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Standard Specification for Steel, Sheet and Strip, Hot-Rolled, Carbon, Structural, High- Strength Low-Alloy and High-Strength Low-Alloy with Improved Formability¹

This standard is issued under the fixed designation A 1011/A 1011M; 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 structural, high-strength low-alloy, and high-strength low-alloy with improved formability steel sheet and strip, in coils and cut lengths.

1.2 Hot rolled steel sheet and strip is available in the designations as listed in 4.1.

1.3 This specification is not applicable to the steel covered by Specification A 635/A 635M.

1.4 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.

2. Referenced Documents

2.1 ASTM Standards:

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

A 568/A 568M Specification for Steel, Sheet, Carbon, and High-Strength, Low-Alloy, Hot-Rolled and Cold-Rolled, General Requirements for²

A 569/A 569M Specification for Steel, Carbon (0.15 Maximum, Percent), Hot-Rolled Sheet and Strip Commercial³

A 622/A 622M Specification for Drawing Steel (DS), Sheet and Strip, Carbon, Hot-Rolled³

A 635/A 635M Specification for Steel, Sheet and Strip, Heavy-Thickness Coils, Carbon, Hot Rolled²— Specification for Steel, Sheet and Strip, Heavy-Thickness Coils, Carbon, Commercial Steel, Drawing Steel, Structural, High-Strength Low-Alloy and High-Strength Low-Alloy with Improved Formability, Hot-Rolled, General Requirements for²

A 749/A 749M Specification for Steel, Strip, Carbon and High-Strength, Low-Alloy, Hot-Rolled, General Requirements for²

A 941 Terminology Relating to Steel, Stainless Steel, Related Alloys, and Ferroalloys⁴

3. Terminology

3.1 *Definitions*— For definitions of other terms used in this specification refer to Terminology A 941.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *aging*—loss of ductility with an increase in hardness, yield strength, and tensile strength that occurs when steel, which has been slightly cold worked (such as by temper rolling) is stored for some time.

3.2.1.1 *Discussion*—Aging also increases the tendency toward stretcher strains and fluting.

3.2.2 *stabilization*—the addition of one or more nitride or carbide forming elements, or both, such as titanium and columbium, to control the level of the interstitial elements carbon and nitrogen in the steel.

3.2.2.1 *Discussion*—Stabilization improves formability and increases resistance to aging.

3.2.3 *vacuum degassing*—a process of refining liquid steel in which the liquid is exposed to a vacuum as part of a special technique for removing impurities or for decarburizing the steel.

4. Classification

4.1 Hot-rolled steel sheet and steel strip is available in the following designations:

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 Annual Book of ASTM Standards, Vol 01.03.

³ Discontinued; see 2000 Annual Book of ASTM Standards, Vol 01.03. Replaced by A 1011/A 1011M.

⁴ Annual Book of ASTM Standards, Vol 01.01.

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

4.1.1 Commercial Steel (CS Types A, B, and C),

4.1.2 Drawing Steel (DS Types A and B),

NOTE 1—CS Type B and DS Type B describe the most common product previously included, respectively, in Specifications A 569/A 569M and A 622/A 622M.

4.1.3 Structural Steel (SS grades 30[205], 33[230], 36[250] Types 1 and 2, 40[275], 45[310], 50[340], and 55[380]),

4.1.4 High-Strength Low-Alloy Steel (HSLAS, classes 1 and 2, in grades 45[310], 50[340], 55[380], 60[410], 65[450], and 70[480]).

4.1.5 High-Strength Low-Alloy Steel with Improved Formability (HSLAS-F grades 50[340], 60[410], 70[480], and 80[550]).

4.1.5.1 HSLAS-F steel has improved formability when compared to HSLAS. The steel is fully deoxidized, made to a fine grain practice, and includes microalloying elements such as columbium, vanadium, and zirconium. The steel may be treated to achieve inclusion control.

5. Ordering Information

5.1 It is the purchaser's responsibility to specify in the purchase order all ordering information necessary to describe the required material. Examples of such information include, but are not limited to, the following:

5.1.1 ASTM specification number and year of issue,

5.1.2 Name of material and designation (hot-rolled steel sheet) (include grade, type and class, as appropriate, for CS, DS, SS, HSLAS and HSLAS-F) (see 4.1),

5.1.2.1 When a type is not specified for CS or DS, Type B will be furnished (see 4.1),

5.1.2.2 When a class is not specified for HSLAS, Class 1 will be furnished (see 4.1),

5.1.2.3 When a type is not specified for SS Grade 36, Type 1 will be furnished (see 4.1),

5.1.3 Finish (see 9.1)

5.1.4 Type of edge (see 9.3),

5.1.5 Oiled or not oiled, as required (see 9.2),

5.1.6 Dimensions (thickness, thickness tolerance table (see 5.1.6.1), width, and whether cut lengths or coils),

5.1.6.1 As agreed upon between the purchaser and the producer, material ordered to this specification will be supplied to meet the appropriate thickness tolerance table shown in Specifications A 568/A 568M for sheet and A 749/A 749M for strip.

