



Standard Specification for Steel, Sheet and Strip, Heavy-Thickness Coils, Hot-Rolled, Carbon, Commercial, Drawing, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, and Ultra-High Strength¹

This standard is issued under the fixed designation A1018/A1018M; 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.

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

1. Scope

1.1 This specification covers hot-rolled, heavy-thickness coils beyond the size limits of Specification [A1011/A1011M](#).

1.2 The product is available in six designations: Commercial Steel, Drawing Steel, Structural Steel, High-Strength Low-Alloy Steel, High-Strength Low-Alloy Steel with Improved Formability, and Ultra-High Strength Steel.

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

Product	Size Limits, Coils Only	
	Width, in. [mm]	Thickness, in. [mm]
Strip	Over 8 to 12, incl [Over 200 to 300]	0.230 to 1.000, incl [From 6.0 through 25]
Sheet	Over 12 [Over 300]	0.230 to 1.000, incl [From 6.0 through 25]

NOTE 1—The changes in width limits with the publication of [A635/A635M](#) – 06a result in a change in tensile testing direction for material from 0.180 in. [4.5 mm] to 0.230 in. exclusive [6.0 mm exclusive] over 48 in. [1200 mm] wide as that material is now covered by Specification [A568/A568M](#) – 06a. The purchaser is advised to discuss this change with

the supplier.

1.4 Sheet and strip in coils of sizes noted in 1.3 are covered by this specification only with the following provisions:

1.4.1 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.

1.4.2 The material is not to be converted into steel plates for structural or pressure vessel use unless tested in complete accordance with the appropriate sections of Specifications [A6/A6M](#) (plates provided from coils) or [A20/A20M](#) (plates

produced from coils). Plate converted from coils is no longer governed by this sheet steel specification and since this material is now a plate, the requirements of the appropriate plate specification shall apply, except in cases where there is a conflict between the requirements of the plate specification and this specification. In these cases, the more restrictive limits of either specification shall apply.

1.4.3 The dimensional tolerances of Specification [A635/A635M](#) are applicable to material produced to this specification.

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

1.5 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.

2. Referenced Documents

2.1 *ASTM Standards*:²

- [A6/A6M Specification for General Requirements for Rolled Structural Steel Bars, Plates, Shapes, and Sheet Piling](#)
- [A20/A20M Specification for General Requirements for Steel Plates for Pressure Vessels](#)
- [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](#)
- [A572/A572M Specification for High-Strength Low-Alloy Columbium-Vanadium 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 [A01.19](#) on Steel Sheet and Strip.

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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

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

A751 Test Methods, Practices, and Terminology for Chemical Analysis of Steel Products

A941 Terminology Relating to Steel, Stainless Steel, Related Alloys, and Ferroalloys

A1011/A1011M Specification for Steel, Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, and Ultra-High Strength

E29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications

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

resistance of these steels is equivalent to plain carbon steels. With copper specified, the atmospheric corrosion is somewhat enhanced.

5.1.5 *High-Strength Low-Alloy Steel with Improved Formability*—(HSLAS-F Grades 50[340], 60[410], 70[480], 80[550]).

5.1.5.1 This material has improved formability when compared with HSLAS. The steel is killed and made to a fine ferritic grain practice and includes microalloying elements such as columbium, titanium, vanadium, zirconium, and so forth. The steel shall be treated to achieve inclusion control. The material is intended for miscellaneous applications where higher strength, savings in weight, improved formability, and weldability are important. Atmospheric corrosion resistance of these steels is equivalent to plain carbon steels. With copper specified, the atmospheric corrosion resistance is somewhat enhanced.

NOTE 2—For methods of establishing the atmospheric corrosion resistance of low-alloy steels, see Guide **G101**.

5.1.6 *Ultra-High Strength Steel*—(UHSS Grades 90 [620] and 100 [690], Types 1 and 2).

5.1.6.1 This material has increased strength compared with HSLAS-F. The steel is killed and made to a fine ferritic grain practice, and includes microalloying elements such as columbium (niobium), titanium, vanadium, molybdenum, and so forth. The steel shall be treated to achieve inclusion control. The material is intended for miscellaneous applications where higher strength, savings in weight, and weldability are important. Atmospheric corrosion resistance of these steels is equivalent to plain carbon steels. With copper specified, the atmospheric corrosion resistance is somewhat enhanced.

