



Designation: A606/A606M – 18

Standard Specification for Steel, Sheet and Strip, High-Strength, Low-Alloy, Hot-Rolled and Cold-Rolled, with Improved Atmospheric Corrosion Resistance¹

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 (ϵ) 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, hot- and cold-rolled sheet and strip in cut lengths or coils, 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: 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 contains additional alloying elements and provides 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.

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.

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 international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the*

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 A01.19 on Steel Sheet and Strip.

Current edition approved March 1, 2018. Published March 2018. Originally approved in 1970. Last previous edition approved in 2015 as A606/A606M – 15. DOI: 10.1520/A0606_A0606M-18.

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

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

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 Material furnished under this specification shall conform to the applicable requirements of the current edition of Specification A568/A568M and the dimensional tolerance tables of Specification A109/A109M, 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,

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

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 3/8 in. [10 mm] minimum edge distance (see Supplementary Requirement in Specification A568/A568M), 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 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 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 in three types: Type 2, Type 4, and Type 5. 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.

6.3 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.

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 ^B		
Carbon ^A	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

^A 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).

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

TABLE 2 Tensile Requirements^A 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

^A 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 ^A

^A 0.0448 in. [1.1 mm] and under in thickness—20 %.

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, 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 shall be taken with the axis of the test specimen parallel to the rolling direction (longitudinal 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.

8.2 Oiling:

8.2.1 *Hot-Rolled*—Unless otherwise specified, hot-rolled as-rolled material shall be furnished dry, and hot-rolled pickled or blast-cleaned material shall be furnished oiled. When required, pickled or blast-cleaned material may be specified to be furnished dry, and as-rolled material may be specified to be furnished oiled.

8.2.2 *Cold-Rolled*—Unless otherwise specified, cold-rolled material shall be oiled. When required, cold-rolled material may be specified to be furnished dry, but is not recommended due to the increased possibility of rusting.

8.3 Surface Finish:

8.3.1 *Hot-Rolled*—Unless otherwise specified, hot-rolled material shall have an as-rolled, not pickled surface finish. When required, material may be specified to be pickled or blast-cleaned.

8.3.2 *Cold-Rolled*—Unless otherwise specified, cold-rolled material shall have a matte (dull) finish.

9. Retests and Disposition of Non-Conforming Material

9.1 Retests, conducted in accordance with the requirements of Section 11.1 of Specification **A568/A568M**, are permitted when an unsatisfactory test result is suspected to be the consequence of the test method procedure.

9.2 Disposition of non-conforming material shall be subject to the requirements of Section 11.2 of Specification **A568/A568M**.

10. Certification

10.1 When requested, the manufacturer shall furnish copies of a test report showing the results of the heat or cast analysis and mechanical property tests made to determine compliance with this specification. The report shall include the purchase order number, the ASTM designation number, and the heat or lot number correlating the test results with the material represented.

10.1.1 The heat or cast analysis shall include reporting the elements listed in **6.1** and reporting the following elements.

10.1.1.1 Copper, chromium, nickel, phosphorous, niobium, vanadium, titanium, molybdenum, sulphur, nitrogen, manganese, and carbon.

10.1.1.2 For niobium, titanium, vanadium; if less than 0.008 wt % they may be reported as <0.008 wt %.

10.1.1.3 Other elements as agreed upon between purchaser and producer.

NOTE 6—Niobium and columbium are alternate names for element 41 in the periodic table of the elements.

11. Keywords

11.1 alloy steel sheet; alloy steel strip; cold rolled steel sheet; cold rolled steel strip; high strength low alloy steel; hot rolled steel sheet; hot rolled steel strip; steel sheet; steel strip

APPENDIX

(Nonmandatory Information)

XI. BENDING PROPERTIES

TABLE X1.1 Suggested Minimum Inside Radius for Cold Bending^A

NOTE 1—(*t*) equals a radius equivalent to the steel thickness.

NOTE 2—The suggested radii should be used as minimums for 90° bends in actual shop practice.

Grade	Minimum Inside Radius for Cold Bending
Hot Rolled or Cold Rolled	$2\frac{1}{2} t$

^A Material which does not perform satisfactorily, when fabricated in accordance with the above requirements, may be subject to rejection pending negotiation with the steel supplier.

SUMMARY OF CHANGES

Committee A01 has identified the location of selected changes to this standard since the last issue (A606/A606M – 15) that may impact the use of this standard. (Approved March 1, 2018.)

- | | |
|--|---|
| <ul style="list-style-type: none"> (1) Added Type 5 steel and welding references to Section 1. (2) Added new references to A6/A6M and AWS D1.1 in Section 2. (3) Added impact toughness option in Section 4. (4) Added hot rolling, normalizing and precipitation hardening requirements for Type 5 in Section 5. | <ul style="list-style-type: none"> (5) Revised chemical composition table for Type 4 and Type 5 steels in Section 6. (6) Added impact toughness provision option for purchaser in Section 7. (7) Revised title of Section 8 which reflects actual product requirements of edging and oiling. |
|--|---|

Committee A01 has identified the location of selected changes to this standard since the last issue (A606/A606M – 09a) that may impact the use of this standard. (Approved Nov. 1, 2015.)

- | | |
|---|--|
| <ul style="list-style-type: none"> (1) Revised Sections 4 and 7 to add CS (no mandatory mechanical properties) class of material. (2) Revised Section 10 (updated for reporting of composition). | <ul style="list-style-type: none"> (3) Revised Section 6 to remove references to a specific method in Guide G101. |
|---|--|

ASTM International takes no position respecting the validity of any patent rights asserted in connection with any item mentioned in this standard. Users of this standard are expressly advised that determination of the validity of any such patent rights, and the risk of infringement of such rights, are entirely their own responsibility.

This standard is subject to revision at any time by the responsible technical committee and must be reviewed every five years and if not revised, either reapproved or withdrawn. Your comments are invited either for revision of this standard or for additional standards and should be addressed to ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee, which you may attend. If you feel that your comments have not received a fair hearing you should make your views known to the ASTM Committee on Standards, at the address shown below.

This standard is copyrighted by ASTM International, 100 Barr Harbor Drive, PO Box C700, West Conshohocken, PA 19428-2959, United States. Individual reprints (single or multiple copies) of this standard may be obtained by contacting ASTM at the above address or at 610-832-9585 (phone), 610-832-9555 (fax), or service@astm.org (e-mail); or through the ASTM website (www.astm.org). Permission rights to photocopy the standard may also be secured from the Copyright Clearance Center, 222 Rosewood Drive, Danvers, MA 01923, Tel: (978) 646-2600; http://www.copyright.com/