NOTE 2—Not all producers are capable of meeting all the limitations of the thickness tolerance tables in Specifications A 568/A 568M and A 749/A 749M. The purchaser should contact the producer prior to placing an order.

5.1.7 Coil size (inside diameter, outside diameter, and maximum weight),

5.1.8 Copper bearing steel (if required),

5.1.9 Quantity,

5.1.10 Application (part identification and description),

5.1.11 Special requirements (if required) or supplementary requirement S1 for HSLAS, and

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

NOTE 3—A typical ordering description is as follows: ASTM A 1011-XX, hot rolled steel sheet, CS Type A, pickled and oiled, cut edge, 0.075 by 36 by 96 in., thickness tolerance Table 4 of Specification A 568/A 568M, 100 000 lb, for part no. 6310, for shelf bracket.

or:

ASTM A 1011M-XX, hot rolled steel sheet, CS Type B, pickled and oiled, cut edge, 3.7 by 117 mm by coil, ID 600 mm, OD 1500 mm, max weight 10 000 kg, thickness tolerance Table A1.1 of Specification A 568/A 568M, 50 000 kg, for upper control arm.

6. General Requirements for Delivery

6.1 Material furnished under this specification shall conform to the applicable requirements of the current edition of Specification A 568/A 568M for sheets and Specification A 749/A 749M for strip, unless otherwise provided for herein.

7. Chemical Composition

7.1 The heat analysis of the steel shall conform to the chemical composition requirements of the appropriate designation shown in Table 1 for CS and DS and Table 2 for SS, HSLAS, and HSLAS-F.

7.2 Each of the elements listed in Tables 1 and 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 %, report the analysis as < 0.02 % or the actual determined value. When the amount of vanadium, columbium, or titanium is less than 0.008 %, report the analysis as < 0.008 % or the actual determined value.

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

8. Mechanical Properties

8.1 *CS and DS:*



TABLE 1 Chemical Composition^A
For Hot Rolled Steel Sheet and Strip Designations CS and DS

	Composition, % Heat Analysis													
	Element maximum unless otherwise shown													
	C	Mn	P	S	Al	Si	Cu	Ni	Cr ^B	Mo	V	Cb	Ti ^C	N
CS Type A ^{D,E,F,G}	0.10	0.60	0.030	0.035	...	...	0.20 ^H	0.20	0.15	0.06	0.008	0.008	0.025	...
CS Type B ^F	0.02 to 0.15	0.60	0.030	0.035	...	...	0.20 ^H	0.20	0.15	0.06	0.008	0.008	0.025	...
CS Type C ^{D,E,F,G}	0.08	0.60	0.10	0.035	...	...	0.20 ^H	0.20	0.15	0.06	0.008	0.008	0.025	...
DS Type A ^{D,E,G}	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	...

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

^B Chromium is permitted, at the producer's option, to 0.25 % maximum when the carbon content is less than or equal to 0.05 %.

^C Titanium is permitted, at producer's option, to 0.025 % provided the ratio of % titanium to % nitrogen does not exceed 3.4.

^D Specify Type B to avoid carbon levels below 0.02 %.

^E For carbon levels less than or equal to 0.02 %, vanadium, columbium, or titanium, or combinations thereof, may be used as stabilizing elements at the producer's option. In such case, the limits for these elements are 0.10 % for vanadium or columbium and 0.15 % for titanium.

^F When an aluminum deoxidized steel is required, it may be ordered to a minimum of 0.01 % total aluminum.

^G May be furnished as a vacuum degassed or chemically stabilized steel, or both, at producer's option.

^H 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.