5.1.7 When required for HSLAS, HSLAS-F, and UHSS steels, limitations on the use of one or more of the microalloy elements shall be specified on the order.

5.2 The limits for copper, chromium, nickel, and molybdenum are available in two levels, Limits A and Limits B (see **Table 1**).

6. Ordering Information

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

6.1.1 ASTM specification number and year of issue.

6.1.2 Name of material and designation (hot-rolled steel sheet or hot-rolled strip) (include grade and, as appropriate, type and class for CS, DS, SS, HSLAS, HSLAS-F, and UHSS) (see **5.1**).

6.1.2.1 For CS and DS, when a type is not specified, Type B will be furnished.

6.1.2.2 For SS Grade 36, when a type is not specified, Type 1 will be furnished (see **5.1**).

6.1.2.3 For UHSS, when a type is not specified, Type 1 shall be furnished.

6.1.2.4 For HSLAS, when a class is not specified, Class 1 will be furnished (see **5.1**).

6.1.3 Copper bearing, (if required),

6.1.4 For SS, HSLAS, and HSLAS-F and selected CS steels, specify the limits for chemical requirements listed in

3. Terminology

3.1 *Definitions*—For definitions of other terms used in this specification refer to Terminology **A941**.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *inclusion control, n*—the process of reducing the volume fraction of inclusions or modifying the shape of inclusions to improve formability, weldability, and machinability.

3.2.1.1 *Discussion*—Inclusions, especially those elongated during the rolling process, create the conditions for initiating or propagating cracks, or both, when the material is stretched or bent during the manufacture of a part. The adverse effects of inclusions are minimized by reducing the content of inclusions in the steel, or by altering the shape of inclusions through the use of additions during the steelmaking process that change the elongated shape of the inclusions to less harmful small, well dispersed globular inclusions, or both.

4. General Requirements for Delivery

4.1 Material furnished under this specification shall conform to the applicable requirements of the current edition of Specification **A635/A635M**, unless otherwise provided herein.

5. Classification

5.1 Heavy thickness coils are available in the following designations:

5.1.1 *Commercial Steel (CS Types A and B, and Standard Steel Designations)*

5.1.2 *Drawing Steel (DS Types A and B, and Standard Steel Designations)*

5.1.3 *Structural Steel*—(SS Grades 30[205], 33[230], 36[250] Types 1 and 2, 40[275] and 45[310]).

5.1.4 *High-Strength Low-Alloy Steel*—(HSLAS Grades 45[310], 50[340], 55[380], 60[410], 65[450], 70[480]) in Classes 1 and 2.

5.1.4.1 This material is intended for miscellaneous applications where greater strength and savings in weight are important. The material is available in two classes. They are similar in strength level, except that Class 2 offers improved weldability and more formability than Class 1. Atmospheric corrosion

TABLE 1 Chemical Requirements: Cu, Ni, Cr and Mo for Commercial Steels, Structural Steels, High-Strength Low-Alloy Steels, and High-Strength Low-Alloy Steels with Improved Formability

Designation	Limits	% Heat Analysis, Element Maximum Unless Otherwise Shown			
		Cu ^{A,B}	Ni ^B	Cr ^{B,C}	Mo ^{B,C}
CS:	A	0.20	0.20	0.15	0.06
Grades 1015, 1016, 1017, 1018, 1019, 1020, 1021, 1022, 1023, 1524	B	0.40	0.40	0.30	0.12
SS:	A	0.20	0.20	0.15	0.06
All grades	B	0.40	0.40	0.30	0.12
HSLAS:	A	0.20	0.20	0.15	0.06
All grades and classes except for Grade 70 [480]	B	0.40	0.40	0.30	0.12
Grade 70 [480] Class 1 and Class 2	A	0.20	0.20	0.15	0.16
	B	0.40	0.40	0.30	0.16
HSLAS-F:	A	0.20	0.20	0.15	0.06
Grades 50 [340] and 60 [410]	B	0.40	0.40	0.30	0.12
Grade 70 [480] and 80 [550]	A	0.20	0.20	0.15	0.16
	B	0.40	0.40	0.30	0.16

^A When copper bearing steel is specified, the minimum limit for copper is 0.20 %. When copper bearing steel is not specified, the maximum limit for copper is as shown in the table.

^B For Limits B steels, the sum of copper, nickel, chromium and molybdenum shall not exceed 1.00 % on heat analysis. When one or more of these elements are specified by the purchaser, the sum does not apply; in which case, only the individual limits on the remaining elements shall apply.

