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# Standard Specification for Steel, Sheet, Carbon, Structural, and High-Strength, Low- Alloy, Hot-Rolled and Cold-Rolled, General Requirements for<sup>1</sup>

This standard is issued under the fixed designation A568/A568M; 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 ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

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

## 1. Scope\*

1.1 This specification covers the general requirements for steel sheet in coils and cut lengths. It applies to the following specifications that describe carbon steel, structural steel, and high-strength, low-alloy steel (HSLA) furnished as hot-rolled sheet and cold-rolled sheet: Specifications ~~A 414/A 414M, A414/A414M, A 424, A424, A 606, A606, A 659/A 659M, A659/A659M, A 794, A794, A 1008/A 1008M, A1008/A1008M, A 1011/A 1011M, A1011/A1011M, and A 1039/A 1039M, and A1039/A1039M.~~

1.2 This specification is not applicable to hot-rolled heavy-thickness carbon sheet coils (Specification ~~A 635/A 635M, A635/A635M~~).

1.3 In case of any conflict in requirements, the requirements of the individual material specification shall prevail over those of this general specification.

1.4 For the purposes of determining conformance with this and the appropriate product specification referenced in 1.1, values shall be rounded to the nearest unit in the right hand place of figures used in expressing the limiting values in accordance with the rounding method of Practice E 29E29.

1.5 Annex A1 lists permissible variations in dimensions and mass (see Note 1) in SI [metric] units. The values listed are not exact conversions of the values listed in the inch-pound tables, but instead are rounded or rationalized values. Conformance to Annex A1 is mandatory when the “M” specification is used.

NOTE 1—The term *weight* is used when inch-pound units are the standard. However, under SI the preferred term is *mass*.

1.6 The values stated in either ~~inch-pound~~ SI units or ~~SI~~ inch-pound 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~~ may not be exact equivalents; therefore, each system must ~~shall~~ be used independently of the other. Combining values from the two systems may result in non-conformance with the ~~specification standard.~~

1.7 This specification and the applicable material specifications are expressed in both inch-pound units and SI units. However, unless the order specifies the applicable “M” specification designation (SI units), the material shall be furnished to inch-pound units.

## 2. Referenced Documents

### 2.1 ASTM Standards:<sup>2</sup>

A370 Test Methods and Definitions for Mechanical Testing of Steel Products

A414/A414M Specification for Steel, Sheet, Carbon, and High-Strength, Low-Alloy for Pressure Vessels

A424 Specification for Steel, Sheet, for Porcelain Enameling

A606 Specification for Steel, Sheet and Strip, High-Strength, Low-Alloy, Hot-Rolled and Cold-Rolled, with Improved Atmospheric Corrosion Resistance

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

A659/A659M Specification for Commercial Steel (CS), Sheet and Strip, Carbon (0.16 Maximum to 0.25 Maximum Percent), Hot-Rolled

<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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<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.

- A700 Practices for Packaging, Marking, and Loading Methods for Steel Products for Shipment
- A751 Test Methods, Practices, and Terminology for Chemical Analysis of Steel Products
- A794 Specification for Commercial Steel (CS), Sheet, Carbon (0.16 % Maximum to 0.25 % Maximum), Cold-Rolled
- A941 Terminology Relating to Steel, Stainless Steel, Related Alloys, and Ferroalloys
- A1008/A1008M Specification for Steel, Sheet, Cold-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, Solution Hardened, and Bake Hardenable
- 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
- A1030/A1030M Practice for Measuring Flatness Characteristics of Steel Sheet Products
- A1039/A1039M Specification for Steel, Sheet, Hot Rolled, Carbon, Commercial, Structural, and High-Strength Low-Alloy, Produced by Twin-Roll Casting Process
- E11 Specification for Woven Wire Test Sieve Cloth and Test Sieves
- E29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications
- E59 Practice for Sampling Steel and Iron for Determination of Chemical Composition<sup>3</sup>
- E290 Test Methods for Bend Testing of Material for Ductility
- 2.2 *Military Standards:*<sup>4</sup>
- MIL-STD-129 Marking for Shipment and Storage
- 2.3 *Federal Standards:*<sup>4</sup>
- Fed. Std. No. 123 Marking for Shipments (Civil Agencies)
- ~~Fed. Std. No. 183 Continuous Identification Marking of Iron and Steel Products~~ Marking for Shipments (Civil Agencies)

### 3. Terminology

#### 3.1 Definitions of Terms Specific to This Standard:

##### 3.1.1 Steel Types:

3.1.2 *carbon steel*—designation for steel when no minimum content is specified or required for aluminum, chromium, cobalt, columbium, molybdenum, nickel, titanium, tungsten, vanadium, zirconium, or any element added to obtain a desired alloying effect; when the specified minimum for copper does not exceed 0.40 %; or when the maximum content specified for any of the following elements does not exceed the percentages noted: manganese 1.65, silicon 0.60, or copper 0.60.

3.1.2.1 *Discussion*—In all carbon steels small quantities of certain residual elements unavoidably retained from raw materials are sometimes found which are not specified or required, such as copper, nickel, molybdenum, chromium, etc. These elements are considered as incidental and are not normally determined or reported.

3.1.3 *high-strength, low-alloy steel*—specific group of steels in which higher strength, and in some cases additional resistance to atmospheric corrosion or improved formability, are obtained by moderate amounts of one or more alloying elements.

##### 3.1.4 Product Types:

3.1.5 *hot-rolled sheet*—manufactured by hot rolling slabs in a continuous mill to the required thickness and can be supplied in coils or cut lengths as specified.

(1) ~~Hot-rolled carbon and high-strength low-alloy (HSLA) steel sheet~~ is commonly classified by size as follows:

<u>Width, in.</u>	<u>Coils and Cut Lengths</u>	<u>Thickness, in.</u>
Over 12		0.031 to 0.230, excl
All Widths <sup>A</sup>		0.027 to 0.230, excl

<sup>A</sup> Hot-rolled sheet in coils and cut lengths less than 12 in. in width must have cut edges. Hot-rolled material with mill edges 12 in. and less in width is considered hot-rolled strip.