TABLE 2 Chemical Composition^A
For Hot Rolled Steel Sheet and Strip Designations SS, HSLAS, and HSLAS-F

Designation	% Heat Analysis, Element Maximum unless otherwise shown												
	C	Mn	P	S	Al	Si	Cu ^{B,C}	Ni ^B	Cr ^{B,D}	Mo ^{B,D}	V	Cb	N
SS:													
Grade 30 [205]	0.25	0.90	0.035	0.04	...	...	0.20	0.20	0.15	0.06	0.008	0.008	...
Grade 33 [230]	0.25	0.90	0.035	0.04	...	...	0.20	0.20	0.15	0.06	0.008	0.008	...
Grade 36[250] Type 1	0.25	0.90	0.035	0.04	...	...	0.20	0.20	0.15	0.06	0.008	0.008	...
Grade 36[250] Type 2	0.25	1.35	0.035	0.04	...	...	0.20	0.20	0.15	0.06	0.008	0.008	...
Grade 40 [275]	0.25	0.90	0.035	0.04	...	...	0.20	0.20	0.15	0.06	0.008	0.008	...
Grade 45 [310]	0.25	1.35	0.035	0.04	...	...	0.20	0.20	0.15	0.06	0.008	0.008	...
Grade 50 [340]	0.25	1.35	0.035	0.04	...	...	0.20	0.20	0.15	0.06	0.008	0.008	...
Grade 55 [380]	0.25	1.35	0.035	0.04	...	...	0.20	0.20	0.15	0.06	0.008	0.008	...
HSLAS: ^E													
Grade 45[310] Class 1	0.22	1.35	0.04	0.04	...	...	0.20	0.20	0.15	0.06	0.01 min	0.005 min	...
Grade 45[310] Class 2	0.15	1.35	0.04	0.04	...	...	0.20	0.20	0.15	0.06	0.01 min	0.005 min	...
Grade 50[340] Class 1	0.23	1.35	0.04	0.04	...	...	0.20	0.20	0.15	0.06	0.01 min	0.005 min	...
Grade 50[340] Class 2	0.15	1.35	0.04	0.04	...	...	0.20	0.20	0.15	0.06	0.01 min	0.005 min	...
Grade 55[380] Class 1	0.25	1.35	0.04	0.04	...	...	0.20	0.20	0.15	0.06	0.01 min	0.005 min	...
Grade 55[380] Class 2	0.15	1.35	0.04	0.04	...	...	0.20	0.20	0.15	0.06	0.01 min	0.005 min	...
Grade 60[410] Class 1	0.26	1.50	0.04	0.04	...	...	0.20	0.20	0.15	0.06	0.01 min	0.005 min	...
Grade 60[410] Class 2	0.15	1.50	0.04	0.04	...	...	0.20	0.20	0.15	0.06	0.01 min	0.005 min	0.020
Grade 65[450] Class 1	0.26	1.50	0.04	0.04	...	...	0.20	0.20	0.15	0.06	0.01 min	0.005 min	0.012
Grade 65[450] Class 2	0.15	1.50	0.04	0.04	...	...	0.20	0.20	0.15	0.06	0.01 min	0.005 min	0.020
Grade 70[480] Class 1	0.26	1.65	0.04	0.04	...	...	0.20	0.20	0.15	0.06	0.01 min	0.005 min	0.012
Grade 70[480] Class 2	0.15	1.65	0.04	0.04	...	...	0.20	0.20	0.15	0.06	0.01 min	0.005 min	0.020
HSLAS-F: ^{F,G}													
Grade 50[340], 60[410], 70[480], and 80[550]	0.15	1.65	0.020	0.025	...	...	0.20	0.20	0.15	0.06	...	...	...

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

^B The sum of copper, nickel, chromium, and molybdenum shall not exceed 0.50 % 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 unspecified elements shall apply.

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

^D For SS steels, the sum of chromium and molybdenum shall not exceed 0.16 % on heat analysis. When one or more of these elements are specified by the purchaser the sum does not apply, in which case, the individual limit on the remaining unspecified element shall apply.

^E For HSLAS steels, columbium and vanadium may be added singly or in combination.

^F These steels shall also contain one or more of the following elements: vanadium, titanium, and columbium. Other alloying elements may be present, but are not required.

^G These steels may be treated for inclusion control.

8.1.1 Typical, nonmandatory mechanical properties for CS and DS are found in Table 3.

8.1.2 The material shall be capable of being bent at room temperature in any direction through 180° flat on itself without cracking on the outside of the bent portion (see the section on bend test in Test Methods and Definitions A 370).

8.2 SS, HSLAS, and HSLAS-F:

8.2.1 The available grades and corresponding mechanical properties for SS, HSLAS, and HSLAS-F are shown in Table 4.

8.2.2 Tension Tests:

8.2.2.1 Requirements— Material as represented by the test specimen shall conform to the mechanical property requirements specified in Table 4. These requirements do not apply to the uncropped ends of unprocessed coils.