^C For Limits B steels, the sum of chromium and molybdenum shall not exceed 0.32 % on heat analysis. When one or more of these elements are specified, the sum does not apply; in which case, only the individual limits on the remaining elements shall apply.

Table 1 (elements Cu, Cr, Ni, and Mo). When Limits A or Limits B is not specified, Limits A shall be furnished.

6.1.5 *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,

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

6.1.7 Dimensions (decimal thickness and width of material),

NOTE 3—Not all producers are capable of meeting all the limitations of the thickness tolerance tables in Specification **A635/A635M**. The purchaser should contact the producer regarding possible limitations prior to placing an order.

6.1.8 Coils size and weight requirements (must include inside diameter (ID), outside diameter (OD), and maximum weight),

6.1.9 Quantity (weight),

6.1.10 Application (part identification and description). Orders for conversion to plate shall include reference to the applicable ASTM plate specification.

6.1.11 A report is required of heat analysis and mechanical properties as determined by the tension test, and

6.1.12 Special requirements (if any).

6.1.12.1 When the purchaser requires a limit on “carbon equivalent” (see Supplementary Requirement S1), this requirement shall be specified in the purchase order or contract.

6.1.12.2 When the purchaser requires thickness tolerances for 3/8 in. [10 mm] minimum edge distance (see Supplementary

Requirement in Specification **A635/A635M**), this requirement shall be specified in the purchase order or contract.

NOTE 4—A typical ordering description is as follows: (inch pound units) ASTM A1018/A1018M: Grade 50, High-Strength, Low-Alloy Steel, Class 2, Limits B, 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 lb., maximum; 200 000 lb. for roll forming shapes; (SI units) ASTM A1018/A1018M: Grade 340, High-Strength Low-Alloy Steel, Class 2, Limits B, hot-rolled sheet coils, pickled and oiled, cut edge; 10 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. For conversion to plate: (inch-pound units) ASTM A1018/A1018M: Grade 50, High-Strength Low-Alloy Steel, Class 1, Limits A, hot-rolled sheet coils, as rolled, mill edge, 0.500 by 50 in. by coil, ID 24 in., OD 72 in., maximum; coil weight 40 000 lb., maximum; 200 000 lb. for conversion to plate, Specification **A572/A572M** Grade 50; (SI units) ASTM A1018/A1018M: Grade 340, Structural Steel, hot-rolled sheet coils, as rolled, mill edge; 10 by 1000 mm by coil; ID 600 mm, OD 1800 mm, maximum; coil weight 18 000 kg maximum; 100 000 kg for conversion to plate, Specification **A572/A572M** Grade 340.

7. Chemical Composition

7.1 The heat analysis of commercial steel and drawing steel shall conform to the requirements of **Table 2**, and where appropriate, **Table 3**.

7.2 The heat analysis of structural steel, high-strength low-alloy steel, high-strength low-alloy steel with improved formability, and ultra-high strength steel shall conform to the requirements of **Tables 2 and 3**.

7.3 **Table 1** describes the heat analysis requirements for two sets of limits (A and B) for the elements copper, chromium,