<u>Width, mm</u>	<u>Coils and Cut Lengths</u>	<u>Thickness, mm</u>
Over 300		0.7 to 6.0, excl
All Widths <sup>A</sup>		0.7 to 6.0, excl

<sup>A</sup> Hot-rolled sheet in coils and cut lengths less than 300 mm. in width must have cut edges. Hot-rolled material with mill edges 300 mm and less in width is considered hot-rolled strip.

(2) Hot-rolled high-strength low-alloy steel sheet is commonly classified by size as follows:

<u>Width, in.</u>	<u>Coils and Cut Lengths</u>	<u>Thickness, in.</u>
All Widths <sup>A</sup>		0.031 to 0.230, excl

<sup>A</sup> Hot-rolled sheet in coils and cut lengths less than 12 in. in width must have cut edges. Hot-rolled material with mill edges 12 in. and less in width is considered hot-rolled strip.

Coils and Cut Lengths

<sup>3</sup> Withdrawn.

<sup>3</sup> Withdrawn. The last approved version of this historical standard is referenced on [www.astm.org](http://www.astm.org).

<sup>4</sup> Available from Standardization Documents Order Desk, DODSSP, Bldg. 4, Section D, 700 Robbins Ave., Philadelphia, PA 19111-5098, <http://www.dodssp.daps.mil>.

Width, in.  
All Widths<sup>A</sup>

Thickness, mm  
0.8 to 6.0, excl

<sup>A</sup> Hot-rolled sheet in coils and cut lengths less than 300 mm in width must have cut edges. Hot-rolled material with mill edges 300 mm and less in width is considered hot-rolled strip.

NOTE 2—The changes in width limits with the publication of A568/A568M – 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. Material formerly tested in the transverse direction will be tested in the longitudinal direction. This is expected to result in some changes in reported properties. The purchaser is advised to discuss this change with the supplier.

3.1.6 *cold-rolled sheet*—manufactured from hot-rolled descaled coils by cold reducing to the desired thickness, generally followed by annealing to recrystallize the grain structure. If the sheet is not annealed after cold reduction it is known as full hard with a hardness of 84 HRB minimum and can be used for certain applications where ductility and flatness are not required.

(1) Cold-rolled carbon sheet is commonly classified by size as follows:

Width, in.	Thickness, in.
All Widths <sup>A,B</sup>	Through 0.142
Width, mm	Thickness, mm
All Widths <sup>A,B</sup>	Through 4.0

<sup>A</sup> Cold-rolled sheet coils and cut lengths, slit from wider coils with cut edge (only) and in thicknesses through 0.142 in. [4.0 mm] carbon 0.25 % maximum by cast analysis.

<sup>B</sup> When no special edge or finish (other than matte, commercial bright, or luster finish) or single strand rolling of widths, or both under 24 in. [600 mm] is not specified or required.

(2) Cold-rolled high-strength low-alloy sheet is commonly classified by size as follows:

Width, in.	Thickness, in.
Through 12 <sup>A</sup>	0.019 through 0.082
Over 12 <sup>B</sup>	0.020 and over
Width, mm	Thickness, mm
To 300, incl <sup>A</sup>	0.5 to 2.0, incl
Over 300 <sup>B</sup>	0.5 and Over

<sup>A</sup> Cold-rolled sheet coils and cut lengths, slit from wider coils with cut edge (only) and in thicknesses 0.019 in. [0.5 mm] through 0.082 in. [2.0 mm] carbon 0.25 % maximum by cast analysis.

<sup>B</sup> When no special edge or finish (other than matte, commercial bright, or luster finish) or single strand rolling of widths, or both under 24 in. [600 mm] is not specified or required.

3.1.6.1 *Discussion*—Steel products are available in various thickness, width, and length combinations depending upon equipment and processing capabilities of various manufacturers and processors. Historic limitations of a product based upon dimensions (thickness, width, and length) do not take into account current production and processing capabilities. To qualify any product for a particular product specification requires all appropriate and necessary tests be performed and that the results meet the limits prescribed in that product specification. If the necessary tests required by a product specification cannot be conducted, the product cannot be qualified to that specification. This general requirements specification contains permitted variations for the commonly available sizes. Permitted variations for other sizes are subject to agreement between the customer and the manufacturer or processor, whichever is applicable.

3.1.7 *retests, n*—additional test, or tests, made from the original material when the original test did not meet the appropriate acceptance criteria required by a product specification and the failure was mechanical in nature as described in Section 11.

3.1.8 *resample, n*—additional test or tests made when the test on the original sample did not meet the appropriate acceptance criteria required by the product specification, but possibly requiring that the material in question have an appropriate amount discarded prior to securing the new sample or samples.

3.1.9 *steel manufacturer, n*—the organization that directly controls or is responsible for the melting and refining of steel and the conversion of that steel into semifinished steel products known as slabs either through continuous casting, conventional or compact methods, or ingot casting and subsequent conversion of the ingots to slabs, and for one or more additional operations such as testing, marking, loading for shipment, and certification.

3.1.10 *coil processor*—the organization that directly controls or is responsible for operations involved in processing the coil such as leveling, cutting to length, testing, inspection, blanking, slitting, pickling, cold rolling (cold reduction), heat treating, temper rolling, coating, packaging, marking, loading for shipment, and certification.

3.1.10.1 *Discussion*—The processing operations need not be controlled by the organization that hot rolls the slab into a coil. If only one organization controls or is responsible for (or both) the hot rolling and processing operations, that organization is termed the manufacturer. If more than one organization controls or is responsible for (or both) hot rolling and processing operations, the organization that controls and is responsible for the hot rolling is termed the hot roll manufacturer and the organization or organizations controlling and responsible for the processing operations is/are termed the processor or processors. Likewise, one organization may be the manufacturer of the hot roll coil and another the manufacturer of the cold roll coil. In such case, the organization responsible for the conversion of the hot roll coil to a cold roll coil and other processing operations will also be termed the cold roll manufacturer and organizations performing additional processing operations to the cold roll coil will be termed the coil processor or coil processors.

