |

<sup>A</sup> Copper when specified shall have a minimum content of 0.20 % by heat analysis (0.18 % by product analysis).

<sup>B</sup> 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. 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 %.

<sup>C</sup> 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]

<sup>D</sup> Silicon content in excess of 0.40 % by heat analysis must be negotiated.

<sup>E</sup> Columbium and niobium are interchangeable names for the same element.

**TABLE 4 Grade 50 [345] Alloy Content**

| Type <sup>A</sup> | Elements                                       | Heat Analysis, %        |
|-------------------|--|-------------------------|
| 1                 | Columbium (niobium) <sup>B</sup>               | 0.005–0.05 <sup>C</sup> |
| 2                 | Vanadium                                       | 0.01–0.15 <sup>D</sup>  |
| 3                 | Columbium (niobium) <sup>B</sup>               | 0.005–0.05 <sup>C</sup> |
|                   | Vanadium                                       | 0.01–0.15 <sup>D</sup>  |
|                   | Columbium (niobium) <sup>B</sup> plus vanadium | 0.02–0.15 <sup>E</sup>  |

<sup>A</sup> 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.

<sup>B</sup> Columbium and niobium are interchangeable names for the same element.

<sup>C</sup> Product analysis limits = 0.004 to 0.06 %.

<sup>D</sup> Product analysis limits = 0.005 to 0.17 %.

<sup>E</sup> 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*—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.

**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, % <sup>A</sup> |           |
|-------------------------|-----------------------------|-----------|
|                         | Type A                      | Type B    |
| Carbon <sup>B</sup>     | 0.19 max                    | 0.20 max  |
| Manganese <sup>B</sup>  | 0.80–1.25                   | 0.75–1.35 |
| Phosphorus <sup>C</sup> | 0.030 max                   | 0.030 max |
| Sulfur <sup>C</sup>     | 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 |

<sup>A</sup> Weldability data for these types have been qualified by FHWA for use in bridge construction.

<sup>B</sup> 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 %.

<sup>C</sup> 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 <sup>A</sup>              | 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) <sup>B</sup> | . . .   | 0.01–0.03                 |
| Aluminum                         | 0.010–0.040                                   | 0.020–0.050               |
| Nitrogen                         | 0.015 max                                     | 0.015 max                 |

<sup>A</sup> The steel shall be calcium treated for sulfide shape control.

<sup>B</sup> Columbium and niobium are interchangeable names for the same element.

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.

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

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

<sup>A</sup> 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 %.

<sup>B</sup> The sum of columbium (niobium) and vanadium shall not exceed 0.15 %.

<sup>C</sup> 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) <sup>A</sup> | 0.05  | 0.05                   | 0.05                    |
| Vanadium                         | 0.06  | 0.08                   | 0.09                    |

<sup>A</sup> 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. 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 10).

#### 5. General Requirements for Delivery

5.1 Structural products furnished under this specification shall conform to the requirements of the current edition of