**TABLE 2 Chemical Requirements^A
Commercial and Drawing Steels**

Designation	% Heat Analysis, Element Maximum Unless Otherwise Shown														
	C	Mn	P	S	Al	Si	Cu	Ni	Cr	Mo	V	Cb	Ti ^B	N	B
Commercial Steels (CS)															
CS Type A	0.10	0.60	0.030	0.035	...	...	0.20 ^C	0.20	0.15	0.06	0.008	0.008	0.025	...	...
CS Type B	0.02 to 0.15	0.60	0.030	0.035	...	...	0.20 ^C	0.20	0.15	0.06	0.008	0.008	0.025	...	...
1007	0.02 to 0.10	0.50	0.030	0.035	...	...	0.20 ^C	0.20	0.15	0.06	0.008	0.008	0.025	...	...
1008	0.10	0.50	0.030	0.035	...	...	0.20 ^C	0.20	0.15	0.06	0.008	0.008	0.025	...	...
1009	0.15	0.60	0.030	0.035	...	...	0.20 ^C	0.20	0.15	0.06	0.008	0.008	0.025	...	...
1010	0.08 to 0.13	0.30 to 0.60	0.030	0.035	...	...	0.20 ^C	0.20	0.15	0.06	0.008	0.008	0.025	...	...
1012	0.10 to 0.15	0.30 to 0.60	0.030	0.035	...	...	0.20 ^C	0.20	0.15	0.06	0.008	0.008	0.025	...	...
1015	0.13 to 0.18	0.30 to 0.60	0.030	0.035	...	...					0.008	0.008	0.025	...	...
1016	0.13 to 0.18	0.60 to 0.90	0.030	0.035	...	...					0.008	0.008	0.025	...	...
1017	0.15 to 0.20	0.30 to 0.60	0.030	0.035	...	...					0.008	0.008	0.025	...	...
1018	0.15 to 0.20	0.60 to 0.90	0.030	0.035	...	...					0.008	0.008	0.025	...	...
1019	0.15 to 0.20	0.70 to 1.00	0.030	0.035	...	...					0.008	0.008	0.025	...	...
1020	0.18 to 0.23	0.30 to 0.60	0.030	0.035	...	...					0.008	0.008	0.025	...	...
1021	0.18 to 0.23	0.60 to 0.90	0.030	0.035	...	...					0.008	0.008	0.025	...	...
1022	0.18 to 0.23	0.70 to 1.00	0.030	0.035	...	...					0.008	0.008	0.025	...	...
1023	0.20 to 0.25	0.30 to 0.60	0.030	0.035	...	...					0.008	0.008	0.025	...	...
1524	0.19 to 0.25	1.35 to 1.65	0.030	0.035	...	...					0.008	0.008	0.025	...	...
Drawing Steels (DS)															
DS Type A	0.08	0.50	0.020	0.030	0.01 min	...	0.20	0.20	0.15	0.06	0.008	0.008	0.025	...	...
DS Type B	0.02 to 0.08	0.50	0.020	0.030	0.01 min	...	0.20	0.20	0.15	0.06	0.008	0.008	0.025	...	...
1006	0.08	0.45	0.030	0.035	0.01 min	...	0.20	0.20	0.15	0.06	0.008	0.008	0.025	...	...
1006A	0.02 to 0.08	0.45	0.030	0.035	0.01 min	...	0.20	0.20	0.15	0.06	0.008	0.008	0.025	...	...

^A Where an ellipsis (. . .) appears in the table, there is no requirement, but the analysis shall be reported.

^B Titanium is permitted at the producer's option, to the lesser of 3.4N + 1.5S or 0.025 %.

^C When copper steel is specified, the copper limit is a minimum requirement. When copper steel is not specified, the copper limit is a maximum requirement.

nickel, and molybdenum. The required set of limits (A and B) for these elements shall be specified on the order.

7.4 Chemical analysis shall be conducted in accordance with Test Methods, Practices, and Terminology **A751**.

TABLE 3 Chemical Requirements^A
Structural Steels, High-Strength Low-Alloy Steels, and High-Strength Low-Alloy Steels with Improved Formability