3.1.11 *hot roll manufacturer, n*—the organization that directly controls or is responsible for the conversion of steel slabs, by hot

rolling into coils, and for one or more additional operations such as leveling, cutting to length, testing, inspection, blanking, slitting, pickling, cold rolling, heat treating, coating, packaging, marking, loading for shipment, and certification.

3.1.12 *cold roll manufacturer, n*—the organization that directly controls or is responsible for the conversion of hot roll coils into cold roll coils, and for one or more additional operations such as pickling, annealing, temper rolling, slitting, cutting to length, testing, inspection, blanking, coating, packaging, marking, loading for shipment, and certification.

3.2 Refer to Terminology A 941

3.2 Refer to Terminology A941 for additional definitions of terms used in this standard.

#### 4. Materials and Manufacture

4.1 Unless otherwise specified, hot-rolled material shall be furnished hot-rolled, not annealed, not pickled.

4.2 Coil breaks, stretcher strains, and fluting can occur during the user’s processing of hot-rolled or hot-rolled pickled sheet. When any of these features are detrimental to the application, the manufacturer shall be notified at time of ordering in order to properly process the sheet.

4.3 Cold-rolled carbon steel sheet is available as discussed in 10.2, 10.3, and in Table 1.

4.4 Unless specified as a full-hard product, cold-rolled sheet is annealed after being cold reduced to thickness. The annealed, cold-rolled sheet can be used as annealed last (dead soft) for unexposed end-use applications. When cold-rolled sheet is used for unexposed applications and coil breaks are a hazard in uncoiling, it may be necessary to further process the material. In this case the manufacturer should be consulted. After annealing, cold-rolled sheet is generally given a light skin pass to impart shape or may be given a heavier skin pass or temper pass to prevent the phenomenon known as stretcher straining or fluting, when formed. Temper passing also provides a required surface texture.

4.5 *Temper Rolling:*

4.5.1 Unless otherwise specified, cold-rolled sheet for exposed applications shall be temper rolled and is usually specified and furnished in the strain free condition as shipped. See Appendix X1, Effect of Aging of Cold-Rolled Carbon Steel Sheet on Drawing and Forming.

4.5.2 Cold-rolled sheet for unexposed applications may be specified and furnished “annealed last” or “temper rolled.” “Annealed last” is normally produced without temper rolling but may be lightly temper rolled during oiling or rewinding. Unexposed temper-rolled material may be specified strain-free or nonfluting. Where specific hardness range or limit or a specified surface texture is required, the application is considered as exposed.

NOTE 3—Skin-passed sheet is subject to an aging phenomenon (see Appendix X1). Unless special killed (nonaging) steel is specified, it is to the user’s interest to fabricate the sheet as soon as possible, for optimum performance.

#### 5. Chemical Composition

5.1 *Limits:*

5.1.1 The chemical composition shall be in accordance with the applicable product specification. However, if other compositions are required for carbon steel, they shall be prepared in accordance with Appendix X2.

**TABLE 1 Cold-Rolled Sheet Steel Class Comparison**

	Exposed	Unexposed
Major imperfections:		
Cut lengths	Mill rejects	Mill rejects
Coils	Purchaser accepts within the manufacturer’s published standards (policy)	Purchaser accepts within the manufacturer’s published standards (policy)
Minor imperfections:		
Cut lengths	Mill rejections repetitive imperfections. May contain random imperfections which the purchaser accepts within the manufacturer’s published standards (policy)	Purchaser accepts all minor imperfections
Coils	Purchaser accepts within the manufacturer’s published standards (policy)	Purchaser accepts all minor imperfections
Finish	Matte unless otherwise specified	Purchaser accepts all finishes
Special oils	May be specified	May not be specified
Thickness, width and length tolerance:		
Standard	Will be met	Will be met
Restricted	May be specified	May not be specified
Flatness tolerance:		
Standard	Will be met	Will be met (temper rolled) Not guaranteed—normally within twice standard (annealed last)
Restricted Squareness	May be specified	May not be specified
Coil wraps	Purchaser accepts within the manufacturer’s published standards (policy)	Purchaser accepts all
Coil welds	Purchaser accepts within the manufacturer’s published standards (policy)	Purchaser accepts within the manufacturer’s published standards (policy)
Outside inspection	May be specified	May not be specified
Special testing	May be specified	May not be specified

5.1.2 Where the material is used for fabrication by welding, care must be exercised in selection of chemical composition or mechanical properties to assure compatibility with the welding process and its effect on altering the properties.

**5.2 Cast or Heat Analysis:**

5.2.1 An analysis of each cast or heat of steel shall be made by the steel manufacturer to determine the percentage of elements specified or restricted by the applicable specification.

5.2.2 When requested, cast or heat analysis for elements listed or required shall be reported to the purchaser or to his representative. The steel manufacturer, or the hot roll manufacturer, cold roll manufacturer, or processor, if different from the steel manufacturer, is responsible for providing this information to the purchaser or his representative as requested.

**5.3 Product, Check, or Verification Analysis:**

5.3.1 Non-killed steels such as capped or rimmed steels are not technologically suited to product analysis due to the nonuniform character of their chemical composition and therefore, the tolerances in Table 2 do not apply. Product analysis is appropriate on these types of steel only when misapplication is apparent or for copper when copper steel is specified.

5.3.2 For steels other than non-killed (capped or rimmed), product analysis may be made by the purchaser. The chemical analysis shall not vary from the limits specified by more than the amounts in Table 2. The several determinations of any element in a cast shall not vary both above and below the specified range.

**5.4 Sampling for Product Analysis:**

5.4.1 To indicate adequately the representative composition of a cast by product analysis, it is general practice to select samples to represent the steel, as fairly as possible, from a minimum number of pieces as follows: 3 pieces for lots up to 15 tons incl, and 6 pieces for lots over 15 tons (see Practice E-59E59).

5.4.2 When the steel is subject to tension test requirements, samples for product analysis may be taken either by drilling entirely through the used tension test specimens themselves, or as covered in 5.4.3.

