Designation: A 20/A 20M – 07

Standard Specification for General Requirements for Steel Plates for Pressure Vessels[1]

This standard is issued under the fixed designation A 20/A 20M; 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 Department of Defense.

1. Scope*

1.1 This general requirements specification[2] covers a group of common requirements that, unless otherwise specified in the applicable product specification, apply to rolled steel plates for pressure vessels covered by each of the following product specifications issued by ASTM:

Title of Specification	ASTM Designation[A]
Pressure Vessel Plates, Alloy Steel, Chromium-Manganese Silicon	A 202/A 202M
Pressure Vessel Plates, Alloy Steel, Nickel	A 203/A 203M
Pressure Vessel Plates, Alloy Steel, Molybdenum	A 204/A 204M
Pressure Vessel Plates, Alloy Steel, Manganese-Vanadium	A 225/A 225M
Pressure Vessel Plates, Carbon Steel, Low- and Intermediate-Tensile Strength	A 285/A 285M
Pressure Vessel Plates, Carbon Steel, Manganese-Silicon	A 299/A 299M
Pressure Vessel Plates, Alloy Steel, Manganese-Molybdenum and Manganese-Molybdenum-Nickel	A 302/A 302M
Pressure Vessel Plates, Alloy Steel, 9 Percent Nickel Double-Normalized and Tempered	A 353/A 353M
Pressure Vessel Plates, Alloy Steel, Chromium-Molybdenum	A 387/A 387M
Pressure Vessel Plates, Carbon Steel, High Strength Manganese	A 455/A 455M
Pressure Vessel Plates, Carbon Steel, for Intermediate- and Higher-Temperature Service	A 515/A 515M
Pressure Vessel Plates, Carbon Steel, Moderate- and Lower-Temperature Service	A 516/A 516M
Pressure Vessel Plates, Alloy Steel, High-Strength, Quenched and Tempered	A 517/A 517M
Pressure Vessel Plates, Alloy Steel, Quenched and Tempered Manganese-Molybdenum and Manganese-Molybdenum-Nickel	A 533/A 533M
Pressure Vessel Plates, Heat-Treated, Carbon-Manganese-Silicon Steel	A 537/A 537M
Pressure Vessel Plates, Alloy Steel, Quenched and Tempered Chromium-Molybdenum	A 542/A 542M
Pressure Vessel Plates, Alloy Steel, Quenched and Tempered Nickel-Chromium-Molybdenum	A 543/A 543M
Pressure Vessel Plates, Alloy Steel, Quenched and Tempered 8 and 9 Percent Nickel	A 553/A 553M
Pressure Vessel Plates, Carbon Steel, Manganese-Titanium for Glass or Diffused Metallic Coatings	A 562/A 562M
Pressure Vessel Plates, Carbon Steel, High Strength, for Moderate and Lower Temperature Service	A 612/A 612M
Pressure Vessel Plates, Five Percent Nickel Alloy Steel, Specially Heat Treated	A 645/A 645M
Pressure Vessel Plates, Carbon-Manganese, for Moderate and Lower Temperature Service	A 662/A 662M
Pressure Vessel Plates, Carbon Steel, Quenched and Tempered, for Welded Layered Pressure Vessels	A 724/A 724M
Pressure Vessel Plates, Alloy Steel and High-Strength Low-Alloy Steel, Quenched and Tempered	A 734/A 734M
Pressure Vessel Plates, Low-Carbon Manganese-Molybdenum-Columbium Alloy Steel, for Moderate and Lower Temperature Service	A 735/A 735M
Pressure Vessel Plates, Low-Carbon Age-Hardening Nickel-Copper-Chromium-Molybdenum-Columbium Alloy Steel	A 736/A 736M
Pressure Vessel Plates, High-Strength Low-Alloy Steel	A 737/A 737M
Pressure Vessel Plates, Heat-Treated, Carbon-Manganese-Silicon Steel, for Moderate and Lower Temperature Service	A 738/A 738M
Pressure-Vessel Plates, Quenched and Tempered, Manganese-Chromium-Molybdenum-Silicon-Zirconium Alloy Steel	A 782/A 782M
Pressure Vessel Plates, Alloy Steel, Chromium-Molybdenum-Vanadium	A 832/A 832M
Pressure Vessel Plates, Produced by the Thermo-Mechanical Control Process (TMCP)	A 841/A 841M
Pressure Vessel Plates, 9 % Nickel Alloy, Produced by the Direct-Quenching Process	A 844/A 844M
Pressure Vessel Plates, 9 % Nickel Alloy, Produced by the Direct-Quenching Process	A 844/A 844M
Pressure Vessel Plates, 9 % Nickel Alloy, Produced by the Direct-Quenching Process	A 844/A 844M
Pressure Vessel Plates, Alloy Steel, Chromium-Molybdenum-Tungsten	A 1017/ A 1017M
Pressure Vessel Plates, Alloy Steel, Higher Strength Chromium-Molybdenum-Tungsten	A 1041/ A 1041M

[A] These designations refer to the latest issue of the respective specification which appears in the *Annual Book of ASTM Standards*, Vol 01.04.

1.1.1 This general requirements specification also covers a group of supplementary requirements that are applicable to several of the above product specifications as indicated therein. Such requirements are provided for use if additional testing or additional restrictions are required by the purchaser, and apply only if specified individually in the purchase order.

1.2 Appendix X1 provides information on coil as a source of plates for pressure vessels.

1.3 Appendix X2 provides information on the variability of tensile properties in plates for pressure vessels.

1.4 Appendix X3 provides information on the variability of Charpy-V-Notch impact test properties in plates for pressure vessels.

1.5 Appendix X4 provides information on cold bending of plates, including suggested minimum inside radii for cold bending.

[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 A01.11 on Steel Plates for Boilers and Pressure Vessels.

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[2] For ASME Boiler and Pressure Vessel Code applications, see related Specification SA-20/SA-20M in Section II of that Code.

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

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1.6 These materials are intended to be suitable for fusion welding. When the steel is to be welded, it is presupposed that a welding procedure suitable for the grade of steel and intended use or service will be utilized.

1.7 In case of any conflict in requirements, the requirements of the applicable product specification prevail over those of this general requirements specification.

1.8 Additional requirements that are specified in the purchase order and accepted by the supplier are permitted, provided that such requirements do not negate any of the requirements of this general requirements specification or the applicable product specification.

1.9 For purposes of determining conformance with this general requirements specification and the applicable product specification, values are to 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 29.

1.10 The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in non-conformance with the standard.

1.11 This general requirements specification and the applicable product specification are expressed in both inch-pound units and SI units; unless the order specifies the applicable "M" specification designation (SI units), the plates are to be furnished to inch-pound units.

2. Referenced Documents

2.1 *ASTM Standards:* [3]

A 202/A 202M Specification for Pressure Vessel Plates, Alloy Steel, Chromium-Manganese-Silicon[4]

A 203/A 203M Specification for Pressure Vessel Plates, Alloy Steel, Nickel

A 204/A 204M Specification for Pressure Vessel Plates, Alloy Steel, Molybdenum

A 225/A 225M Specification for Pressure Vessel Plates, Alloy Steel, Manganese-Vanadium-Nickel

A 285/A 285M Specification for Pressure Vessel Plates, Carbon Steel, Low- and Intermediate-Tensile Strength

A 299/A 299M Specification for Pressure Vessel Plates, Carbon Steel, Manganese-Silicon

A 302/A 302M Specification for Pressure Vessel Plates, Alloy Steel, Manganese-Molybdenum and Manganese-Molybdenum-Nickel

A 353/A 353M Specification for Pressure Vessel Plates, Alloy Steel, 9 Percent Nickel, Double-Normalized and Tempered

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

A 387/A 387M Specification for Pressure Vessel Plates, Alloy Steel, Chromium-Molybdenum

A 435/A 435M Specification for Straight-Beam Ultrasonic Examination of Steel Plates

A 455/A 455M Specification for Pressure Vessel Plates, Carbon Steel, High-Strength Manganese

A 515/A 515M Specification for Pressure Vessel Plates, Carbon Steel, for Intermediate- and Higher-Temperature Service

A 516/A 516M Specification for Pressure Vessel Plates, Carbon Steel, for Moderate- and Lower-Temperature Service

A 517/A 517M Specification for Pressure Vessel Plates, Alloy Steel, High-Strength, Quenched and Tempered

A 533/A 533M Specification for Pressure Vessel Plates, Alloy Steel, Quenched and Tempered, Manganese-Molybdenum and Manganese-Molybdenum-Nickel

A 537/A 537M Specification for Pressure Vessel Plates, Heat-Treated, Carbon-Manganese-Silicon Steel

A 542/A 542M Specification for Pressure Vessel Plates, Alloy Steel, Quenched-and-Tempered, Chromium-Molybdenum, and Chromium-Molybdenum-Vanadium

A 543/A 543M Specification for Pressure Vessel Plates, Alloy Steel, Quenched and Tempered Nickel-Chromium-Molybdenum

A 553/A 553M Specification for Pressure Vessel Plates, Alloy Steel, Quenched and Tempered 8 and 9 % Nickel

A 562/A 562M Specification for Pressure Vessel Plates, Carbon Steel, Manganese-Titanium for Glass or Diffused Metallic Coatings

A 577/A 577M Specification for Ultrasonic Angle-Beam Examination of Steel Plates

A 578/A 578M Specification for Straight-Beam Ultrasonic Examination of Rolled Steel Plates for Special Applications

A 612/A 612M Specification for Pressure Vessel Plates, Carbon Steel, High Strength, for Moderate and Lower Temperature Service

A 645/A 645M Specification for Pressure Vessel Plates, 5 % and 5 12 % Nickel Alloy Steels, Specially Heat Treated

A 662/A 662M Specification for Pressure Vessel Plates, Carbon-Manganese-Silicon Steel, for Moderate and Lower Temperature Service

A 700 Practices for Packaging, Marking, and Loading Methods for Steel Products for Shipment

A 724/A 724M Specification for Pressure Vessel Plates, Carbon-Manganese-Silicon Steel, Quenched and Tempered, for Welded Pressure Vessels

A 734/A 734M Specification for Pressure Vessel Plates, Alloy Steel and High-Strength Low-Alloy Steel, Quenched-and-Tempered

A 735/A 735M Specification for Pressure Vessel Plates, Low-Carbon Manganese-Molybdenum-Columbium Alloy Steel, for Moderate and Lower Temperature Service

A 736/A 736M Specification for Pressure Vessel Plates, Low-Carbon Age-Hardening Nickel-Copper-Chromium-Molybdenum-Columbium and Nickel-Copper-Manganese-Molybdenum-Columbium Alloy Steel

[3] 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.