Designation	% Heat Analysis, Element Maximum Unless Otherwise Shown									
	C	Mn	P	S	Al	Si	V	Cb	Ti	N
SS^B										
Grade 30 [205]	0.25	1.50	0.035	0.04	...	...	0.008	0.008	0.025	0.014
Grade 33 [230]	0.25	1.50	0.035	0.04	...	...	0.008	0.008	0.025	0.014
Grade 36 [250] Type 1	0.25	1.50	0.035	0.04	...	...	0.008	0.008	0.025	0.014
Grade 36 [250] Type 2	0.25	... ^C	0.035	0.04	...	...	0.008	0.008	0.025	0.014
Grade 40 [275]	0.25	1.50	0.035	0.04	...	...	0.008	0.008	0.025	0.014
Grade 45 [310]	0.25	1.50	0.035	0.04	...	...	0.008	0.008	0.025	0.014
HSLAS^D										
Grade 45 [310] Class 1	0.22	1.50	0.04	0.04	...	...	0.005 min	0.005 min	0.005 min	...
Grade 45 [310] Class 2	0.15	1.50	0.04	0.04	...	...	0.005 min	0.005 min	0.005 min	^E
Grade 50 [340] Class 1	0.23	1.50	0.04	0.04	...	...	0.005 min	0.005 min	0.005 min	...
Grade 50 [340] Class 2	0.15	1.50	0.04	0.04	...	...	0.005 min	0.005 min	0.005 min	^E
Grade 55 [380] Class 1	0.25	1.50	0.04	0.04	...	...	0.005 min	0.005 min	0.005 min	...
Grade 55 [380] Class 2	0.15	1.50	0.04	0.04	...	...	0.005 min	0.005 min	0.005 min	^E
Grade 60 [410] Class 1	0.26	1.50	0.04	0.04	...	...	0.005 min	0.005 min	0.005 min	...
Grade 60 [410] Class 2	0.15	1.50	0.04	0.04	...	...	0.005 min	0.005 min	0.005 min	^E
Grade 65 [450] Class 1	0.26	1.50	0.04	0.04	...	...	0.005 min	0.005 min	0.005 min	^E
Grade 65 [450] Class 2	0.15	1.50	0.04	0.04	...	...	0.005 min	0.005 min	0.005 min	^E
Grade 70 [480] Class 1	0.26	1.65	0.04	0.04	...	...	0.005 min	0.005 min	0.005 min	^E
Grade 70 [480] Class 2	0.15	1.65	0.04	0.04	...	...	0.005 min	0.005 min	0.005 min	^E
HSLAS-F^D										
Grade 50 [340]	0.15	1.65	0.025	0.035	...	...	0.005 min	0.005 min	0.005 min	^E
Grade 60 [410]	0.15	1.65	0.025	0.035	...	...	0.005 min	0.005 min	0.005 min	^E
Grade 70 [480]	0.15	1.65	0.025	0.035	...	...	0.005 min	0.005 min	0.005 min	^E
Grade 80 [550]	0.15	1.65	0.025	0.035	...	...	0.005 min	0.005 min	0.005 min	^E

^A An ellipsis (. . .) indicates that no limits have been set for that element. See Table 1 for requirements for Cu, Ni, Cr, and Mo.

^B Titanium is permitted for SS designations, at the producer's option, to the lesser of 3.4N + 1.5S or 0.025 %.

^C For product greater than 0.75 in. [20 mm] in thickness, the manganese requirement is 0.80 to 1.20 %. 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 %.

^D HSLAS and HSLAS-F steels contain the strengthening elements columbium, vanadium, and titanium added singly or in combination. The minimum requirements only apply to the microalloy elements selected for strengthening of the steel.

^E The purchaser has the option of restricting the nitrogen content. It should be noted that, depending on the microalloying scheme (for example, use of vanadium) of the producer, nitrogen may be a deliberate addition. Consideration should be made for the use of nitrogen binding elements (for example, vanadium, titanium).

7.5 Each of the elements listed in Tables 2 and 4 shall be included in the report of the heat analysis. When the amount of copper, nickel, chromium, or molybdenum is less than 0.02 %, report the analysis as <0.02 % or the actual value. When the amount of columbium, titanium, or vanadium is less than 0.008 %, report the analysis as <0.008 % or the actual determined value. When the amount of boron is less than 0.0005 %, report the analysis as <0.0005 % or the actual determined value.

7.6 For Structural Steel (SS) the addition of microalloying elements, including columbium, vanadium, or titanium, as well as nitrogen, as strength enhancers is prohibited.

7.7 Sheet steel grades defined by this specification are suitable for welding if appropriate welding conditions are selected. For certain welding processes, more restrictive composition limits may be desirable and should be requested at the time of inquiry and ordering.

TABLE 4 Chemical Requirements
Ultra-High Strength Steels

Designation	% Heat Analysis, Element Maximum Unless Otherwise Shown											
	C	Mn	P	S	Cu ^A	Ni	Cr	Mo	V ^B	Cb ^B	Ti ^B	N
UHSS												
Grade 90 [620] Type 1	0.15	2.00	0.020	0.025	0.20	0.20	0.15	0.40	0.005 min	0.005 min	0.005 min	^C
Grade 90 [620] Type 2	0.15	2.00	0.020	0.025	0.60	0.50	0.30	0.40	0.005 min	0.005 min	0.005 min	^C
Grade 100 [690] Type 1	0.15	2.00	0.020	0.025	0.20	0.20	0.15	0.40	0.005 min	0.005 min	0.005 min	^C
Grade 100 [690] Type 2	0.15	2.00	0.020	0.025	0.60	0.50	0.30	0.40	0.005 min	0.005 min	0.005 min	^C

^A When copper steel is specified, a minimum of 0.20 % is required. When copper steel is not specified, the copper limit is a maximum requirement.