5.4.3 When the steel is not subject to tension test requirements, the samples for analysis must be taken by milling or drilling entirely through the sheet in a sufficient number of places so that the samples are representative of the entire sheet or strip. The sampling may be facilitated by folding the sheet both ways, so that several samples may be taken at one drilling. Steel subjected to certain heating operations by the purchaser may not give chemical analysis results that properly represent its original composition. Therefore, users must analyze chips taken from the steel in the condition in which it is received from the steel manufacturer.

5.5 *Specimen Preparation*—Drillings or chips must be taken without the application of water, oil, or other lubricant, and must be free of scale, grease, dirt, or other foreign substances. They must not be overheated during cutting to the extent of causing decarburization. Chips must be well mixed and those too coarse to pass a No. 10 sieve or too fine to remain on a No. 30 sieve are not suitable for proper analysis. Sieve size numbers are in accordance with Specification E-4E11.

5.6 *Test Methods*—In case a referee analysis is required and agreed upon to resolve a dispute concerning the results of a

**TABLE 2 Tolerances for Product Analysis**

Element	Limit, or Maximum of Specified Element, %	Tolerance	
		Under Minimum Limit	Over Maximum Limit
Carbon	to 0.15 incl	0.02	0.03
	over 0.15 to 0.40 incl	0.03	0.04
	over 0.40 to 0.80 incl	0.03	0.05
	over 0.80	0.03	0.06
Manganese	to 0.60 incl	0.03	0.03
	over 0.60 to 1.15 incl	0.04	0.04
	over 1.15 to 1.65 incl	0.05	0.05
Phosphorus		... <sup>A</sup>	0.01
Sulfur		... <sup>A</sup>	0.01
Silicon	to 0.30 incl	0.02	0.03
	over 0.30 to 0.60 incl	0.05	0.05
Copper		0.02	... <sup>A</sup>
Nickel	to 1.00 incl	... <sup>A</sup>	0.03
Chromium	to 0.90 incl	... <sup>A</sup>	0.04
Molybdenum	to 0.20 incl	... <sup>A</sup>	0.01
Vanadium	to 0.10 incl	0.01 <sup>B</sup>	0.01 <sup>B</sup>
Columbium (Niobium)	to 0.10 incl	0.01 <sup>B</sup>	0.01 <sup>B</sup>
Titanium	to 0.15 incl	0.01 <sup>A</sup>	0.01 <sup>B</sup>
Aluminum	to 0.10 incl	0.03 <sup>C</sup>	... <sup>A</sup>
Nitrogen	to 0.030 incl	0.005	0.005

<sup>A</sup> Where an ellipsis ( . . . ) appears in the table, the requirements have not been defined.

<sup>B</sup> If the minimum of the range is 0.01%, the under tolerance is 0.005%.

<sup>C</sup> If the minimum of the range is 0.01%, the under tolerance is 0.005% and if the minimum of the range is 0.02%, the under tolerance is 0.01%.

chemical analysis, the procedure of performing the referee analysis must be in accordance with the latest issue of Test Methods, Practices, and Terminology ~~A-751~~A751, unless otherwise agreed upon between the manufacturer and the purchaser.

## 6. Mechanical Properties

6.1 The mechanical property requirements, number of specimens, and test locations and specimen orientation shall be in accordance with the applicable product specification.

6.2 Unless otherwise specified in the applicable product specification, test specimens must be prepared in accordance with Test Methods and Definitions ~~A-370~~A370.

6.3 Mechanical tests shall be conducted in accordance with Test Methods and Definitions ~~A-370~~A370.

6.4 Bend tests where required shall be conducted in compliance with Test Method ~~E-290~~E290.

6.5 To determine conformance with the product specification, a calculated value should be rounded to the nearest 1 ksi tensile strength and yield point or yield strength, and to the nearest unit in the right hand place of figures used in expressing the limiting value for other values in accordance with the rounding off method given in Practice ~~E-29E~~E29.

6.6 Structural sheet steels 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. Each of the appropriate product specifications lists in the appendix the suggested minimum inside radius for cold bending. These radii should be used as minima for 90° bends. They presuppose “hard way” bending (bend axis parallel to rolling direction) and reasonably good shop forming practices. Where possible, the use of larger radii or “easy way” bends are recommended for improved performance.

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

## 7. General Requirements for Delivery

7.1 The products covered by this specification are produced to inch-pound or metric decimal thickness only and the appropriate thickness tolerances apply.

7.2 Steel may be produced as ingot-cast or strand-cast. When different grades of strand-cast steel are sequentially cast, identification and separation of the transition material is required.

## 8. Dimensions, Tolerances, and Allowances

8.1 Dimensions, tolerances, and allowances applicable to products covered by this specification are contained in Tables 3-23 [Annex A1, Tables A1.1-A1.20]. The appropriate tolerance tables shall be identified in each individual specification.

8.2 *Flatness Tolerances:*

8.2.1 Standard flatness tolerances are contained in Table 15 and Table 16 for hot-rolled sheet and Table 23 for cold-rolled sheet.

8.2.2 Measurement techniques for flatness characteristics are described in Practice ~~A-1030/A-1030M~~A1030/A1030M.

8.2.3 Two alternative methods for flatness determination are the use of I-units and percent steepness. A description of these two alternative methods is contained in Practice ~~A-1030/A-1030M~~A1030/A1030M, as well as Appendix X5.

8.2.3.1 The use of I-units or percent steepness as a flatness standard is subject to negotiation between the purchaser and the producer.

8.2.3.2 Measurement techniques for I-units and percent steepness and rejection limits are subject to negotiation between the purchaser and the producer.

## 9. Finish and Condition

9.1 Hot-rolled sheet has a surface with an oxide or scale resulting from the hot-rolling operation. The oxide or scale can be removed by pickling or blast cleaning when required for press-work operations or welding. Hot-rolled and hot-rolled descaled

**TABLE 3 List of Tables for Dimensions, Tolerances, and Allowances**

Carbon <sup>A</sup> and High-Strength Low-Alloy Steel				
Dimensions	Table No.			
	Hot-Rolled Sheet		Cold-Rolled Sheet	
	Inch-Pound Units	SI Units	Inch-Pound Units	SI Units
Camber tolerances	12	A1.9	12, 22	A1.9, A1.19
Diameter tolerances of sheared circles	11	A1.8	11	A1.8
Flatness tolerances	15, 16	A1.12, A1.13	23	A1.20
Length tolerances	10	A1.7	19, 20	A1.16, A1.17
Out-of-square tolerances	13	A1.10	13	A1.10
Restricted Squareness tolerances	14	A1.11	14	A1.11
Thickness tolerances	4, 5, 6, 7	A1.1, A1.2, A1.3, A1.4	17, 18	A1.14, A1.15
Width tolerances of cut edge	9	A1.6	9, 21	A1.6, A1.18
Width tolerances of mill edge	8	A1.5	...	