[4] Withdrawn.

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A 737/A 737M Specification for Pressure Vessel Plates, High-Strength, Low-Alloy Steel
A 738/A 738M Specification for Pressure Vessel Plates, Heat-Treated, Carbon-Manganese-Silicon Steel, for Moderate and Lower Temperature Service
A 751 Test Methods, Practices, and Terminology for Chemical Analysis of Steel Products
A 770/A 770M Specification for Through-Thickness Tension Testing of Steel Plates for Special Applications
A 782/A 782M Specification for Pressure-Vessel Plates, Quenched-and-Tempered, Manganese-Chromium-Molybdenum-Silicon Zirconium Alloy Steel
A 832/A 832M Specification for Pressure Vessel Plates, Alloy Steel, Chromium-Molybdenum-Vanadium
A 841/A 841M Specification for Steel Plates for Pressure Vessels, Produced by Thermo-Mechanical Control Process (TMCP)
A 844/A 844M Specification for Steel Plates, 9 % Nickel Alloy, for Pressure Vessels, Produced by the Direct-Quenching Process
A 941 Terminology Relating to Steel, Stainless Steel, Related Alloys, and Ferroalloys
A 1017/A 1017M Specification for Pressure Vessel Plates, Alloy Steel, Chromium-Molybdenum-Tungsten
A 1041/A 1041M Specification for Pressure Vessel Plates, Alloy Steel, Higher Strength Chromium-Molybdenum-Tungsten
E 21 Test Methods for Elevated Temperature Tension Tests of Metallic Materials
E 29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications
E 112 Test Methods for Determining Average Grain Size
E 208 Test Method for Conducting Drop-Weight Test to Determine Nil-Ductility Transition Temperature of Ferritic Steels
E 709 Guide for Magnetic Particle Examination

2.2 *American Society of Mechanical Engineers Code:*
ASME Boiler and Pressure Vessel Code, Section IX, Welding Qualifications [5]

2.3 *U.S. Military Standard:*
MIL-STD-163 Steel Mill Products Preparation for Shipment and Storage[6]

2.4 *U.S. Federal Standard:*
Fed. Std. No. 123, Marking for Shipment (Civil Agencies)[6]

2.5 *Automotive Industry Action Group Standard:*
B 1 Bar Code Symbology Standard[7]

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *coil*—hot-rolled steel in coil form for processing into finished plates.

3.1.2 *exclusive*—when used in relation to ranges, as for ranges of thicknesses in the tables of permissible variations in dimensions, the term is intended to exclude only the greater value of the range. Thus, a range from 60 to 72 in. [1500 to 1800 mm] *exclusive* includes 60 in. [1500 mm], but does not include 72 in. [1800 mm].

3.1.3 *heat treatment terms*—see 3.1.8, and Terminology A 941.

3.1.4 *hot forming*—a forming operation producing permanent deformation, performed after the plate has been heated to the temperature required to produce grain refinement.

3.1.5 *manufacturer*—the organization that directly controls the conversion of steel ingots or slabs, by hot rolling, into plate-as-rolled or into coil; and for plates produced from plate-as-rolled, the organization that directly controls, or is responsible for, one or more of the operations involved in finishing the plates. Such finishing operations include leveling, cutting to length, testing, inspection, conditioning, heat treatment (if applicable), packaging, marking, loading for shipment, and certification.

3.1.5.1 *Discussion*—The finishing operations need not be done by the organization that did the hot rolling of the plate. For plates produced from coil, see also 3.1.13.1.

3.1.6 *plate identifier*—the alpha, numeric, or alphanumeric designation used to identify the plate.

3.1.7 *plates*— flat hot-rolled steel, ordered to thickness or weight and typically to width and length, commonly available by size as follows:

Width, in. [mm]	Thickness, in. [mm]
Over 8 [200]	over 0.229 [6.0 mm and over]
Over 48 [1200]	over 0.179 [4.6 mm and over]

3.1.7.1 *Discussion*—Steel plates are available in various thickness, width, and length combinations dependent upon equipment and processing capabilities of various manufacturers and processors. Historic limitations of a plate based upon dimensions (thickness, width, and length) do not take into account current production and processing capabilities. To qualify any plate to a particular product specification requires that 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 can not be conducted, the plate can not 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 purchaser and the manufacturer or processor, whichever is applicable.

3.1.8 *precipitation heat treatment*—a subcritical temperature thermal treatment performed to cause precipitation of submicroscopic constituents, and so forth, to result in enhancement of some desirable property.

3.1.9 *processor*—the organization that directly controls, or is responsible for, operations involved in the processing of coil into finished plates. Such processing operations include decoiling, leveling, cutting to length, testing, inspection, conditioning, heat treatment (if applicable), packaging, marking, loading for shipment, and certification.

3.1.9.1 *Discussion*—The processing operations need not be done by the organization that did the hot rolling of the coil. If

[5] Available from American Society of Mechanical Engineers (ASME), ASME International Headquarters, Three Park Ave., New York, NY 10016-5990, http://www.asme.org.

[6] Available from the procuring activity or as directed by the contracting office or from Standardization Documents Order Desk, Bldg. 4 Section D, 700 Robbins Ave., Philadelphia, PA 19111-5094, Attn: NPODS.

[7] Available from Automotive Industry Action Group, 26200 Lahser Road, Suite 200, Southfield, MI 48034.

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only one organization is involved in the hot rolling and processing operations, that organization is termed the *manufacturer* for the hot rolling operation and the *processor* for the processing operations. If more than one organization is involved in the hot rolling and processing operations, the organization that did the hot rolling is termed the *manufacturer* and the organization that does one or more processing operations is termed a *processor*.

3.2 Refer to Terminology A 941 for additional terms used in this standard.

4. Ordering Information

4.1 Orders should include the following information, as necessary, to adequately describe the desired product.

4.1.1 Quantity (weight [mass] or number of plates),

4.1.2 Dimensions,

4.1.3 Name of product (for example, plates, carbon steel; plates, alloy steel),

4.1.4 Specification designation (including type, class, and grade as applicable) and year-date,

4.1.5 Condition (as-rolled, normalized, quenched and tempered, etc. If heat treatment of plate is to be performed by the fabricator, this is to be stated. Also, if purchaser specifies a heat-treatment cycle, this is to be stated),

4.1.6 Impact test requirements, if any (see Section 12). (For Charpy V-notch test, include test specimen orientation, testing temperature, and acceptance criteria. For drop-weight test, give testing temperature),

4.1.7 Exclusion of either plates produced from coil or plates produced from plate-as-rolled, if applicable. (See 5.4 and Appendix X1.)

4.1.8 Limits for grain refining elements other than aluminum, if applicable (see 8.2.4),

4.1.9 Paint marking (see 13.2.1),

4.1.10 Supplementary requirements, if any (test specimen heat treatment, special impact test requirements, etc.), and

4.1.11 Additional requirements, if any.

5. Materials and Manufacture

5.1 The steel shall be made in an open-hearth, basic-oxygen, or electric-arc furnace, possibly followed by additional refining in a ladle metallurgy furnace (LMF), or by another method; or secondary melting by vacuum-arc remelting (VAR), electroslag remelting (ESR), or another method.

5.2 The steel may be strand cast or cast in stationary molds.

5.2.1 *Strand Cast Slabs*:

5.2.1.1 If heats of the same nominal chemical composition are consecutively strand cast at one time, the heat number assigned to the cast product (slab) may remain unchanged until all of the steel in the slab is from the following heat.

5.2.1.2 When two consecutively strand cast heats have different nominal chemical composition ranges, the manufacturer shall remove the transition material by any established procedure that positively separates the grades.

5.3 The ratio of reduction of thickness from a strand-cast slab to plate shall be at least 3.0:1, except that reduction ratios as low as 2.0:1 are permitted if all of the following limitations are met:

5.3.1 The purchaser agrees to the use of such reduction ratios.

5.3.2 The applicable product specification is A 299/A 299M, A 515/A 515M, A 516/A 516M, A 537/A 537M, A 662/A 662M, or A 737/A 737M.

