



Designation: A606/A606M – 23

# Standard Specification for Steel, Sheet and Strip, High-Strength, Low-Alloy, Hot-Rolled and Cold-Rolled, with Improved Atmospheric Corrosion Resistance<sup>1</sup>

This standard is issued under the fixed designation A606/A606M; 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 reappraisal. A superscript epsilon ( $\epsilon$ ) indicates an editorial change since the last revision or reappraisal.

*This standard has been approved for use by agencies of the U.S. Department of Defense.*

## 1. Scope\*

1.1 This specification covers high-strength, low-alloy, cold-rolled sheet and strip in cut lengths or coils, hot-rolled sheet and strip steel in cut lengths or coils with ordered thickness less than 0.230 in. [6.0 mm], and hot-rolled sheet coils (not cut lengths) with ordered thickness 0.230 in. [6.0 mm] and thicker, intended for use in structural and miscellaneous purposes, where savings in weight or added durability are important. These steels have enhanced atmospheric corrosion resistance and are supplied in three types or as commercial steel (CS). Type 2 contains 0.20 % minimum copper based on cast or heat analysis (0.18 % minimum Cu for product check). Type 4 and Type 5 contain additional alloying elements and provide a level of corrosion resistance substantially better than that of carbon steels with or without copper addition (Note 1). When properly exposed to the atmosphere, Type 4 and Type 5 steels can be used in the bare (unpainted) condition for many applications. CS is intended for applications that require enhanced atmospheric corrosion resistance which do not require a specified strength. CS shall contain the chemical requirements of Type 2, Type 4, or Type 5. CS as contained within this specification is not associated with the requirements of CS that are referenced in other Subcommittee A01.19 on Steel Sheet and Strip specifications.

NOTE 1—For methods of establishing the atmospheric corrosion resistance of low-alloy steels, see Guide G101.

1.2 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.

<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 A01.19 on Steel Sheet and Strip.

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1.3 *Welding*—In general, the steels listed in this specification are weldable with commonly obtained welding electrodes. When the steel is to be welded, a suitable welding procedure based on its composition should be used, taking into account intended use and service temperatures.

NOTE 2—For a general discussion of the weldability of steel and carbon equivalents, consult Appendix X3 of A6/A6M.

1.4 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.5 *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
- A109/A109M Specification for Steel, Strip, Carbon (0.25 Maximum Percent), Cold-Rolled
- A370 Test Methods and Definitions for Mechanical Testing of Steel Products
- A568/A568M Specification for Steel, Sheet, Carbon, Structural, and High-Strength, Low-Alloy, Hot-Rolled and Cold-Rolled, General Requirements for
- A635/A635M Specification for Steel, Sheet and Strip, Heavy-Thickness Coils, Hot-Rolled, Alloy, Carbon, Structural, High-Strength Low-Alloy, and High-Strength Low-Alloy with Improved Formability, General Requirements for

<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

**A749/A749M** Specification for Steel, Strip, Carbon and High-Strength, Low-Alloy, Hot-Rolled, General Requirements for  
**G101** Guide for Estimating the Atmospheric Corrosion Resistance of Low-Alloy Steels

### 3. General Requirements for Delivery

3.1 Cold-rolled sheet furnished under this specification shall conform to the applicable general requirements of the current edition of Specification **A568/A568M** and cold rolled strip shall conform to the dimensional tolerance tables of the current edition of Specification **A109/A109M**, unless otherwise provided herein.

3.2 Hot-rolled sheet furnished under this specification shall conform to the applicable general requirements of the current edition of Specifications **A568/A568M** and **A635/A635M**, and hot-rolled strip shall conform to the dimensional requirements of the current edition of Specification **A749/A749M**, unless otherwise provided herein.

### 4. Ordering Information

4.1 Orders for material under this specification shall include the following information, as required, to describe adequately the desired material:

4.1.1 ASTM specification number and date of issue, and type,

4.1.2 Name of material (high-strength low-alloy hot-rolled sheet or strip or high-strength low-alloy cold-rolled sheet or strip),

4.1.2.1 Hot-rolled sheet shall either be CS or Grade 50 (Grade 50 shall be supplied if not specified).

4.1.2.2 Cold-rolled sheet shall either be CS or Grade 45 (Grade 45 shall be supplied if not specified).

4.1.3 Condition (specify oiled or dry, as required),

4.1.4 Edges (must be specified for hot-rolled sheet or strip) (see 8.1),

4.1.5 Finish—Cold-rolled only (indicate exposed (E) or unexposed (U). Matte (dull) finish will be supplied unless otherwise specified), and

4.1.6 Dimensions (thickness, width, and whether cut lengths or coils).

NOTE 3—Not all producers are capable of meeting all of the limitations of the thickness tolerance tables in Specification **A568/A568M**. The purchaser should contact the producer regarding possible limitations prior to placing an order.