8.2.2.2 Number of Tests— Two tension tests shall be made from each heat or from each 50 tons [45 000 kg]. When the amount of finished material from a heat is less than 50 tons [45 000 kg], one tension test shall be made. When material rolled from one



**TABLE 3 Typical Ranges of Mechanical Properties^A
(Nonmandatory)^B
For Hot-Rolled Steel Sheet and Strip Designations CS and DS**

Designation	Yield Strength ^C		Elongation in 2 in. [50 mm] % ^C
	ksi	MPa	
CS Types A, B, and C	30 to 50	[205 to 340]	≥ 25
DS Types A and B	30 to 45	[205 to 310]	≥ 28

^A The yield strength tends to increase and the elongation tends to decrease as the sheet thickness decreases. These properties represent those typical of material in the thickness range of 0.100 to 0.150 in. [2.5 to 3.5 mm].

^B The typical mechanical property values presented here are nonmandatory. They are provided to assist the purchaser in specifying a suitable steel for a given application. Values outside these ranges are to be expected.

^C Yield strength and elongation are measured in the longitudinal direction in accordance with Test Methods A 370.

**TABLE 4 Mechanical Property Requirements^A
For Hot Rolled Steel Sheet and Strip Designations SS, HSLAS, and HSLAS-F**

Designation	Yield Strength	Tensile Strength ^B	Elongation in 2 in. [50 mm] min, % for Thicknesses:			Elongation in 8 in. [200 mm], % for Thickness:
			Under 0.230 [6.0mm] to 0.097 [2.5mm]	Under 0.097 [2.5mm] to 0.064 [1.6mm]	Under 0.064 [1.6mm] to 0.025 [0.65mm]		Under 0.230 [6.0mm]
	ksi [MPa] min	ksi [MPa] min				
SS:						
Grade 30 [205]	30 [205]	49 [340]	25.0	24.0	21.0	19.0
Grade 33 [230]	33 [230]	52 [360]	23.0	22.0	18.0	18.0
Grade 36 [250] Type 1	36 [250]	53 [365]	22.0	21.0	17.0	17.0
Grade 36 [250] Type 2	36 [250]	58-80 [400-550]	21.0	20.0	16.0	16.0
Grade 40 [275]	40 [275]	55 [380]	21.0	20.0	15.0	16.0
Grade 45 [310]	45 [310]	60 [410]	19.0	18.0	13.0	14.0
Grade 50 [340]	50 [340]	65 [450]	17.0	16.0	11.0	12.0
Grade 55 [380]	55 [380]	70 [480]	15.0	14.0	9.0	10.0
HSLAS:						
			Over 0.097 in.[2.5 mm]	Up to 0.097 [2.5 mm]		...
Grade 45 [310] Class 1	45 [310]	60 [410]	25.0	23.0		...
Grade 45 [310] Class 2	45 [310]	55 [380]	25.0	23.0		...
Grade 50 [340] Class 1	50 [340]	65 [450]	22.0	20.0		...
Grade 50 [340] Class 2	50 [340]	60 [410]	22.0	20.0		...
Grade 55 [380] Class 1	55 [380]	70 [480]	20.0	18.0		...
Grade 55 [380] Class 2	55 [380]	65 [450]	20.0	18.0		...
Grade 60 [410] Class 1	60 [410]	75 [520]	18.0	16.0		...
Grade 60 [410] Class 2	60 [410]	70 [480]	18.0	16.0		...
Grade 65 [450] Class 1	65 [450]	80 [550]	16.0	14.0		...
Grade 65 [450] Class 2	65 [450]	75 [520]	16.0	14.0		...
Grade 70 [480] Class 1	70 [480]	85 [585]	14.0	12.0		...
Grade 70 [480] Class 2	70 [480]	80 [550]	14.0	12.0		...
HSLAS-F:						
Grade 50 [340]	50 [340]	60 [410]	24.0	22.0		...
Grade 60 [410]	60 [410]	70 [480]	22.0	20.0		...
Grade 70 [480]	70 [480]	80 [550]	20.0	18.0		...
Grade 80 [550]	80 [550]	90 [620]	18.0	16.0		...

^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 has been specified for SS36 Type 2.

heat differs 0.050 in. [1.27 mm] or more in thickness, one tension test shall be made from the thickest and thinnest material regardless of the weight represented.

8.2.2.3 Tension test specimens shall be taken at a point immediately adjacent to the material to be qualified.

8.2.2.4 Tension test specimens shall be taken from the full thickness of the sheet as-rolled.

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

8.2.2.6 Tension test specimens shall be taken with the lengthwise axis of the test specimen parallel to the rolling direction (longitudinal test)

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

8.2.3 *Bending Properties:*

8.2.3.1 The suggested minimum inside radii for cold bending are listed in Appendix X1 and is discussed in more detail in Specifications A 568/A 568M (6.6) and A 749/A 749M (7.6). Where a tighter bend radius is required, where curved or offset bends