5.3.3 The specified plate thickness is 3.0 in. [75 mm] or more.

5.3.4 One or more of the following low hydrogen practices are used: vacuum degassing during steelmaking; controlled soaking of the slabs or plates; or controlled slow cooling of the slabs or plates.

5.3.5 The sulfur content is 0.004 % or less, based upon heat analysis.

5.3.6 One or more of the following practices are used: electromagnetic stirring during strand casting; soft reduction during strand casting; heavy pass reductions or other special practices during plate rolling; or combined forging and rolling during plate rolling.

5.3.7 The plates are ultrasonically examined in accordance with Specification A 578/A 578M, Level C based on continuous scanning over 100 % of the plate surface.

5.3.8 The plates are through-thickness tension tested in accordance with Specification A 770/A 770M.

5.4 Unless otherwise specified in the purchase order, plates shall be produced from plate-as-rolled or from coil.

5.5 Coils are excluded from qualification to the applicable product specification until they are decoiled, leveled, cut to length, and tested by the processor in accordance with the specified requirements (see Sections 9, 10, 11, 12, 13, 14, 15, 16, and 20.)

5.5.1 Plates produced from coil shall not contain splice welds, unless approved by the purchaser.

6. Heat Treatment

6.1 If plates are required to be heat treated, the heat treatment shall be performed by the manufacturer, the processor, or the fabricator, unless otherwise specified in the applicable product specification.

6.2 If the heat treatment required by the applicable product specification is to be performed by the purchaser or the purchaser's agent, and the plates are to be supplied by the manufacturer or processor in a condition other than that required by the applicable product specification, the order shall so state.

6.2.1 If plates are ordered without the heat treatment required by the applicable product specification, heat treatment of the plates to conform to the requirements of the applicable product specification shall be the responsibility of the purchaser.

6.3 If heat treatment is to be performed, the plates shall be heat treated as specified in the applicable product specification. The purchaser may specify the heat treatment to be used, provided it is not in conflict with the requirements of the applicable product specification.

6.4 If normalizing is to be performed by the fabricator, the plates shall be either normalized or heated uniformly for hot forming, provided that the temperature to which the plates are heated for hot forming does not significantly exceed the normalizing temperature.

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6.5 If no heat treatment is required, the manufacturer or processor shall have the option of heat treating the plates by normalizing, stress relieving, or normalizing and then stress relieving to meet the requirements of the applicable product specification.

6.6 If approved by the purchaser, cooling rates faster than those obtained by cooling in air are permissible to achieve specified mechanical properties, provided that the plates are subsequently tempered in the temperature range from 1100 to 1300 °F [595 to 705 °C].

7. Chemical Composition

7.1 *Heat Analysis*

7.1.1 Sampling for chemical analysis and methods of analysis shall be in accordance with Test Methods, Practices, and Terminology A 751.

7.1.2 For each heat, the heat analysis shall include determination of the content of carbon, manganese, phosphorus, sulfur, silicon, nickel, chromium, molybdenum, copper, vanadium, columbium; any other element that is specified or restricted by the applicable product specification for the applicable grade, class, and type; aluminum, if the aluminum content is to be used in place of austenitic grain size testing of the heat (see 8.2.2.1); and any other austenitic grain refining element for which limits are specified in the purchase order (see 8.2.4).

7.1.3 Heat analyses shall conform to the heat analysis requirements of the applicable product specification for the applicable grade, class, and type. In addition, for elements that are listed in Table 1 but are not specified or restricted in the applicable product specification for the applicable grade, class, and type, heat analyses shall conform to the applicable heat analysis limits given in Table 1.

7.2 *Product Analysis:*

7.2.1 Sampling for chemical analysis and methods of analysis shall be in accordance with Test Methods, Practices, and Terminology A 751.

7.2.2 For each plate-as-rolled, the purchaser shall have the option of chemically analyzing a broken tension test specimen or a sample taken from the same relative location as that from which the tension test specimen was obtained.

7.2.3 For elements that are specified or restricted by the applicable product specification for the applicable grade, class, and type, product analyses shall conform to the product analysis requirements of the applicable product specification for the applicable grade, class, and type.

7.2.4 For elements that are listed in Table 1 but are not specified or restricted by the applicable product specification for the applicable grade, class, and type, product analyses shall conform to the applicable product analysis limits given in Table 1.

7.3 *Referee Analysis*—For referee purposes, Test Methods, Practices, and Terminology A 751 shall be used.

8. Metallurgical Structure

8.1 If coarse austenitic grain size is specified, the steel shall have a carburized austenitic grain size number in the range from 1 to 5, inclusive, as determined by the McQuaid-Ehn Test. Determinations shall be in accordance with Test Methods E 112, Plate IV, by carburizing for 8 h at 1700 °F [925 °C]. At least 70 % of the grains in the area examined shall conform to the specified grain size requirement. One test per heat shall be made.

TABLE 1 Limits on Elements (see 7.1.3 and 7.2.4)

Copper, max %[A]	Heat analysis	0.40
	Product analysis	0.43
Nickel, max %[A]	Heat analysis	0.40
	Product analysis	0.43
Chromium, max %[A,B]	Heat analysis	0.30
	Product analysis	0.34
Molybdenum, max %[A,B]	Heat analysis	0.12
	Product analysis	0.13
Vanadium, max %[C]	Heat analysis	0.03
	Product analysis	0.04
Columbium, max %[D]	Heat analysis	0.02
	Product analysis	0.03
Titanium, max %[E]	Heat analysis	0.03
	Product analysis	0.04

[A] In addition for each heat, based upon the heat analysis, the sum of copper, nickel, chromium, and molybdenum shall not exceed 1.00 %, unless one or more of those elements are specified or restricted by the applicable product specification for the applicable grade, class, and type.

[B] In addition for each heat, based upon the heat analysis, the sum of chromium and molybdenum shall not exceed 0.32 %, unless one or both of those elements are specified or restricted by the applicable product specification for the applicable grade, class, and type.

[C] By agreement between the purchaser and the supplier, the heat analysis limit for vanadium is permitted to be increased to a value not higher than 0.10 %, and the product analysis limit for vanadium is permitted to be increased to a value not higher than 0.11 %.

[D] By agreement between the purchaser and the supplier, the heat analysis limit for columbium is permitted to be increased to a value not higher that 0.05 %, and the product analysis limit for columbium is permitted to be increased to a value not higher than 0.06 %.

[E] By agreement between the purchaser and the supplier, the heat analysis limit for titanium is permitted to be increased to a value not higher than 0.04 %, and the product analysis limit for titanium is permitted to be increased to a value not higher than 0.05 %.

8.2 *Fine Austenitic Grain Size*:

8.2.1 If fine austenitic grain size is specified, aluminum shall be used as the grain refining element, except as allowed by 8.2.4.

8.2.2 If fine austenitic grain size is specified, except as allowed by 8.2.2.1, the steel shall have a carburized austenitic grain size number of 5 or higher (finer) as determined by the McQuaid-Ehn test in accordance with Methods E 112, Plate IV. One test per heat shall be made.

8.2.2.1 If aluminum is used as the grain refining element, the fine austenitic grain size requirement shall be deemed to be fulfilled if, on heat analysis, the aluminum content is not less than 0.020 % total aluminum or, alternatively, 0.015 % acid soluble aluminum.

8.2.3 If specified in the purchase order, one McQuaid-Ehn test (see 8.1) per heat shall be made and the austenitic grain size of the steel, as represented by the test, shall be Number 5 or finer.

8.2.4 By agreement between the purchaser and the manufacturer or processor, elements other than aluminum may be used for grain refining. In such instances, the heat analysis limits for the element, or elements, permitted shall be as

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specified in the purchase order. In addition, the McQuaid-Ehn test of 8.2.3 shall be required.

9. Quality

9.1 *General*— Plates shall be free of injurious defects and shall have a workmanlike finish.

9.2 *Surface Imperfections*:

9.2.1 For plates produced from plate-as-rolled, all injurious surface imperfections shall be removed by the manufacturer. For plates produced from coil, all injurious surface imperfections shall be removed by the processor.

9.2.1.1 Shallow imperfections shall be ground to sound metal; the ground area shall be well faired and the thickness of the ground plate shall not be reduced below the minimum thickness permitted.

9.2.1.2 All surface imperfections, the removal of which will reduce the plate thickness below the minimum thickness permitted, shall be cause for rejection of the plate, except that, by agreement with the purchaser, the metal so removed may be replaced with weld metal (see 9.4).

9.3 *Edge Imperfections*:

9.3.1 Laminar-type discontinuities 1 in. [25 mm] and less in length visible to the unaided eye on an edge of a plate as prepared for shipment by the manufacturer or processor are acceptable and do not require exploration.

9.3.2 All larger discontinuities shall be explored to determine their depth and extent. Discontinuities shall be considered continuous when located in the same plane within 5 % of the plate thickness and separated by a distance less than the length of the smaller of two adjacent discontinuities.

9.3.3 Indications visible to the unaided eye on the cut edges of a plate as prepared for shipment by the manufacturer or processor shall not exceed the limits given in Columns 1 and 2 of Table A1.14 [A2.14].

9.3.4 Larger indications shall be removed by the manufacturer or processor by grinding, provided that the resultant cavity does not exceed the limits given in Columns 3 and 4 of Table A1.14 [A2.14].