^B UHSS steels contain the strengthening elements columbium (niobium), vanadium, and titanium added singly or in combination. The minimum requirements only apply to the microalloy elements selected for strengthening of the steel.

^C The purchaser has the option of restricting the nitrogen content. It should be noted that, depending on the microalloying scheme (for example, use of vanadium) of the producer, nitrogen may be a deliberate addition. Consideration should be made for the use of nitrogen binding elements (for example, vanadium, titanium).

8. Mechanical Properties

8.1 Test specimen preparation and mechanical testing shall be in accordance with Test Methods and Definitions **A370**.

8.2 *Tensile Properties*—The material, structural steel, high-strength low-alloy steel, high-strength low-alloy steel with improved formability, and ultra-high strength steel, as represented by the test specimens shall conform to the mechanical property requirements as stated in **Table 5**. These requirements do not apply to the uncropped ends of unprocessed coils.

8.3 *Tension Test Specimen Location and Orientation*—Tension test specimens shall be taken sufficiently far from the as hot-rolled coil ends so that the sample is representative of material which received the designed processing. The test shall be taken approximately midway between the center and edge of the material as rolled. For coils wider than 24 in. [600 mm], Tension test specimens shall be taken such that the longitudinal axis of the specimens is perpendicular to the direction of rolling (transverse test). For coils through 24 in. [600 mm] in width, tension test specimens shall be taken such that longitudinal axis of the specimen is parallel to the direction of rolling (longitudinal test).

8.4 *Tension Tests*—Two tension tests shall be conducted from each heat or each of 50 tons [45 Mg]. When the amount of finished material from a heat is less than 50 tons [45 Mg],

only one tension test shall be conducted. When material rolled from one heat differs 0.050 in. [1.3 mm] or more in thickness, one tension test shall be conducted from both the thickest and the thinnest material rolled regardless of the weight represented.

8.5 To determine conformance with this specification, a test value should be rounded to the nearest 1 ksi [7 Mpa] of tensile strength and yield point, and to the nearest unit in the right-hand place of figures used in expressing the limiting value for other places in accordance with the rounding off methods given in Practice **E29**.

8.6 Structural steel, high-strength low-alloy steel, high-strength low-alloy steel with improved formability, and ultra-high strength steel covered by this specification are commonly fabricated by cold bending. There are many interrelated factors that affect the ability of a given steel to cold form over a given radius under shop conditions. These factors include thickness, strength level, degree of restraint, relationship to rolling direction, chemistry, and microstructure. The producer shall be consulted concerning the recommended minimum inside radius and bending direction. Where possible, a larger radius or “easy way” bending (with the bend axis perpendicular to rolling direction), or both, are recommended for improved performance.

TABLE 5 Mechanical Property Requirements^A for Hot Rolled Heavy Thickness Coils

Designations SS, HSLAS, and HSLAS-F				
Designation	Yield Strength min ksi [MPa]	Tensile Strength min ^B ksi [MPa]	Elongation in 2 in. [50 mm], min, %	Elongation in 8 in. [200 mm], min, %
SS				
Grade 30 [205]	30 [205]	49 [340]	22	17
Grade 33 [230]	33 [230]	52 [360]	22	16
Grade 36 [250] Type 1	36 [250]	53 [365]	21	15
Grade 36 [250] Type 2	36 [250]	58 to 80 [400 to 550]	21	18
Grade 40 [275]	40 [275]	55 [380]	19	14
Grade 45 [310]	45 [310]	60 [413]	18	13
HSLAS				
Grade 45 [310] Class 1	45 [310]	60 [410]	22	17
Grade 45 [310] Class 2	45 [310]	55 [380]	22	17
Grade 50 [340] Class 1	50 [340]	65 [450]	20	16
Grade 50 [340] Class 2	50 [340]	60 [410]	20	16
Grade 55 [380] Class 1	55 [380]	70 [480]	18	15
Grade 55 [380] Class 2	55 [380]	65 [450]	18	15
Grade 60 [410] Class 1	60 [410]	75 [520]	16	14
Grade 60 [410] Class 2	60 [410]	70 [480]	16	14
Grade 65 [450] Class 1	65 [450]	80 [550]	14	12
Grade 65 [450] Class 2	65 [450]	75 [520]	14	12
Grade 70 [480] Class 1	70 [480]	85 [590]	12	10
Grade 70 [480] Class 2	70 [480]	80 [550]	12	10
HSLAS-F				
Grade 50 [340]	50 [340]	60 [410]	22	16
Grade 60 [410]	60 [410]	70 [480]	16	14
Grade 70 [480]	70 [480]	80 [550]	12	10
Grade 80 [550]	80 [550]	90 [620]	12	10
UHSS				
Grade 90 [620] Types 1 and 2	90 [620]	100 [690]	10	8
Grade 100 [690] Types 1 and 2	100 [690]	110 [760]	10	8

^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.