<sup>A</sup> Tolerances for hot-rolled carbon sheet steel with 0.25 % maximum carbon, cast or heat analysis.

**TABLE 4 Standard Thickness Tolerances for Hot-Rolled Sheet (Carbon and Structural Steel Only)— $\frac{3}{8}$ -in. (Cut Edge) and  $\frac{3}{4}$ -in. (Mill Edge) Minimum Edge Distance (Coils and Cut Lengths, Including Pickled)**

NOTE 1—Thickness is measured at any point across the width not less than  $\frac{3}{8}$  in. from a cut edge and not less than  $\frac{3}{4}$  in. from a mill edge. This table does not apply to the uncropped ends of mill edge coils.

NOTE 2—Micrometers used for measurement of thickness shall be constructed with anvils and spindles having minimum diameters of 0.188 in. [4.80 mm]. The tip of the spindle shall be flat, and the tip of the anvil shall be flat or rounded with a minimum radius of curvature of 0.10 in. [2.55 mm]. Micrometers with pointed tips are not suitable for thickness measurements.

NOTE 3—The thickness of material <1 in. wide shall be measured at mid-width.

Specified Width, in.	Specified Ordered Thickness, in. <sup>A</sup>					
	0.027 to 0.051, incl	Over 0.051 to 0.057, incl	Over 0.057 to 0.071, incl	Over 0.071 to 0.098, incl	Over 0.098 to 0.180, excl	0.180 to 0.230, excl
	Thickness Tolerances Over, in., No Tolerance Under <sup>B</sup>					
Over 12 to 20 incl	0.010	0.010	0.012	0.012	0.014	0.014
To 20 incl	0.010	0.010	0.012	0.012	0.014	0.014
Over 20 to 40 incl	0.010	0.010	0.012	0.014	0.014	0.016
Over 40 to 48 incl	0.010	0.012	0.012	0.014	0.016	0.018
Over 48 to 60 incl	... <sup>C</sup>	0.012	0.014	0.014	0.016	0.020
Over 60 to 72 incl	... <sup>C</sup>	0.014	0.014	0.016	0.016	0.022
Over 72	... <sup>C</sup>	... <sup>C</sup>	... <sup>C</sup>	0.016	0.016	0.024

<sup>A</sup> The specified thickness range captions apply independent of whether the ordered thickness is stated as a nominal or minimum.

<sup>B</sup> The tolerances provided in the table are based on minimum thickness (tolerance over, no tolerance under). For nominal thickness, the tolerance is divided equally over and under.

<sup>C</sup> Where an ellipsis (. . .) appears in the table, the requirements have not been defined.

**TABLE 5 Restricted Thickness Tolerances for Hot-Rolled Sheet (Carbon and Structural Steel Only)— $\frac{5}{8}$ -in. (Cut Edge) and 1-in. (Mill Edge) Minimum Edge Distance (Coils and Cut Lengths, Including Pickled)**

NOTE 1—Thickness is measured at any point across the width not less than  $\frac{5}{8}$  in. from a cut edge and not less than 1 in. from a mill edge. This table does not apply to the uncropped ends of mill edge coils.

NOTE 2—Micrometers used for measurement of thickness shall be constructed with anvils and spindles having minimum diameters of 0.188 in. [4.80 mm]. The tip of the spindle shall be flat, and the tip of the anvil shall be flat or rounded with a minimum radius of curvature of 0.10 in. [2.55 mm]. Micrometers with pointed tips are not suitable for thickness measurements.

NOTE 3—This table was constructed by multiplying the values in the standard table by 0.75 and rounding to 3 decimal places using standard ASTM practice.

NOTE 4—The thickness of material <2 in. wide shall be measured at mid-width.

Specified Width, in.	Specified Ordered Thickness, in. <sup>A</sup>					
	0.027 to 0.051, incl	Over 0.051 to 0.057, incl	Over 0.057 to 0.071, incl	Over 0.071 to 0.098, incl	Over 0.098 to 0.180, excl	0.180 to 0.230, excl
	Thickness Tolerances Over, in., No Tolerance Under <sup>B</sup>					
Over 12 to 20 incl	0.008	0.008	0.009	0.009	0.010	0.010
To 20 incl	0.008	0.008	0.009	0.009	0.010	0.010
Over 20 to 40, incl	0.008	0.008	0.009	0.010	0.010	0.012
Over 40 to 48, incl	0.008	0.009	0.009	0.010	0.012	0.014
Over 48 to 60, incl	... <sup>C</sup>	0.009	0.010	0.010	0.012	0.015
Over 60 to 72, incl	... <sup>C</sup>	0.010	0.010	0.012	0.012	0.016
Over 72	... <sup>C</sup>	... <sup>C</sup>	... <sup>C</sup>	0.012	0.012	0.018

<sup>A</sup> The specified thickness range captions apply independent of whether the ordered thickness is stated as a nominal or minimum.

<sup>B</sup> The tolerances provided in the table are based on minimum thickness (tolerance over, no tolerance under). For nominal thickness, the tolerance is divided equally over and under.

<sup>C</sup> Where an ellipsis (. . .) appears in the table, the requirements have not been defined.

sheet is not generally used for exposed parts where surface is of prime importance.