4.2 The purchaser has the option to specify additional requirements, including but are not limited, to the following:

4.2.1 Coil size (must include inside diameter, outside diameter, and maximum weight),

4.2.2 Application (show part identification and description),

4.2.3 Cast or heat (formerly ladle) analysis and mechanical properties report (if required) (see 10.1), and

4.2.4 When the purchaser requires thickness tolerances for  $\frac{3}{8}$  in. [10 mm] minimum edge distance (see Supplementary Requirement in Specifications **A568/A568M** and **A635/A635M**), this requirement shall be specified in the purchase order or contract.

4.2.5 Impact toughness requirements at a specified test temperature, if required.

4.2.6 Other special requirements, if any.

NOTE 4—A typical ordering description is as follows: “ASTM A606–XX, Grade 50, Type 4 high-strength low-alloy hot-rolled sheet, dry, mill edge 0.106 by 48 by 96 in. for truck frame side members.” Or, “ASTM A606M–XX, Grade 345, Type 5 high-strength low-alloy hot-rolled sheet, dry, mill edge, 2.7 mm by 1220 mm by coil for truck frame side members.”

### 5. Materials and Manufacture

5.1 *Condition*—The material shall be furnished hot-rolled or cold-rolled as specified on the purchase order.

5.2 *Heat Treatment*—Unless otherwise specified, Type 2 and Type 4 steels shall be furnished as hot-rolled. When hot-rolled annealed or hot-rolled normalized material is required, it shall be specified on the purchase order.

5.2.1 For Type 5, although the recommended maximum hot rolling temperature is 2100 °F [1150 °C], the actual temperature selected is at the discretion of the producer.

5.2.2 Type 5 is normalized by heating to 1600 to 1700 °F [870 to 925 °C] and then cooled in still air. The yield strength of Type 5 is increased by precipitation hardening at 1000 to 1050 °F [535 to 565 °C] for 20 to 60 min, depending on the amount of strength increase desired by the producer.

### 6. Chemical Composition

6.1 The maximum limits of carbon, manganese, and sulfur shall be as prescribed in **Table 1**, unless otherwise agreed upon between the manufacturer and the purchaser.

6.2 The manufacturer shall use alloying elements, such as chromium, nickel, copper, and phosphorus, combined with the carbon, manganese, and sulfur within the limits prescribed in

**TABLE 1 Chemical Requirements**

Type of A606 Steel	Composition, max, %; ranges and minimum excepted	
	Cast or Heat (Formerly Ladle) Analysis	Product Check, or Verification Analysis
Type 2 and Type 4 <sup>B</sup>		
Carbon <sup>A</sup>	0.22	0.26
Manganese	1.25	1.30
Sulfur	0.04	0.06
Copper	0.20 min	0.18 min
Type 5		
Carbon	0.09	0.12
Manganese	0.70–0.95	0.66–1.00
Phosphorus	0.025	0.030
Sulfur	0.010	0.015
Silicon	0.40	0.45
Nickel	0.52–0.76	0.50–0.79
Chromium	0.30	0.34
Copper	0.65–0.98	0.63–1.00
Titanium	0.15	0.16
Vanadium	0.15	0.16
Niobium	0.08	0.09

<sup>A</sup> For compositions with a maximum carbon content of 0.15 % on heat or cast analysis, the maximum limit for manganese on heat or cast analysis may be increased to 1.40 % (with product analysis limits of 0.19 % carbon and 1.45 % manganese).

<sup>B</sup> The addition of other alloying elements to obtain the required atmospheric corrosion resistance is at the discretion of the manufacturer for Type 4.

**Table 1** to satisfy the mechanical properties prescribed in **Table 2** or **Table 3**. As indicated in **1.1**, these steels have enhanced atmospheric corrosion resistance and are supplied as: Type 2, Type 4, Type 5, and CS. When requested, the producer shall supply acceptable evidence of corrosion resistance to the purchaser.

6.2.1 For Type 2 steel, confirmation of the minimum copper content requirement of **1.1** shall be sufficient evidence of corrosion resistance.

6.2.2 For Type 4 and Type 5 steels, the basis for this evidence can be a corrosion-resistance index calculated from the chemical composition of the steel in accordance with Guide **G101**. To comply with Specification A606, Type 4 or Type 5 steel shall have a minimum corrosion-resistance index of 6.0, based upon Guide **G101** (see **Note 5**).

**NOTE 5**—The user is cautioned that the Guide **G101** predictive equation for calculation of an atmospheric corrosion index has been verified only for the composition limits stated in that guide. The composition of Type 4 or Type 5 steels determines which calculation procedure (Larabee-Coburn or Townsend methods) should be used to obtain a minimum index of 6.0 in accordance with Guide **G101**. The Larabee-Coburn equation of 6.3.1.1 limits the amount of copper to 0.51 % max. Type 5 steels exceed this limit and some Type 4 compositions may contain more than 0.51 % copper, requiring use of the Townsend method of Section 6.3.2.