9.3.5 Indications of greater magnitude shall be cause for rejection of the plate, except that, by agreement with the purchaser, the defects may be removed and replaced with weld metal (see 9.4).

9.3.6 Indications on the edges of a plate cut during the fabrication shall be cause for rejection of the plate at the discretion of the purchaser if the magnitude exceeds the limits given in Columns 5 and 6 of Table A1.14 [A2.14]. The defects may be removed and replaced with weld metal (see 9.4).

9.3.7 Fabricators should be aware that edge cracks may initiate upon bending a sheared or burned edge during the fabrication process. 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.

9.4 *Repair by Welding*:

9.4.1 Repair welding shall be permitted only with the approval of the purchaser.

9.4.2 Preparation for repair welding shall include inspection to confirm complete removal of the defect.

9.4.3 Repairs shall be made utilizing welding procedures qualified in accordance with Section IX of the ASME Code and repair welding shall be done by welders or welding operators meeting the qualification requirements of ASME Section IX.

9.4.4 The weld metal shall have the A-number analysis corresponding to the equivalent ASME P-number of the plate, except that A-1 or A-2 analysis weld metal may be employed for P-1 plates. Other weld metals may be employed that are compatible with the plate being repaired, if so approved by the purchaser. Such weld metals shall be qualified in accordance with the requirements of Section IX of the ASME Code.

9.4.5 If Charpy impact tests of the plate are required, the welding procedure qualification tests shall also include Charpy impact tests of the weld, the heat-affected zone, and the plate, and the test results shall be reported to the purchaser.

9.4.6 If the plate is subjected to normalizing, quenching and tempering, hot forming, or post-weld heat treating, the welding procedure qualification test plates and the weld repaired plate shall be subjected to the thermal heat treatment as specified by the purchaser.

9.4.7 In addition, repair welds shall meet the requirements of the construction code specified by the purchaser.

10. Test Methods

10.1 All tests shall be conducted in accordance with Test Methods and Definitions A 370.

10.2 Yield strength shall be determined by either the 0.2 % offset method or the 0.5 % extension under load method, unless otherwise stated in the applicable product specification.

10.3 *Rounding Procedures*—For purposes of determining conformance with the applicable product specification, a calculated value shall be rounded to the nearest 1 ksi [5 MPa] for tensile and yield strengths, 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 method given in Practice E 29.

11. Tension Tests

11.1 *Number of Test Coupons*:

11.1.1 *Plates Produced from As-Rolled Plates*—For other than quenched and tempered plates, one tension test coupon shall be taken from each plate-as-rolled. Two tension test coupons shall be taken from each quenched and tempered plate, as heat treated. If plates are furnished by the manufacturer or processor in accordance with 11.4.2 and qualified by using test specimens taken from heat-treated test coupons (including normalized, normalized and tempered, and quenched and tempered), one tension test coupon shall be taken from each plate-as-rolled (see Terminology A 941 for the definition of plate-as-rolled).

11.1.2 *Plates Produced from Coil and Furnished without Heat Treatment or with Stress Relieving Only*—Except as allowed by 11.1.2.1 and 11.1.4, a minimum of three tension coupons shall be taken from each coil as follows:

11.1.2.1 The first test coupon shall be taken immediately prior to the first plate to be qualified to the applicable product specification, the second test coupon shall be taken from the approximate center lap, and the third test coupon shall be taken immediately after the last plate to be qualified to the applicable product specification. If, during decoiling, the amount of material decoiled is less than that required to reach the next

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standard test location, a test for qualification of that particular portion of the coil shall be made from a test coupon taken from a location adjacent to the innermost portion decoiled.

11.1.2.2 All plates between any two test locations that meet the requirements of the applicable product specification are acceptable.

11.1.2.3 All plates between a test location that fails to meet the requirements of the applicable product specification and an adjacent test location that meets the requirements of the applicable product specification are rejectable, except that the processor has the option to make other tests after cutting back the coil in either direction.

11.1.3 *Plates Produced from Coil and Furnished Heat Treated by Other than Stress Relieving*—For other than quenched and tempered plates, one tension test coupon shall be taken from each coil. Two tension test coupons shall be taken from each quenched and tempered plate, as heat treated.

11.1.4 *Plates Produced from Coil and Qualified Using Test Specimens Taken from Test Coupons Heat Treated by Other than Stress Relieving*—One tension test coupon shall be taken from each coil.

11.2 *Orientation of Test Specimens*—The longitudinal axis of the tension test specimens shall be transverse to the final rolling direction of the plate.

11.3 *Location of Test Coupons*—Tension test coupons shall be taken from a corner of the plate. For quenched and tempered plates, the two tension test coupons shall be taken from opposite ends of the plate.

11.4 *Tests from Heat-Treated Plates*:

11.4.1 If heat treatment is performed by the manufacturer or processor, the test specimens shall be taken from the plate in the heat-treated condition or from full-thickness coupons simultaneously heat treated with the plate.

11.4.2 If heat treatment is to be performed by the fabricator, the plates shall be accepted on the basis of tests made on test specimens taken from full-thickness coupons heat treated in accordance with the requirements specified in the applicable product specification or the purchase order. If the heat-treatment temperatures are not specified, the manufacturer or processor shall heat treat the coupons under conditions it considers appropriate. The purchaser shall be informed of the procedure followed in heat treating the specimens.

11.4.3 If approved by the purchaser, the procedures of 11.4.2 may be implemented on plates heat treated by the manufacturer or processor.

11.4.4 For plates that are heat treated with a cooling rate faster than still-air cooling from the austenitizing temperature, one of the following shall apply in addition to other requirements specified herein:

11.4.4.1 The gage length of the tension test specimen shall be taken at least 1*T* from any as-heat treated edge, where *T* is the thickness of the plate, and shall be at least ½ in. [12.5 mm] from flame-cut or heat-affected-zone surfaces.

11.4.4.2 A steel thermal buffer pad, 1*T* by 1*T* by at least 3*T*, shall be joined to the plate edge by a partial penetration weld completely sealing the buffered edge prior to heat treatment.

11.4.4.3 Thermal insulation or other thermal barriers shall be used during the heat treatment adjacent to the plate edge where the test specimens are to be removed. It shall be demonstrated that the cooling rate of the tension test specimen is no faster than, and not substantially slower than, that attained by the method described in 11.4.4.2.

11.4.4.4 When test coupons cut from the plate but heat treated separately are used, the coupon dimensions shall be not less than 3*T* by 3*T* by *T* and each tension test specimen cut from it shall meet the requirements of 11.4.4.1.

11.4.4.5 If cooling rate data for the plate and cooling rate control devices for the test coupons are available, the test coupons may be heat treated separately in the device, provided that this method is approved by the purchaser.

11.5 *Test Specimen Preparation*:

11.5.1 Tension test specimens for plates ¾ in. [20 mm] and under in thickness shall be the full thickness of the plates. The test specimens shall conform to the requirements for either the 1½-in. [40-mm] wide or the ½-in. [12.5-mm] wide rectangular tension test specimen of Methods and Definitions A 370. The 1½-in. [40-mm] wide test specimen may have both edges parallel. The ½-in. [12.5–mm] wide specimen may have a maximum nominal thickness of ¾ in. [20 mm].

11.5.2 For plates up to 4 in. [100 mm], inclusive, in thickness, tension test specimens may be the full thickness of the plate and conform to the requirements for the 1½-in. [40–mm] wide rectangular tension test specimen of Methods and Definitions A 370 if adequate testing machine capacity is available.

11.5.3 For plates over ¾ in. [20 mm] in thickness, except as permitted in 11.5.2, tension test specimens shall conform to the requirements for the 0.500-in. [12.5-mm] diameter test specimen of Methods and Definitions A 370. The axis of the test specimen shall be located midway between the center of thickness and the top or bottom surface of the plate.

11.6 *Elongation Requirement Adjustments*:

11.6.1 Due to the specimen geometry effect encountered when using the rectangular tension test specimen for testing thin plate, adjustments in elongation requirements must be provided for thicknesses under 0.312 in. [8 mm]. Accordingly, the following deductions shall be made from the base elongation requirements in the applicable product specification:

Plate Nominal Thickness Range, in. [mm]	Elongation Deduction, %
0.299–0.311 [7.60–7.89]	0.5
0.286–0.298 [7.30–7.59]	1.0
0.273–0.285 [7.00–7.29]	1.5
0.259–0.272 [6.60–6.99]	2.0
0.246–0.258 [6.20–6.59]	2.5
0.233–0.245 [5.90–6.19]	3.0
0.219–0.232 [5.50–5.89]	3.5
0.206–0.218 [5.20–5.49]	4.0
0.193–0.205 [4.90–5.19]	4.5
0.180–0.192 [4.60–4.89]	5.0

11.6.2 Due to the inherently lower elongation that is obtainable in thicker plate, adjustments in elongation requirements in 2-in. [50-mm] gage length shall be provided for thicknesses over 3.5 in. [90 mm]. Accordingly, the following deductions shall be made from the base elongation requirements in 2 in. [50 mm] prescribed in the applicable product specification:

Plate Nominal Thickness Range, in. [mm]	Elongation Deduction, %
3.501–3.999 [90.00–102.49]	0.5

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4.000–4.499 [102.50–114.99]	1.0
4.500–4.999 [115.00–127.49]	1.5
5.000–5.499 [127.50–139.99]	2.0
5.500–5.999 [140.0–152.49]	2.5
6.000 and thicker [152.50 and thicker]	3.0

11.6.3 A characteristic of certain types of alloy steels is a local disproportionate increase in the degree of necking down or contraction of the test specimens during the tension test, resulting in a decrease in the percentage of elongation as the gage length is increased. The effect is not so pronounced in thicker plates. For such material, if so stated in the applicable product specification for plates up to ¾ in. [20 mm], inclusive, in thickness, if the percentage of elongation of an 8-in. [200-mm] gage length test specimen falls not more than 3 percentage points below the amount prescribed, the elongation shall be considered satisfactory if the percentage of elongation in 2 in. [50 mm] across the break is not less than 25 %.

