



Designation: A 935/A 935M – 97a

Standard Specification for Steel, Sheet and Strip, Heavy Thickness Coils, High Strength, Low-Alloy, Columbium or Vanadium, or Both, Hot- Rolled¹

This standard is issued under the fixed designation A 935/A 935M; 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 hot-rolled, heavy-thickness, high-strength, low-alloy columbium, or vanadium hot-rolled sheet and strip, or combinations thereof, in coils beyond the size limits of Specification A 607. This material is intended for miscellaneous applications where greater strength and savings in weight are important. The material is available as two classes. They are similar in strength level, except that Class 2 offers improved weldability and more formability than Class 1. Atmospheric corrosion resistance of these steels is equivalent to plain carbon steels. With copper specified, the atmospheric corrosion resistance is somewhat enhanced.

NOTE 1—For methods of establishing the atmospheric corrosion resistance of low-alloy steels see Guide G 101.

1.1.1 This material is available only in coils described as follows:

Size Limits, Coils Only

Product	Width, in. (mm)	Thickness, in. (mm)
Strip	Over 8 to 12 incl (Over 200 to 300)	0.230 to 1.000 incl (Over 6.0 to 25)
Sheet	Over 12 to 48 incl (Over 300 to 1200)	0.230 to 1.000 incl (Over 6.0 to 25)
	Over 48 (Over 1200)	0.180 to 1.000 incl (Over 4.5 to 25)

1.2 Sheet and strip in coils of sizes noted in 1.1 can be included in this specification only with the following:

1.2.1 The material is not to be converted into steel plates for structural or pressure vessel use unless tested in complete accordance with the appropriate section of Specifications A 6/A 6M (plates provided from coils) or A 20/A 20M (plates produced from coils).

1.2.2 This specification is not applicable to the steels covered by Specification A 635/A 635M.

1.2.3 The dimensional tolerances of Specification A 635/A 635M are applicable to material produced to this specification.

1.2.4 The material is to be fed directly from coils into a blanking press, drawing or forming operation, tube mill, rolling mill, or sheared or slit into blanks for subsequent drawing or forming.

1.2.5 Not all strength levels are available in all thicknesses. The user should consult the producer for appropriate size limitations.

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

2. Referenced Documents

2.1 ASTM Standards:

A 370 Test Methods and Definitions for Mechanical Testing of Steel Products²

A 607 Specification for Steel, Sheet and Strip, High-Strength, Low-Alloy, Columbium or Vanadium, or Both, Hot-Rolled and Cold-Rolled²

A 635/A 635M Specification for Steel, Sheet and Strip, Heavy-Thickness Coils, Carbon, Hot-Rolled²

A 751 Test Methods, Practices, and Terminology for Chemical Analysis of Steel Products²

E 29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications³

G 101 Guide for Estimating the Atmospheric Corrosion on Resistance of Low-Alloy Steels⁴

3. Ordering Information

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

3.1.1 ASTM specification number and year of issue, grade, type and class. When a type is not specified, choice of type will be made by the producer. When a class is not specified, Class 1 will be furnished.

¹ This specification is under the jurisdiction of ASTM Committee A-1 on Steel, Stainless Steel, and Related Alloys and is under the direct responsibility of Subcommittee A01.19 on Steel Sheet and Strip.

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² Annual Book of ASTM Standards, Vol 01.03.

³ Annual Book of ASTM Standards, Vol 14.02.

⁴ Annual Book of ASTM Standards, Vol 03.02.

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3.1.2 Name of material (high-strength, low-alloy hot-rolled sheet coils or high-strength, low-alloy hot-rolled strip coils).

3.1.3 Copper-bearing (if required).

3.1.4 *Condition*—Material in accordance with this specification is furnished in the hot-rolled condition. Pickled (or blast-cleaned) must be specified if required. Material ordered as pickled (or blast-cleaned) will be oiled unless ordered dry.

3.1.5 Type of edge must be specified for hot-rolled sheet coils and strip coils, mill edge or cut edge (sheet), mill edge or slit edge (strip).

3.1.6 Dimensions (decimal thickness and width of material).

3.1.6.1 As agreed upon between the purchaser and the producer, material ordered to this specification will be supplied to meet the appropriate standard or restricted thickness tolerance table shown in Specification A 635/A 635M.

NOTE 2—Not all producers are capable of meeting all the limitations of the thickness tolerance tables in Specification A 635/A 635M. The purchaser should contact the producer regarding possible limitations prior to placing an order.