9.1.1 Hot-rolled sheet can be supplied with mill edges or cut edges as specified. Mill edges are the natural edges resulting from the hot-rolling operation. They do not conform to any particular contour. They may also contain some edge imperfections, the more common types of which are cracked edges, thin edges (feather), and damaged edges due to handling or processing and which should not extend in beyond the ordered width. These edge conditions are detrimental where joining of the mill edges by welding is practiced. When the purchaser intends to shear or to blank, a sufficient width allowance should be made when purchasing to ensure obtaining the desired contour and size of the pattern sheet. The manufacturer may be consulted for guidance. Cut edges are the normal edges which result from the shearing, slitting, or trimming of mill-edge sheet.

9.1.1.1 The ends of plain hot-rolled mill-edge coils are irregular in shape and are referred to as uncropped ends. Where such ends are not acceptable, the purchaser's order should so specify. Processed coils such as pickled or blast cleaned are supplied with square-cut ends.

9.2 Cold-rolled carbon sheet (exposed) is intended for those applications where surface appearance is of primary importance. This class will meet requirements for controlled surface texture, surface quality, and flatness. It is normally processed by the

**TABLE 6 Standard Thickness Tolerances for Hot-Rolled Sheet (High-Strength, Low-Alloy Steel)— $\frac{3}{8}$ -in. (Cut Edge) and  $\frac{3}{4}$ -in. (Mill Edge) Minimum Edge Distance (Coils and Cut Lengths, Including Pickled)**

NOTE 1—Thickness is measured at any point across the width not less than  $\frac{3}{8}$  in. from a cut edge and not less than  $\frac{3}{4}$  in. from a mill edge. This table does not apply to the uncropped ends of mill edge coils.

NOTE 2—Micrometers used for measurement of thickness shall be constructed with anvils and spindles having minimum diameters of 0.188 in. [4.80 mm]. The tip of the spindle shall be flat, and the tip of the anvil shall be flat or rounded with a minimum radius of curvature of 0.10 in. [2.55 mm]. Micrometers with pointed tips are not suitable for thickness measurements.

NOTE 3—The thickness of material <1 in. wide shall be measured at mid-width.

Specified Width, in.	Specified Ordered Thickness, in. <sup>A</sup>						
	0.031 to 0.051, incl	Over 0.051 to 0.059, incl	Over 0.059 to 0.070, incl	Over 0.070 to 0.082, incl	Over 0.082 to 0.098, incl	Over 0.098 to 0.180, excl	0.180 to 0.230, excl
	Thickness Tolerances, Over, in., No Tolerance Under <sup>B</sup>						
Over 12 to 15, incl	0.010	0.012	0.012	0.012	0.012	0.014	0.014
To 15, incl	0.010	0.012	0.012	0.012	0.012	0.014	0.014
Over 15 to 20, incl	0.010	0.012	0.014	0.014	0.014	0.016	0.016
Over 20 to 32, incl	0.012	0.012	0.014	0.014	0.014	0.016	0.018
Over 32 to 40, incl	0.012	0.012	0.014	0.014	0.016	0.016	0.018
Over 40 to 48, incl	0.012	0.014	0.014	0.014	0.016	0.020	0.020
Over 48 to 60, incl	... <sup>C</sup>	0.014	0.014	0.014	0.016	0.020	0.020
Over 60 to 72, incl	... <sup>C</sup>	... <sup>C</sup>	0.016	0.016	0.018	0.022	0.022
Over 72 to 80, incl	... <sup>C</sup>	... <sup>C</sup>	... <sup>C</sup>	0.016	0.018	0.024	0.024
Over 80	... <sup>C</sup>	... <sup>C</sup>	... <sup>C</sup>	... <sup>C</sup>	0.020	0.024	0.024 <sup>C</sup>

<sup>A</sup> The specified thickness range captions apply independent of whether the ordered thickness is stated as a nominal or minimum.

<sup>B</sup> The tolerances provided in the table are based on minimum thickness (tolerance over, no tolerance under). For nominal thickness, the tolerance is divided equally over and under.

<sup>C</sup> Where an ellipsis (. . .) appears in the table, the requirements have not been defined.

**TABLE 7 Restricted Thickness Tolerances for Hot-Rolled Sheet (High-Strength, Low-Alloy Steel)— $\frac{5}{8}$ -in. (Cut Edge) and 1-in. (Mill Edge) Minimum Edge Distance (Coils and Cut Lengths, Including Pickled)**

NOTE 1—Thickness is measured at any point across the width not less than  $\frac{5}{8}$  in. from a cut edge and not less than 1 in. from a mill edge. This table does not apply to the uncropped ends of mill edge coils.

NOTE 2—Micrometers used for measurement of thickness shall be constructed with anvils and spindles having minimum diameters of 0.188 in. [4.80 mm]. The tip of the spindle shall be flat, and the tip of the anvil shall be flat or rounded with a minimum radius of curvature of 0.10 in. [2.55 mm]. Micrometers with pointed tips are not suitable for thickness measurements.

NOTE 3—This table was constructed by multiplying the values in the standard table by 0.75 and rounding to 3 places using standard ASTM practice.

NOTE 4—The thickness of material <2 in. wide shall be measured at mid-width.

Specified Width, in.	Specified Ordered Thickness, in. <sup>A</sup>						
	0.031 to 0.051, incl	Over 0.051 to 0.059, incl	Over 0.059 to 0.070, incl	Over 0.070 to 0.082, incl	Over 0.082 to 0.098, incl	Over 0.098 to 0.180, excl	0.180 to 0.230, excl
	Thickness Tolerances All Over, in., No Tolerance Under <sup>B</sup>						
Over 12 to 15, incl	0.008	0.009	0.009	0.009	0.009	0.010	0.010
To 15, incl	0.008	0.009	0.009	0.009	0.009	0.010	0.010
Over 15 to 20, incl	0.008	0.009	0.010	0.010	0.010	0.012	0.012
Over 20 to 32, incl	0.009	0.009	0.010	0.010	0.010	0.012	0.014
Over 32 to 40, incl	0.009	0.009	0.010	0.010	0.012	0.012	0.014
Over 40 to 48, incl	0.009	0.010	0.010	0.010	0.012	0.015	0.015
Over 48 to 60, incl	... <sup>C</sup>	0.010	0.010	0.010	0.012	0.015	0.015
Over 60 to 72, incl	... <sup>C</sup>	... <sup>C</sup>	0.012	0.012	0.014	0.016	0.016
Over 72 to 80, incl	... <sup>C</sup>	... <sup>C</sup>	... <sup>C</sup>	0.012	0.014	0.018	0.018
Over 80	... <sup>C</sup>	... <sup>C</sup>	... <sup>C</sup>	... <sup>C</sup>	0.015	0.018	0.018 <sup>C</sup>

<sup>A</sup> The specified thickness range captions apply independent of whether the ordered thickness is stated as a nominal or minimum.