6.2.3 Material ordered as CS shall conform to the chemical requirements specified in **Table 1** for Type 2, Type 4, or Type 5, at the producer's option unless specified otherwise by the purchaser. Sufficient evidence of corrosion-resistance is based on the stated requirements of **6.2.1** or **6.2.2** for the comparable chemistry specified in **Table 1**.

6.3 When the steel is used in welded applications, welding procedure shall be suitable for the steel chemistry as described in **6.2** and the intended service.

## 7. Mechanical Property Requirements

7.1 Material ordered as CS has no mechanical properties requirements. Specific requirements may be added if agreed upon between the purchaser and the producer.

### 7.2 Tension Tests:

7.2.1 *Requirements*—Material ordered to either Grade 50 as hot rolled or Grade 45 as cold rolled shall conform to the tensile requirements specified in **Table 2** (hot-rolled material) or in **Table 3** (cold-rolled material).

7.2.2 *Number of Tests*—Two tensile tests shall be made from each heat or from each lot of 50 tons [45 000 kg]. When the amount of finished material from a heat or lot is less than 50 tons [45 000 kg], one test shall be made. When material rolled from one heat differs 0.050 in. [1.27 mm] or more in thickness,

**TABLE 2 Tensile Requirements<sup>A</sup> for Hot-Rolled Grade 50 Material**

	As-Rolled	Annealed or Normalized
Tensile strength, min ksi (MPa)	70 [480]	65 [450]
Yield strength, min, ksi (MPa)	50 [340]	45 [310]
Elongation in 2 in. or 50 mm, min %	22	22

<sup>A</sup> For coil products, testing by the producer is limited to the end of the coil. Mechanical properties throughout the coil shall comply with the minimum values specified.

**TABLE 3 Tensile Requirements for Cold-Rolled Grade 45 Material**

	Cut Lengths and Coils
Tensile strength, min, ksi (MPa)	65 [450]
Yield strength, min, ksi (MPa)	45 [310]
Elongation in 2 in. or 50 mm, min, %	22 <sup>A</sup>

<sup>A</sup> 0.0448 in. [1.1 mm] and under in thickness—20 %.

one tensile test shall be made from the thickest and thinnest material regardless of the weight represented.

### 7.2.3 Location and Orientation:

7.2.3.1 Tensile test specimens shall be taken at a point immediately adjacent to the material to be qualified.

7.2.3.2 Tensile test samples shall be taken from the full thickness of the sheet as rolled.

7.2.3.3 Tensile test specimens shall be taken from a location approximately halfway between the center of the sheet and the edge of the material as rolled.

7.2.3.4 Tensile test specimens for cold-rolled sheet and strip, and hot-rolled strip shall be taken with the axis of the test specimen parallel to the rolling direction (longitudinal test).

7.2.3.5 Tensile test specimens for hot-rolled sheet with ordered thickness less than 0.230 in. [6.0 mm] shall be taken with the axis of the test specimen parallel to the rolling direction (longitudinal test) and ordered thickness 0.230 in. [6.0 mm] and thicker shall be taken with the axis of the test specimen perpendicular to the rolling direction (transverse test).

7.2.4 *Test Method*—Yield strength shall be determined by either the 0.2 % offset method or by the 0.5 % extension under load method unless otherwise specified.

7.3 *Bending Properties*—The minimum forming radius (radii) that steel covered by this specification can be expected to sustain is listed in the **Appendix X1** and is discussed in more detail in Specifications **A568/A568M** and **A749/A749M**. Where tighter bend radii are required, where curved or offset bends are involved, or where stretching or drawing are also a consideration, the producers should be consulted.

7.4 *Charpy V-notch Impact Properties*—The purchaser has the option to require minimum Charpy V-notch impact properties of 15 ft-lbs [20 J] or more at a specified test temperature, based on a full size test specimen of 0.3937 in [10 mm] thickness. Typically the test temperature is the lowest anticipated service temperature of the application. The minimum thickness permitted in accordance with Table 9 of Test Methods **A370** for a subsize Charpy V-notch specimen is 0.100 in [2.5 mm].

## 8. Edges, Oiling, Surface Finish, and Appearance

### 8.1 Edges:

8.1.1 *Hot-Rolled*—In the as-rolled condition the material has mill edges. Pickled or blast-cleaned material has cut edges. When required, as-rolled material may be specified to have cut edges. If mill edge material is required it must be specified.

8.1.2 *Cold-Rolled*—Cold-rolled material shall have cut edges only.