3.1.7 Coil size and weight requirements (must include inside diameter (ID), outside diameter (OD), and maximum weight).

3.1.8 Quantity (weight).

3.1.9 Application (part identification and description).

3.1.10 Special requirements (if required) or Supplementary Requirements S1.

3.1.11 Cast or heat analysis.

3.1.12 Test reports.

NOTE 3—A typical ordering description is as follows: (Inch-Pound) ASTM A 935/A 935M—XX: Grade 45, Type 2, Class 2, high-strength, low-alloy hot-rolled sheet coils, pickled and oiled, cut edge, 0.500 by 40 in. by coil; ID 24 in., OD 72 in., maximum; coil weight 40 000 lbs maximum; 200 000 lb for roll-forming shapes; (SI) ASTM A 935/A 935M—XX: Grade 310, Type 2, Class 2, high-strength, low-alloy hot-rolled sheet coils, pickled and oiled, cut edge, 10 mm by 900 mm by coil; ID 600 mm, OD 1800 mm, maximum; coil weight 18 000 kg maximum; 90 000 kg for roll-forming shapes.

4. Chemical Composition

4.1 The cast or heat analysis and product analysis of the

steel shall conform to the requirements in accordance with Table 1. Chemical analysis shall be conducted in accordance with Test Methods A 751.

4.1.1 Residual elements may be present. Limits on these elements shall be as stated in Table 2.

4.1.1.1 Each of the elements listed in Table 2 shall be included in the report of the heat analysis. When the amount of copper, nickel, chromium, or molybdenum is less than 0.02 %, these elements may be reported as <0.02 %.

4.2 When the steel is used in welded applications, welding procedure shall be suitable for the steel chemistry and the intended service.

4.3 When a class is not specified, Class 1 will be furnished.

4.4 The enhancement of corrosion resistance by copper additions may be based on a corrosion index calculated using the chemical composition of the steel in accordance with Guide G 101.

5. Mechanical Properties

5.1 Test specimen preparation and mechanical testing shall be in accordance with Test Methods A 370.

5.2 *Tensile Properties*—The material as represented by the test specimens shall conform to the requirements as to tensile properties in accordance with Table 3.

5.3 *Tension Test Specimen Location and Orientation*—The test shall be taken approximately midway between the center and edge of the material as rolled. The longitudinal axis of the tension test specimens shall be perpendicular to the direction of rolling (transverse test).

5.4 *Tension Tests*—Two tension tests shall be made from each heat or from each lot of 50 tons (45 Mg). When the amount of finished material from a heat or lot is less than 50 tons (45 Mg), only one tension test shall be made. When material rolled from one heat differs 0.050 in. (1.3 mm) or more in thickness, one tension test shall be made from both the thickest and the thinnest material rolled regardless of the weight represented.

5.5 To determine conformance with the product specification, a calculated value should be rounded to the nearest 1 Ksi (7 MPa) tensile strength and yield point, and to the nearest unit

TABLE 1 Chemical Requirements^A
Composition, %

NOTE 1—Class 2 requirements for manganese, phosphorus, sulfur, columbium, and vanadium are the same as shown for Class 1.

NOTE 2—An ellipsis (. . .) indicates that no limits have been set for that element.

Element	Grade 45		Grade 50		Grade 55		Grade 60		Grade 65		Grade 70	
	Heat or Cast Analysis	Product Analysis	Heat or Cast Analysis	Product Analysis	Heat or Cast Analysis	Product Analysis	Heat or Cast Analysis	Product Analysis	Heat or Cast Analysis	Product Analysis	Heat or Cast Analysis	Product Analysis
Class 1												
Carbon, max	0.22	0.26	0.23	0.27	0.25	0.29	0.26	0.30	0.26	0.30	0.26	0.30
Manganese, max	1.50	1.55	1.50	1.55	1.50	1.55	1.50	1.55	1.50	1.55	1.65	1.70
Phosphorus, max	0.04	0.05	0.04	0.05	0.04	0.05	0.04	0.05	0.04	0.05	0.04	0.05
Sulfur, max	0.04	0.06	0.04	0.06	0.04	0.06	0.04	0.06	0.04	0.06	0.04	0.06
Columbium or vanadium, min	Cb 0.005	0.004	Cb 0.005	0.004	Cb 0.005	0.004	Cb 0.005	0.004	Cb 0.005	0.004	Cb 0.005	0.004
Nitrogen, max	V 0.01	0.005	V 0.01	0.005	V 0.01	0.005	V 0.01	0.005	V 0.01	0.005	V 0.01	0.005
Class 2												
Carbon, max	0.15	0.18	0.15	0.18	0.15	0.18	0.15	0.18	0.15	0.18	0.15	0.18
Nitrogen, max	0.020	0.024	0.020	0.024	0.020	0.024	0.020	0.024	0.020	0.024	0.020	0.024

^A Copper, when specified, shall have a minimum content of 0.20 % by heat or cast analysis (0.18 % by product analysis).