11.6.4 The tensile requirements tables in many of the product specifications covered by this general requirements specification specify elongation requirements in both 8-in. [200-mm] and 2-in. [50-mm] gage lengths. Unless otherwise provided in the applicable product specification, both requirements are not required to be applied simultaneously, and the elongation need only be determined in the gage length appropriate for the test specimen used. After selection of the appropriate gage length, the elongation requirement for the alternative gage length shall be deemed not applicable.

11.7 This specification does not provide requirements for product tension testing subsequent to shipment (see 15.1). Therefore, the requirements of 11.1 through 11.6 and Section 16 apply only for tests conducted at the place of manufacture prior to shipment. Compliance to Specification A 20/20M and the applicable product specification does not preclude the possibility that product tension test results may vary outside specified ranges. The tensile properties will vary within the same plate-as-rolled or piece, be it as-rolled, control-rolled, or heat-treated. The purchaser should, therefore, be aware that tension testing in accordance with the requirements of Specification A 20/A 20M does not provide assurance that all products of a plate-as-rolled will be identical in tensile properties with the products tested. If the purchaser wishes to have more confidence than that provided by Specification A 20/A 20M testing procedures, additional testing or requirements, such as Supplementary Requirement S4, should be imposed.

11.8 Appendix X2 provides additional information on the variability of tensile properties in plates for pressure vessels.

12. Notch-Toughness Tests

12.1 *Charpy V-Notch Tests*:

12.1.1 *Number of Tests*—Except for quenched and tempered plates, and except as allowed by 12.1.1.1 and 12.1.1.2, one impact test (3 specimens) for each specified orientation (see 12.1.2) shall be made from each plate-as-rolled. For quenched and tempered plates, one impact test shall be made from each plate, as heat treated.

12.1.1.1 *Plates Ordered Without the Heat Treatment Specified by the Applicable Product Specification*—If the applicable product specification requires heat treatment but the plates are ordered without such heat treatment and Charpy V-notch tests are specified, one coupon shall be taken from each plate-as-rolled. The coupon shall be heat treated in accordance with the applicable product specification and the purchase order and the plate shall be qualified by test specimens taken from the heat-treated coupon.

12.1.1.2 *Plates Produced from Coil*—If Charpy V-notch tests are specified, the number of impact tests required shall be the same as the number specified for tension tests in 11.1.2 or 11.1.3, whichever is applicable. The test coupons shall be taken from the material after decoiling and leveling.

12.1.2 *Orientation of Test Specimens*— The long axis of the test specimens shall be oriented either longitudinal (parallel to the final direction of rolling) or transverse (transverse to the final direction of rolling), as specified in the applicable product specification or the purchase order.

12.1.3 *Location of Test Coupons*—The impact test coupons shall be taken adjacent to the tension test coupons. The impact test coupons shall be subject to the same requirements as those specified for tension tests in 11.4, except that the provisions of 11.4.4.1 apply to the area under the notch of the impact test specimen instead of to the gage length of the tension test specimen.

12.1.4 *Test Method*—Impact testing shall be performed in accordance with Test Methods and Definitions A 370 using Charpy V-notch (Type A) specimens as shown in Test Methods and Definitions A 370. Except as allowed by 12.1.4.1, full-size specimens (0.394 by 0.394 in. [10 by 10 mm]) shall be used if the plate thickness permits, and their central axis shall correspond as near as practical to the ¼ *t* plane in the plate thickness *t*. If the plate thickness is insufficient to obtain full-size specimens, the largest possible subsize specimens shall be used.

12.1.4.1 For plates that normally have absorbed energy values in excess of 180 ft·lbf [245 J] if tested using full-size specimens at the specified testing temperature, subsize 0.394 by 0.264 in. [10 by 6.7 mm] specimens may be used in lieu of full-size specimens; however, if this option is used, the acceptance value shall be 75 ft·lbf [100 J] minimum for each test specimen and the lateral expansion in mils [micrometres] shall be reported.

12.1.5 *Test Temperature*—The test temperature shall be as specified in the purchase order, except that the manufacturer or processor shall have the option of using a lower test temperature. If a test temperature is not specified in the purchase order, tests shall be conducted at a temperature no higher than is given in Table A1.15 [A2.15] for the applicable product specification, grade, class, and plate thickness. The actual test temperature used shall be reported with the test results.

12.1.6 *Acceptance Criteria*—Unless otherwise agreed upon, the acceptance criteria shall be as given in Table A1.15 [A2.15] for the applicable product specification, grade, class, and plate thickness.

12.1.6.1 If the acceptance criteria is based upon energy absorption of a full-size specimen, the acceptance criteria for the various subsize specimens shall be as given in Table A1.16 [A2.16], except as otherwise provided in 12.1.4.1.

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12.1.6.2 If the acceptance criterion is based upon lateral expansion opposite the notch, the acceptance value shall be the same for all sizes of test specimens.

12.1.7 *Marking*—The letters "LTV" shall be stenciled or stamped on each plate following the class number, grade, etc.

12.1.8 *Variability*—The impact properties of steel can vary within the same plate-as-rolled or piece, be it as-rolled, control-rolled, or heat-treated. The purchaser should, therefore, be aware that testing of one plate-as-rolled does not provide assurance that all locations within a plate-as-rolled will be identical in toughness with the location tested. Normalizing or quenching and tempering the product will reduce the degree of variation.

12.1.8.1 Appendix X3 provides additional information on the variability of Charpy V-notch test properties in plates for pressure vessels.

12.2 *Drop-Weight Tests*:

12.2.1 Where specified, one drop-weight test, consisting of a set of two test specimens, shall be made to the same frequency stated in 12.1.1 in accordance with Method E 208.

12.2.2 The test coupons shall be obtained adjacent to a tension test coupon. For plates produced from coil, the test coupon locations shall be the same as for Charpy V-notch tests. (See 12.1.) The provisions of 12.1.3 shall also apply.

12.2.3 The testing temperature shall be as specified in the applicable product specification or the purchase order.

12.2.4 Acceptance shall be on the basis of *no-break* performance of both test specimens at the specified testing temperature.

12.2.5 The plates shall be marked as required in 12.1.7, except that the letters "LTD" shall be used instead of "LTV."

13. Identification of Plates

13.1 *Required Markings*:

13.1.1 Except as allowed by 13.4, plates shall be legibly marked with the following information: applicable ASTM designation (see 1.1) (year of issue not required); "G" or" MT" if applicable (see 13.1.2); applicable grade, type, and class; heat number; plate identifier; and name, brand, or trademark of the manufacturer (for plates produced in discrete cut lengths of flat product) or the processor (for plates produced from coil and for subdivided plates (see 13.4)).

13.1.2 Plates that are required to be heat treated, but have not been so heat treated, shall be marked, by the manufacturer or processor, with the letter "G" (denoting green) following the required ASTM designation mark, except that "G" marking is not necessary if such plates are for shipment, for the purpose of obtaining the required heat treatment, to an organization under the manufacturer's control. Such plates shall have been qualified for shipment on the basis of test specimens that have been so heat treated. Plates that are required to be heat treated, and have been so heat treated, shall be marked, by the party that performed the heat treatment, with the letters "MT" (denoting material treated) following the required ASTM designation mark.

NOTE 1—Any stress relief of test specimens intended to simulate post-weld heat treatment is not included in the above heat treatment.

13.2 *Types of Marking*:

13.2.1 Except as allowed by 13.4, the required markings for plates over ¼ in. [6 mm] in thickness shall be by steel die stamping, unless paint marking is specified in the purchase order.

13.2.2 Except as allowed by 13.4, the required markings for plates ¼ in. [6 mm] and under in thickness shall be by paint marking or by steel die stamping using low-stress (either round-nose or interrupted-dot) impressions.

13.3 *Location of Markings*:

13.3.1 Except as allowed by 13.4, the required markings for plates with a maximum lengthwise or crosswise dimension more than 72 in. [1800 mm] shall be in at least two places on each finished plate, at least 12 in. [300 mm] from the edges of the plate.

13.3.2 Except as allowed by 13.4, the required markings for plates with a maximum lengthwise and crosswise dimension of 72 in. [1800 mm] or less shall be in at least one place on each finished plate, approximately midway between the center and an edge of the plate.

13.4 *Subdivided Plates*:

13.4.1 By agreement between the purchaser and the manufacturer or processor, each subdivided plate (a plate separated from a master plate) shall be legibly marked with the name, brand, or trademark of the organization that subdivided the plate plus a code traceable to the required markings, provided that the information required in 13.1, cross referenced to that code, is furnished with the plates.

13.4.2 By agreement between the purchaser and the manufacturer or processor, subdivided plates that are from the same master plate and placed in secured lifts shall have the information required in 13.1 paint marked on the top piece of each lift or shown on a substantial tag attached to each lift.