^B A minimum and maximum tensile strength are specified for SS Grade 36 Type 2.

8.7 Fabricators must be aware that cracks may initiate upon bending a sheared or burned edge. This is not considered a fault of the steel, but is rather a function of the induced cold work or heat affected zone.

9. Workmanship, Finish, and Appearance

9.1 *Edges*—The normal edge condition in heavy-thickness coils is mill edge. If cut edge is required, it must be specified.

9.2 *Oiling*—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, it is permissible to specify pickled or blast cleaned material be furnished dry, or that as-rolled material be furnished oiled.

9.3 *Surface Finish*—Unless otherwise specified, hot-rolled material shall have an as-rolled, not pickled surface finish. When required, material shall be specified to be pickled or blast-cleaned.

10. Retests and Disposition of Non-Conforming Material

10.1 Retests, conducted in accordance with the requirements of Section 10.1 of Specification **A635/A635M**, are

permitted when an unsatisfactory test result is suspected to be the consequence of the test method procedure.

10.2 Disposition of non-conforming material shall be subject to the requirements of Section 10.2 of Specification **A635/A635M**.

11. Certification

11.1 A report of heat analysis shall be supplied, if requested, for CS and DS steels. For material with required mechanical properties, SS, HSLAS, HSLAS-F, and UHSS, a report is required of heat analysis and mechanical properties as determined by the tension test.

12. Keywords

12.1 carbon steel sheet; carbon steel strip; commercial steel; drawing steel; heavy-thickness coils; high-strength low-alloy steel; hot-rolled steel sheet; hot-rolled steel strip; improved formability; steel sheet; steel strip; structural applications; ultra-high strength steel

SUPPLEMENTARY REQUIREMENTS

The following standardized supplementary requirement is for use when desired by the purchaser. These additional requirements shall apply only when specified on the order.

S1. Carbon Equivalent

S1.1 When a purchaser places limits on the carbon equivalent (CE), the CE value shall be calculated in accordance with the following formula:

$$CE = \% \text{ carbon} + \frac{\% \text{ manganese}}{6} + \frac{(\% \text{ chromium} + \% \text{ molybdenum} + \% \text{ vanadium})}{5} + \frac{(\% \text{ nickel} + \% \text{ copper})}{15}$$

APPENDIX
(Nonmandatory Information)
X1. BENDING PROPERTIES—STRUCTURAL STEEL, HIGH-STRENGTH LOW-ALLOY STEEL, HIGH-STRENGTH LOW-ALLOY STEEL WITH IMPROVED FORMABILITY, AND ULTRA-HIGH STRENGTH STEEL
TABLE X1.1 Suggested Minimum Inside Radius for Cold Bending

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

NOTE 2—The suggested radius should be used as a minimum for 90° bend in actual shop practice.

NOTE 3—Material that does not perform satisfactorily, when fabricated in accordance with the above requirements, may be subject to rejection pending negotiation with the steel supplier.

Designation	Grade	Minimum Inside Radius for Cold Bending		
Structural Steel	30 [205]	1t		
	33 [230]	1t		
	36 [250] Type 1	1½t		
	36 [250] Type 2	2 t		
	40 [275]	2 t		
High-Strength Low-Alloy Steel	45 [310]	2½ t		
		Class 1	Class 2	
	45 [310]	1½t	1½t	
	50 [340]	2t	1½t	
	55 [380]	2t	2t	
	60 [410]	2½t	2t	
	65 [450]	3t	2½t	
	70 [480]	3½t	3t	
	High-Strength Low-Alloy Steel with Improved Formability	50 [340]	1t	
		60 [410]	1½t	
70 [480]		2t		
80 [550]		2t		
Ultra-High Strength Steel Types 1 and 2	90 [620]	2½ t		
	100 [690]	2½ t		

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