<sup>B</sup> The tolerances provided in the table are based on minimum thickness (tolerance over, no tolerance under). For nominal thickness, the tolerance is divided equally over and under.

<sup>C</sup> Where an ellipsis (. . .) appears in the table, the requirements have not been defined.

manufacturer to be free of stretcher strain and fluting. Subsequent user roller leveling immediately before fabrication will minimize strain resulting from aging.

9.2.1 Cold-rolled carbon sheet, when ordered for exposed applications, can be supplied in the following finishes:

9.2.1.1 Matte finish is a dull finish, without luster, produced by rolling on rolls that have been roughened by mechanical or chemical means to various degrees of surface texture depending upon application. With some surface preparation matte finish is suitable for decorative painting. It is not generally recommended for bright plating.

9.2.1.2 Commercial bright finish is a relatively bright finish having a surface texture intermediate between that of matte and luster finish. With some surface preparation commercial bright finish is suitable for decorative painting or certain plating applications. If sheet is deformed in fabrication the surface may roughen to some degree and areas so affected will require surface preparation to restore surface texture to that of the undeformed areas.



**TABLE 8 Width Tolerances<sup>4</sup> of Hot-Rolled Mill Edge Sheet (All Designations)**  
(Coils and Cut Lengths, Including Pickled)

Carbon	
Specified Width, in.	Tolerances Over Specified Width, in. No Tolerance Under
Over 12 to 14 incl	7/16
Over 14 to 17 incl	1/2
Over 17 to 19 incl	9/16
Over 19 to 21 incl	5/8
Over 21 to 24 incl	11/16
Over 24 to 26 incl	13/16
Over 26 to 30 incl	15/16
Over 30 to 50 incl	1 1/8
Over 50 to 78 incl	1 1/2
Over 78	1 7/8
High-Strength Low-Alloy	
Over 12 to 14 incl	7/16
Over 14 to 17 incl	1/2
Over 17 to 19 incl	9/16
Over 19 to 21 incl	5/8
Over 21 to 24 incl	11/16
Over 24 to 26 incl	13/16
Over 26 to 28 incl	15/16
Over 28 to 35 incl	1 1/8
Over 35 to 50 incl	1 1/4
Over 50 to 60 incl	1 1/2
Over 60 to 65 incl	1 5/8
Over 65 to 70 incl	1 3/4
Over 70 to 80 incl	1 7/8
Over 80	2

<sup>4</sup> The above tolerances do not apply to the uncropped ends of mill edge coils (10.1.1.1).

**TABLE 9 Width Tolerances of Hot-Rolled Cut Edge Sheet and Cold-Rolled Sheet (Over 12 in. Width) (All Designations)**  
(Not Resquared, Coils and Cut Lengths, Including Pickled)

Specified Width, in.	Tolerances Over Specified Width, in. No Tolerance Under
Over 12 to 30 incl	1/8
To 30 incl	1/8
Over 30 to 48 incl	3/16
Over 48 to 60 incl	1/4
Over 60 to 80 incl	5/16
Over 80	3/8

9.2.1.3 Luster finish is a smooth bright finish produced by rolling on ground rolls and is suitable for decorative painting or plating with additional special surface preparation by the user. The luster may not be retained after fabrication; therefore, the formed parts will require surface preparation to make them suitable for bright plating.

9.3 Cold-rolled carbon sheet, when intended for unexposed applications, is not subject to limitations on degree and frequency of surface imperfections, and restrictions on texture and mechanical properties are not applicable. When ordered as “annealed last,” the product will have coil breaks and a tendency toward fluting and stretcher straining. Unexposed cold-rolled sheet may contain more surface imperfections than exposed cold-rolled sheet because steel applications, processing procedures, and inspection standards are less stringent.

9.4 Cold-rolled high-strength low-alloy sheet is supplied with a matte finish, unless otherwise specified.

9.5 The cold-rolled products covered by this specification are furnished with cut edges and square cut ends, unless otherwise specified.

9.6 *Oiling:*

9.6.1 Plain hot-rolled sheet is customarily furnished not oiled. Oiling must be specified, when required.

9.6.2 Hot-rolled pickled or descaled sheet is customarily furnished oiled. If the product is not to be oiled, it must be so specified since the cleaned surface is prone to rusting.

**TABLE 10 Length Tolerances of Hot-Rolled Sheet (All Designations)**  
(Cut Lengths Not Resquared, Including Pickled)

Specified Length, in.	Tolerances Over Specified Length, in. No Tolerance Under
To 15 incl	1/8
Over 15 to 30 incl	1/4
Over 30 to 60 incl	1/2
Over 60 to 120 incl	3/4
Over 120 to 156 incl	1
Over 156 to 192 incl	1 1/4
Over 192 to 240 incl	1 1/2
Over 240	1 3/4

**TABLE 11 Diameter Tolerances of Circles Sheared from Hot-Rolled (Including Pickled) and Cold-Rolled Sheet (Over 12 in. Width) (All Designations)**

Specified Thickness, <sup>A</sup> in.	Tolerances Over Specified Diameter, in. (No Tolerances Under)		
	Under 30	Over 30 to 48 incl	Over 48
0.044 to 0.057 incl	1/16	1/8	3/16
Over 0.057 to 0.098 incl	3/32	5/32	7/32
Over 0.098	1/8	3/16	1/4

<sup>A</sup> 0.071 in. minimum thickness for hot-rolled high-strength low-alloy steel sheet.