13.5 *Bar Coding*—In addition to the requirements of 13.1 to 13.4 inclusive, the manufacturer or processor shall have the option of using bar coding as a supplementary identification method.

NOTE 2—Bar coding should be consistent with AIAG Standard B 1.

14. Permissible Variations in Dimensions or Mass

14.1 One cubic foot of rolled steel shall be assumed to weigh 490 lb, unless otherwise stated in the applicable product specification. One cubic metre of rolled steel is assumed to have a mass of 7850 kg, unless otherwise stated in the applicable product specification.

14.2 For carbon steel plates the permissible variations for dimensions shall not exceed the applicable limits stated in Annex A1, Table A1.1 to Table A1.9 , and Table A1.13 [Annex A2, Table A2.1 to Table A2.9 , and Table A2.13].

14.3 For alloy steel plates the permissible variations for dimensions shall not exceed the applicable limits stated in Annex 1, Table A1.1 to Table A1.4 , Table A1.8 , and Table A1.10 to Table A1.13 . [Annex 2, Table A2.1 to Table A2.4 , Table A2.8 and Table A2.10 to Table A2.13].

15. Inspection and Testing

15.1 The inspector representing the purchaser shall have entry at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works

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that concern the manufacture of the plate ordered. The manufacturer shall afford the inspector all reasonable facilities to be satisfied that the plate is being furnished in accordance with this general requirements specification, the applicable product specification, and the purchase order. All tests (except product analysis) and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the manufacturer's works.

15.2 If plates are produced from coil, 15.1 shall apply to the "processor" instead of to the "manufacturer" and the "place of process" shall apply instead of the "place of manufacture." If plates are produced from coil and the processor is different from the manufacturer, the inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works that concern the manufacture of the plate ordered.

16. Retests

16.1 *Tension Test*—In addition to the provisions of Test Methods and Definitions A 370, the following retest provisions shall apply:

16.1.1 If any test specimen shows defective machining, or develops flaws, it may be discarded and another test specimen substituted.

16.1.2 If the percentage of elongation of any tension test specimen is less than that specified, and any part of the fracture is more than ¾ in. [20 mm] from the center of the gage length of a 2-in. [50-mm] test specimen or is outside the middle half of the gage length of an 8-in. [200-mm] test specimen as indicated by scribe marks on the test specimen before testing, one retest shall be allowed.

16.1.3 If the results from an original tension test specimen fail to meet the specified requirements but are within 2 ksi [10 MPa] of the required tensile strength or within 1 ksi [5 MPa] of the required yield strength or yield point, or within 2 percentage points of the required elongation or reduction of area, one retest shall be permitted to replace the failing test.

16.1.4 The results of the retest shall meet the specified requirements.

16.2 *Charpy V-Notch Tests*:

16.2.1 The retest provisions of Test Methods and Definitions A 370 shall apply, except that the 5 ft·lbf [7 J] absolute minimum for an individual specimen shall not apply if two thirds of the specified minimum average is less than 5 ft·lbf [7 J].

16.2.2 If Charpy V-notch impact test lateral expansion values are specified, if the value of one specimen falls below the specified minimum value and not below ⅔ of the specified minimum value, and if the average of the three specimens equals or exceeds the specified minimum value, a retest of three additional specimens may be made. Each of the three retest specimens shall equal or exceed the specified minimum value.

16.2.3 If the required values are not obtained on Charpy V-notch retests as specified in 16.2.1 and16.2.2, or if the values in the initial test are below the values required for retest, no further retests are permitted unless the plate is heat treated or reheat treated. After heat treatment or reheat treatment, a set of three specimens shall be tested and each shall equal or exceed the specified minimum value.

16.2.4 If the option of 12.1.4.1 is used and the test result falls below the 75 ft·lbf [100 J] minimum specified, another test may be made using full-size test specimens.

17. Retreatment

17.1 If any heat-treated plate fails to meet the mechanical requirements of the applicable product specification, the manufacturer or processor shall have have the option of heat treating the plate again. All mechanical-property tests shall be repeated and the plate surface shall be reexamined for surface defects when it is resubmitted for inspection.

18. Rejection

18.1 Any rejection based upon product analysis made in accordance with the applicable product specification shall be reported to the supplier and samples that represent the rejected plate shall be preserved for 2 weeks from the date of notification of such rejection. In case of dissatisfaction with the results of the tests, the supplier shall have the option of making claim for a rehearing within that time.

18.2 Plates that show injurious defects subsequent to their acceptance at the manufacturer's or processor's works may be rejected. In such cases, the manufacturer or processor shall be notified.

19. Test Reports

19.1 The manufacturer or processor shall report the results of all tests required by the applicable product specification, the applicable supplementary requirements, and the purchase order. The heat number, the plate identifier of the plate tested, and the nominal plate thickness shall be shown on the test report. The year-date of the specification to which the plates are furnished shall be included in the test report.

19.1.1 In reporting elongation values, both the percentage increase and the original gage length shall be stated.

NOTE 3—Where Table 1 applies and the amount of any element listed therein is less than 0.02 %, the applicable analysis for that element may be reported as "<0.02 %."

19.2 For plates rolled from a strand-cast slab with a reduction ratio in the range from 2.0:1 to 3.0:1, exclusive, the specific practices (see 5.3.4 and 5.3.6) that were used by the manufacturer shall be reported, and the test reports shall state that the limitations of 5.3 have been met.

19.3 All heat treatment, exclusive of subcritical heating to soften thermally cut edges, shall be reported, including temperature ranges and times at temperature. This exclusion does not apply to those plates with specified minimum tensile strengths of 95 ksi [655 MPa] or higher, unless such subcritical heating is accomplished at temperatures at least 75 °F [40 °C] below the minimum tempering temperature. The reports shall state whether the plates only, the test coupons only, or both plates and test coupons were heat treated.

19.4 If Charpy V-notch tests are specified, the test specimen size used shall be reported.

19.5 If so specified in the purchaser order, the manufacturer shall also furnish a certificate of compliance stating that the

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plates have been manufactured, inspected, and tested in accordance with the requirements of the applicable product specification. For plates produced from coil, the processor shall furnish the required certification.

19.6 For plates produced from coil and furnished without heat treatment or with stress relieving only, the results of all tests required by 11.1.2 shall be reported for each qualifying coil.

19.7 A signature is not required on the test report; however, the document shall clearly identify the organization submitting the report. Notwithstanding the absence of a signature, the organization submitting the report is responsible for the content of the report.

19.8 Copies of the original manufacturer's test report shall be included with any subsequent test report.

19.9 A test report, certificate of compliance, or similar document printed from or used in electronic form from an electronic data interchange (EDI) transmission shall be regarded as having the same validity as a counterpart printed in the certifier's facility. The content of the EDI transmitted document must meet the requirements of the invoked ASTM standard(s) and conform to any existing EDI agreement between the purchaser and the supplier. Notwithstanding the absence of a signature, the organization submitting the EDI transmission is responsible for the content of the report.

20. Packaging, Marking, and Loading for Shipment

20.1 Packaging, marking, and loading for shipment shall be in accordance with those procedures recommended by Practices A 700.

20.2 *For USA Government Procurement*—Packaging, packing, and marking of material for military procurement shall be in accordance with the requirements of MIL-STD-163, Level A, Level C, or commercial as specified in the contract or purchase order. Marking for shipment of material for civil agencies shall be in accordance with Fed. Std. No. 123.

21. Keywords

21.1 general delivery requirement; pressure containing parts; pressure vessel steels; steel plates; steel plates for pressure vessel applications

SUPPLEMENTARY REQUIREMENTS

The following standardized supplementary requirements are for use if desired by the purchaser. Those that are considered suitable for use with a product specification are listed in the product specification. Other tests may be performed by agreement between the manufacturer or processor and the purchaser. These supplementary requirements shall apply only if specified in the purchase order, in which event the specified tests shall be made by the manufacturer or processor before shipment of the plates.

S1. Vacuum Treatment

S1.1 The steel shall be made by a process that includes vacuum degassing while molten. Unless otherwise agreed upon with the purchaser, it is the responsibility of the manufacturer to select suitable process procedures.

S2. Product Analysis

S2.1 A product analysis shall be made of each plate as rolled. The specimens for analysis shall be taken adjacent to or from a broken tension test specimen.

S3. Simulated Post-Weld Heat Treatment of Mechanical Test Coupons

S3.1 Prior to testing, the test coupons representing the plate for acceptance purposes for mechanical properties shall be thermally treated to simulate a post-weld heat treatment below the critical temperature (Ac_3), using the heat treatment parameters (such as temperature range, time, and cooling rates) specified in the purchase order. For tests using specimens taken from such heat treated test coupons, the test results shall meet the requirements of the applicable product specification.

S4. Additional Tension Test

S4.1 *Other Than Quenched-and-Tempered Plates*—In addition to the required single tension test, a second tension test shall be made using a test specimen taken from a test coupon taken from a corner of the plate-as-rolled on the end opposite the single test specimen and in a direction parallel to the single test specimen. The results obtained using this second test specimen shall meet the requirements of the applicable product specification.

S4.2 *Quenched-and-Tempered Plates 2 in.* [50 mm] *or Greater in Thickness*—In addition to the required tension tests, two additional test coupons shall be taken from the bottom corner of the plate. One shall be taken at the center of the plate thickness and the other immediately beneath the surface. Mandatory conformance of these additional tests with the specified properties shall be a matter of agreement between the manufacturer and the purchaser.

S5. Charpy V-Notch Impact Test

S5.1 Charpy V-notch impact tests shall be conducted in accordance with 12.1.

S5.2 The orientation of the test specimens, whether longitudinal or transverse to the direction of rolling, shall be as specified in the purchase order.

S5.3 The test temperature and the required acceptance criteria, if other than those required in 12.1, shall be as specified in the purchase order.

S5.4 The recorded results shall include test specimen orientation, test specimen size, test temperature, absorbed energy values, and, if specified in the purchase order for other than

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Class VI plates, lateral expansion opposite the notch. The percent shear fracture appearance shall also be recorded if specified in the purchase order.

S6. Drop-Weight Test (for Plates 0.625 in. [16 mm] and Over in Thickness)

S6.1 Drop-weight tests shall be made in accordance with the requirements of Test Method E 208. The specimens shall represent the plates in the final condition of heat treatment. Agreement shall be reached between the purchaser and the manufacturer or processor as to the number of plates to be tested and whether a maximum NDT temperature is mandatory or if the test results are for information only.

S7. High-Temperature Tension Tests

S7.1 A short-time elevated temperature tension test shall be made to represent each plate or each heat of steel as indicated by the purchaser. The specimens for testing shall be obtained as required for the room temperature tension tests specified in the body of this general requirements specification. The high-temperature tests shall be made in accordance with the requirements of Practice E 21. Mandatory conformance of such additional tests with the specified properties shall be a matter for agreement between the manufacturer or processor and the purchaser.

S8. Ultrasonic Examination in Accordance with A 435/ A 435M

S8.1 All plates shall be ultrasonically examined in accordance with the requirements of Specification A 435/A 435M .

S9. Magnetic Particle Examination

S9.1 All plate edges shall be examined by magnetic particles in accordance with the procedures covered in Practice E 709. The acceptability of defects revealed by this examination shall be judged in accordance with the requirements for quality in 9.3.

S10. Charpy V-Notch Impact Transition Curve

S10.1 Sufficient impact tests of the same specimen size shall be made from the plate test material to establish a transition curve. The test temperature range shall be wide enough to establish the upper and lower shelf energies, with sufficient testing at intermediate temperatures to permit plotting a reasonable smooth curve. A plot of the data is not required. The manufacturer shall report the specimen orientation, test temperature, and absorbed energy for each specimen tested. Lateral expansion and percent shear shall also be reported when specified in the purchase order. The number of plates tested and the specimen orientation shall be the same as in 12.1 unless otherwise specified in the purchase order.

S11. Ultrasonic Examination in Accordance with A 577/ A 577M

S11.1 All plates shall be ultrasonically examined in accordance with the requirements of Specification A 577/ A 577M.

S12. Ultrasonic Examination in Accordance with A 578/ A 578M

S12.1 All plates shall be ultrasonically examined in accordance with the requirements of Specification A 578/ A 578M. The acceptance level shall be as specified in the purchase order.

S13. NDT Temperature Determination

S13.1 The NDT temperature shall be established in accordance with Method E 208 using coupons from a single plate. The number of plates to be so tested shall be subject to agreement between the purchaser and the manufacturer or processor.

S15. Reduction of Area Measurement

S15.1 A reduction of area measurement shall be taken while making the required tension test. Reduction of area shall be determined only on the 0.500-in. [12.5–mm] round specimen as shown in Fig. 5 of Test Methods and Definitions A 370. The minimum acceptance limit shall be 40 %.

S16. Thermal Stress Relief of Mechanical Test Coupons

S16.1 Test coupons representing the plates shall be thermally stress relieved by gradually and uniformly heating them to a temperature between 1100 and 1200 °F [595 and 650 °C], or a temperature range otherwise agreed upon between the manufacturer or processor and the purchaser, holding at temperature for at least 1 h/in. [2.4 min/mm] of thickness and cooling in still air to a temperature not exceeding 600 °F [315 °C].

S17. Vacuum Carbon-Deoxidized Steel

S17.1 Material shall be vacuum carbon-deoxidized, in which case the silicon content at the time of vacuum deoxidizing shall be 0.12 % maximum, and the content of deoxidizers such as aluminum, zirconium, and titanium should be kept low enough to allow deoxidation by carbon. The test report shall indicate that the steel was vacuum carbon-deoxidized. The minimum heat analysis and product analysis requirements for silicon do not apply to vacuum carbon-deoxidized steel.

S19. Restricted Chemical Requirements

S19.1 Restricted heat analysis and product analysis limits are applicable, as specified in the purchase order.

S20. Maximum Carbon Equivalent for Weldability

S20.1 Plates shall be supplied with a specific maximum carbon equivalent value. This value shall be based upon the heat analysis. The required chemical analysis as well as the carbon equivalent shall be reported.

S20.2 The carbon equivalent shall be calculated using the following formula:

$$CE = C + Mn/6 + (Cr + Mo + V)/5 + (Ni + Cu)/15.$$

S20.3 The maximum value of the carbon equivalent for carbon steels (including C-Mn, C-Mn-Si, C-Mn-Si-Al steels), are given in Table 2.

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S21. Restricted Limits on Elements

For each heat, based upon the heat analysis, the content shall not exceed 0.35 % for copper, 0.25 % for nickel, 0.25 % for chromium, 0.08 % for molybdenum, or 0.70 % for the sum of those four elements.

S22. Through-Thickness Tension Tests

S22.1 Through-thickness tension tests shall be made in accordance with the requirements of Specification A 770/A 770M . (See Ordering Information in Specification A 770/A 770M for the additional information that may be needed.)

S24. Strain Age Test

S24.1 Test coupons shall be given a strain age treatment designated by the purchaser. Charpy V-notch tests shall be conducted on the strain aged specimens. Heat treatment, strain aging, test temperature, and acceptance criteria shall be as agreed upon between the manufacturer or processor and the purchaser.

S25. Weldability

S25.1 Weldability tests shall

be conducted. The type of test and the acceptance criteria shall be as agreed upon between the manufacturer or processor and the purchaser.

S26. Low-Sulfur Steels

S26.1 The steel shall be made to 0.010 % sulfur maximum. Lower sulfur levels and sulfide shape control practices can be specified by agreement between the manufacturer or processor and the purchaser.

S27. Restrictive Plate Flatness

S27.1 Carbon steel plates, as-rolled or normalized, shall conform to the permissible restrictive variations from flatness given in Table 3 or Table 4.

S27.2 High-strength low-alloy steel plates, as-rolled or normalized, shall conform to the permissible restrictive variations from flatness given in Table 5 or Table 6.

S28. Heat Treatment in the Working Zone of a Surveyed Furnace

S28.1 Plates shall be heat treated in the working zone of a furnace that has been surveyed in accordance with Test Method A 991/A 991M, provided that such working zone was established using a variation of 25 °F [15 °C] or less from the furnace set point.

S28.2 The test report shall indicate that S28 applies.

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TABLE 2 Maximum Carbon Equivalent for Weldability

Specified Minimum UTS ksi [MPa]	Maximum Carbon Equivalent Value	
	Thickness up to 2 in. [50 mm] incl	Thickness over 2 in. [50 mm]
60 ≤ UTS < 70 [415 ≤ UTS < 485]	0.45	0.46
70 ≤ UTS < 80 [485 ≤ UTS < 550]	0.47	0.48[A]
UTS ≥ 80 [UTS ≥ 550]	0.48[A,B]	. . .

[A]If simulated PWHT of the test coupons is specified (S3), the maximum carbon equivalent value may be increased up to 0.50 upon agreement between purchaser and supplier.

[B]Applicable to quenched-and-tempered material; for other conditions, maximum carbon equivalent shall be by agreement between purchaser and supplier.

TABLE 3 Permissible Variations from Flatness for Carbon Steel Plates As-Rolled or Normalized Ordered to Restrictive Flatness

NOTE 1—*Flatness Variations for Length*—The longer dimension specified is considered the length, and variation in flatness along the length shall not exceed the tabular amount for the specified width in plates up to 12 ft in length, or in any 12 ft of longer plates.

NOTE 2—*Flatness Variations for Width*—The flatness variation across the width shall not exceed the tabular amount for the specified width.

NOTE 3—When the longer dimension is under 36 in., the variation in flatness along the length and across the width shall not exceed ¼ in. in each direction. When the longer dimension is from 36 to 72 in., inclusive, the permissible flatness variation shall not exceed 75 % of the tabular amount for the specified width, but in no case less than ¼ in.

NOTE 4—The variations given in this table apply to plates that have a minimum specified tensile strength not over 60 ksi or comparable chemistry or hardness. For plates specified to a higher minimum tensile strength or comparable chemistry or hardness, the permissible variations are 1½ times the amounts shown in the table below.

NOTE 5—This table and these notes cover the flatness variations of circular and sketch plates based on the maximum dimensions of those plates.

NOTE 6—Waviness tolerances for rectangular plates, universal mill plates, and circular and sketch plates do not apply.

NOTE 7—A "Z" indicates that there is no published restricted value for the size.

NOTE 8—Plates shall be in a horizontal position on a flat surface when flatness is measured.