**TABLE 12 Camber Tolerances<sup>A</sup> for Hot-Rolled (Including Pickled) and Cold-Rolled Sheet (Over 12 in. Width) (All Designations)**  
(Cut Lengths, not Resquared)

NOTE 1—Camber is the greatest deviation of a side edge from a straight line, the measurement being taken on the concave side with a straightedge.

Cut Length, ft	Camber Tolerances, in.
To 4 incl	1/8
Over 4 to 6 incl	3/16
Over 6 to 8 incl	1/4
Over 8 to 10 incl	5/16
Over 10 to 12 incl	3/8
Over 12 to 14 incl	1/2
Over 14 to 16 incl	5/8
Over 16 to 18 incl	3/4
Over 18 to 20 incl	7/8
Over 20 to 30 incl	1 1/4
Over 30 to 40 incl	1 1/2

<sup>A</sup> The camber tolerance for coils is 1 in. in any 20 ft.

9.6.3 Cold-rolled products covered by this specification can be furnished oiled or not oiled as specified.

9.7 Sheet steel in coils or cut lengths may contain surface imperfections that can be removed with a reasonable amount of metal finishing by the purchaser.

## 10. Workmanship

10.1 Cut lengths shall have a workmanlike appearance and shall not have imperfections of a nature or degree for the product, the grade, class, and the quality ordered that will be detrimental to the fabrication of the finished part.

10.2 Coils may contain some abnormal imperfections that render a portion of the coil unusable since the inspection of coils does not afford the producer the same opportunity to remove portions containing imperfections as in the case with cut lengths.

### 10.3 Surface Conditions:

10.3.1 Exposed cold-rolled sheet is intended for applications where surface appearance is of primary importance, that is, exposed applications. Unexposed or annealed cold-rolled sheet is intended for applications where surface appearance is not of primary importance, that is, unexposed applications.

**TABLE 13 Out-of-Square Tolerances of Hot-Rolled Cut-Edge  
(Including Pickled) and Cold-Rolled Sheet (Over 12 in. Width) (All  
Designations)**  
(Cut Lengths Not Resquared)

Out-of-square is the greatest deviation of an end edge from a straight line at right angle to a side and touching one corner. It is also obtained by measuring the difference between the diagonals of the cut length. The out-of-square deviation is one half of that difference. The tolerance for all thicknesses and all sizes is  $\frac{1}{16}$  in./6 in. of width or fraction thereof.

**TABLE 14 Restricted Squareness Tolerances of Hot-Rolled  
(Including Pickled) and Cold-Rolled Sheet (Over 12 in. Width) (All  
Designations)**  
(Cut Lengths)

When cut lengths are specified resquared, the width and the length are not less than the dimensions specified. The individual tolerance for over-width, over-length, camber, or out-of-square should not exceed  $\frac{1}{16}$  in. up to and including 48 in. in width and up to and including 120 in. in length. For cut lengths wider or longer, the applicable tolerance is  $\frac{1}{8}$  in.

**TABLE 15 Flatness Tolerances<sup>A</sup> of Temper Rolled or Pickled  
Hot-Rolled Sheet Cut Lengths<sup>B</sup> (All Designations)**

Specified Minimum Thickness, in.	Specified Width, in.	Flatness Tolerances, <sup>C</sup> in.	
		Specified Yield Strength, min, ksi	
		Under 45	45 to 50 <sup>D,E</sup>
0.027 to 0.057 incl	over 12 to 36 incl	$\frac{1}{8}$	$\frac{3}{4}$
	over 36 to 60 incl	$\frac{3}{4}$	$1\frac{1}{8}$
0.027 to 0.057 incl	over 60	†	...
	To 36 incl	$\frac{1}{2}$	$\frac{3}{4}$
	over 36 to 60 incl	$\frac{3}{4}$	$1\frac{1}{8}$
0.057 to 0.180 excl	over 60	1	...
	over 12 to 60 incl	$\frac{1}{2}$	$\frac{3}{4}$
0.057 to 0.180 excl	over 60 to 72 incl	$\frac{3}{4}$	$1\frac{1}{8}$
	over 72	†	$1\frac{1}{2}$
	To 60 incl	$\frac{1}{2}$	$\frac{3}{4}$
	over 60 to 72 incl	$\frac{3}{4}$	$1\frac{1}{8}$
0.180 to 0.230 excl	over 72	1	$1\frac{1}{2}$
	over 12 to 60 incl	$\frac{1}{2}$	$\frac{3}{4}$
0.180 to 0.230 excl	over 60 to 72 incl	$\frac{3}{4}$	$1\frac{1}{8}$
	over 72	†	$1\frac{1}{2}$
	To 60 incl	$\frac{1}{2}$	$\frac{3}{4}$
0.180 to 0.230 excl	over 60 to 72 incl	$\frac{3}{4}$	$1\frac{1}{8}$
	over 72	1	$1\frac{1}{2}$

<sup>A</sup> The above table also applies to lengths cut from coils by the consumer when adequate flattening operations are performed.

<sup>B</sup> Application of this table to product in coil form is not appropriate unless the coil has been rolled out and adequately flattened with all coil set removed.

<sup>C</sup> Maximum deviation from a horizontal flat surface.

<sup>D</sup> Tolerances for steels with specified minimum yield strength in excess of 50 ksi are subject to negotiation.

<sup>E</sup> 0.071 minimum thickness of HSLA.

10.3.2 Cut lengths for exposed applications shall not include individual sheets having major surface imperfections (holes, loose slivers, and pipe) and repetitive minor surface imperfections. Cut lengths may contain random minor surface imperfections that can be removed with a reasonable amount of metal finishing by the purchaser. These imperfections shall be acceptable to the purchaser within the manufacturer's published standards.

10.3.3 For coils for exposed applications, it is not possible to remove the surface imperfections listed in 10.3.2. Coils will contain such imperfections which shall be acceptable to the purchaser within the manufacturer's published standards. Coils contain more surface imperfections than cut lengths because the producer does not have the same opportunity to sort portions containing such imperfections as is possible with cut lengths.

10.3.4 Cut lengths for unexposed applications shall not include individual sheets having major surface imperfections such as holes, loose slivers, and pipe. In addition, unexposed cut lengths can be expected to contain more minor imperfections such as pits,