Specified Thickness, in.	Permissible Variations from a Flat Surface for Specified Widths, in.					
	48 to 60, excl	60 to 72, excl	72 to 84, excl	84 to 96, excl	96 to 108, excl	108 to 120, incl
To ¼ , excl	¾	15/16	Z	Z	Z	Z
¼ to ⅜ , excl	9/16	¾	⅞	15/16	1-1/16	1-⅛
⅜ to ½ , excl	5/16	5/16	⅜	7/16	½	9/16
½ to ¾ , excl	5/16	5/16	5/16	⅜	½	½
¾ to 1, excl	5/16	5/16	5/16	5/16	⅜	7/16
1 to 2, incl	¼	5/16	5/16	5/16	5/16	⅜

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TABLE 4 Permissible Variations from Flatness for Carbon Steel Plates As-Rolled or Normalized Ordered to Restrictive Flatness

NOTE 1—*Flatness Variations for Length*—The longer dimension specified is considered the length, and variation in flatness along the length shall not exceed the tabular amount for the specified width in plates up to 3700 mm in length, or in any 3700 mm of longer plates.

NOTE 2—*Flatness Variations for Width*—The flatness variation across the width shall not exceed the tabular amount for the specified width.

NOTE 3—When the longer dimension is under 900 mm, the variation in flatness along the length and across the width shall not exceed 6 mm in each direction. When the longer dimension is from 900 to 1800 mm, inclusive, the permissible flatness variation shall not exceed 75 % of the tabular amount for the specified width, but in no case less than 6 mm.

NOTE 4—The variations given in this table apply to plates that have a minimum specified tensile strength not over 415 MPa or comparable chemistry or hardness. For plates specified to a higher minimum tensile strength or comparable chemistry or hardness, the permissible variations are 1½ times the amounts shown in the table below.

NOTE 5—This table and these notes cover the flatness variations of circular and sketch plates based on the maximum dimensions of those plates.

NOTE 6—Waviness tolerances for rectangular plates, universal mill plates, and circular and sketch plates do not apply.

NOTE 7—A "Z" indicates that there is no published restricted value for the size.

NOTE 8—Plates shall be in horizontal position on a flat surface when flatness is measured.

Specified Thickness, mm	Permissible Variations from a Flat Surface for Specified Widths, mm					
	1200 to 1500, excl	1500 to 1800, excl	1800 to 2100, excl	2100 to 2400, excl	2400 to 2700, excl	2700 to 3000, incl
To 6, excl	18	24	Z	Z	Z	Z
6 to 10, excl	15	18	22	24	27	29
10 to 12, excl	8	8	10	11	13	15
12 to 20, excl	7	8	8	10	13	13
20 to 25, excl	7	8	8	8	10	11
25 to 50, excl	7	7	7	8	8	8

TABLE 5 Permissible Variations from Flatness for High-Strength Low-Alloy Steel Plates As-Rolled or Normalized Ordered to Restrictive Flatness

NOTE 1—*Flatness Variations for Length*—The longer dimension specified is considered the length, and variation in flatness along the length shall not exceed the tabular amount for the specified width in plates up to 12 ft in length, or in any 12 ft of longer plates.

NOTE 2—*Flatness Variations for Width*—The flatness variation across the width shall not exceed the tabular amount for the specified width.

NOTE 3—When the longer dimension is under 36 in., the variation in flatness along the length and across the width shall not exceed ⅜ in. in each direction. When the larger dimension is from 36 to 72 in., inclusive, the permissible flatness variation shall not exceed 75 % of the tabular amount for the specified width but in no case less than ⅜ in.

NOTE 4—This table and these notes cover the flatness variations of circular and sketch plates based on the maximum dimensions of those plates.

NOTE 5—Waviness tolerances for rectangular plates, universal mill plates, and circular and sketch plates do not apply.

NOTE 6—A "Z" indicates that there is no published restricted value for the size.

NOTE 7—Plates shall be in horizontal position on a flat surface when flatness is measured.

Specified Thickness, in.	Permissible Variations from a Flat Surface for Specified Widths, in.					
	48 to 60, excl	60 to 72, excl	72 to 84, excl	84 to 96, excl	96 to 108, excl	108 to 120, incl
To ¼ , excl	1 1/16	1 7/16	Z	Z	Z	Z
¼ to ⅜ , excl	⅞	1 1/16	1 5/16	1 7/16	1½	1 11/16
⅜ to ½ , excl	½	½	9/16	11/16	¾	13/16
½ to ¾ , excl	7/16	7/16	½	9/16	⅝	11/16
¾ to 1, excl	7/16	7/16	½	½	9/16	11/16
1 to 2, incl	⅜	7/16	7/16	½	½	½

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TABLE 6 Permissible Variations from Flatness for High-Strength Low-Alloy Steel Plates As-Rolled or Normalized Ordered to Restrictive Flatness

NOTE 1—*Flatness Variations for Length*—The longer dimension specified is considered the length, and variation in flatness along the length shall not exceed the tabular amount for the specified width in plates up to 3700 mm in length, or in any 3700 mm of longer plates.

NOTE 2—*Flatness Variations for Width*—The flatness variation across the width shall not exceed the tabular amount for the specified width.

NOTE 3—When the longer dimension is under 900 mm, the variation in flatness along the length and across the width shall not exceed 10 mm in each direction. When the larger dimension is from 900 to 1800 mm, inclusive, the permissible flatness variation shall not exceed 75 % of the tabular amount for the specified width, but in no case less than 10 mm.

NOTE 4—This table and these notes cover the variations for flatness of circular and sketch plates based on the maximum dimensions of those plates.

NOTE 5—Waviness tolerances for rectangular plates, universal mill plates, and circular and sketch plates do not apply.

NOTE 6—A "Z" indicates that there is no published restricted value for the size.

NOTE 7—Plates shall in a horizontal position on a flat surface when flatness is measured.

Specified Thickness, mm	Permissible Variations from a Flat Surface for Specified Widths, mm					
	1200 to 1500, excl	1500 to 1800, excl	1800 to 2100, excl	2100 to 2400, excl	2400 to 2700, excl	2700 to 3000, incl
To 6, excl	27	36	Z	Z	Z	Z
6 to 10, excl	22	27	33	36	39	43
10 to 12, excl	12	12	15	17	19	21
12 to 20, excl	11	11	13	15	16	18
20 to 25, excl	11	11	12	13	15	17
25 to 50, excl	10	11	11	12	13	13

ANNEXES

(Mandatory Information)

A1. PERMISSIBLE VARIATIONS IN DIMENSIONS, ETC.—INCH-POUND UNITS

A1.1 Listed below are permissible variations in dimensions, and notch toughness information, expressed in inch-pound units of measurement.

TABLE A1.1 Permissible Variations in Thickness for Rectangular Plates

NOTE 1—Permissible variation under specified thickness, 0.01 in.

NOTE 2—Thickness to be measured at ⅜ to ¾ in. from the longitudinal edge.

NOTE 3—For thickness measured at any location other than that specified in Note 2, the permissible maximum over-tolerance shall be increased by 75 %, rounded to the nearest 0.01 in.

Specified Thickness, in.	Tolerance Over Specified Thickness for Widths Given, in.											
	48 and under	Over 48 to 60, excl	60 to 72, excl	72 to 84, excl	84 to 96, excl	96 to 108, excl	108 to 120, excl	120 to 132, excl	132 to 144, excl	144 to 168, excl	168 to 182, excl	182 and over
To ¼ , excl	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.04	...	...	...
¼ to 5⁄16 , excl	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.04	...	...	...
5⁄16 to ⅜ , excl	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.05	...	...
⅜ to 7⁄16 , excl	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.05	0.06	0.06	...
7⁄16 to ½ , excl	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.05	0.06	0.06	...
½ to ⅝ , excl	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.05	0.06	0.07	...
⅝ to ¾ , excl	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.05	0.06	0.07	0.07
¾ to 1, excl	0.03	0.03	0.03	0.03	0.04	0.04	0.05	0.05	0.06	0.07	0.08	0.09
1 to 2, excl	0.06	0.06	0.06	0.06	0.06	0.07	0.08	0.10	0.10	0.11	0.13	0.16
2 to 3, excl	0.09	0.09	0.09	0.10	0.10	0.11	0.12	0.13	0.14	0.15	0.15	...
3 to 4, excl	0.11	0.11	0.11	0.11	0.11	0.13	0.14	0.14	0.14	0.15	0.17	...
4 to 6, excl	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.20	0.20	...
6 to 10, excl	0.23	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.27	0.28	...
10 to 12, excl	0.29	0.29	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.35	...
12 to 15, incl	0.29	0.29	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	...

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TABLE A1.2 Permissible Variations in Width and Length for Sheared Plates 1½ in. and Under in Thickness; Length Only for Universal Mill Plates 2½ in. and Under in Thickness

Specified Dimensions, in.		Permissible Variations over Specified Width and Length[A] for Thicknesses Given in inches, in.							
Length	Width	To 3/8 ,excl		3/8 to 5/8 , excl		5/8 to 1, excl		1 to 2, incl[B]	
		Width	Length	Width	Length	Width	Length	Width	Length
To 120, excl	over 8 to 60, excl	3/8	1/2	7/16	5/8	1/2	3/4	5/8	1
	60 to 84, excl	7/16	5/8	1/2	11/16	5/8	7/8	3/4	1
	84 to 108, excl	1/2	3/4	5/8	7/8	3/4	1	1	1 1/8
	108 and over	5/8	7/8	3/4	1	7/8	1 1/8	1 1/8	1 1/4
120 to 240, excl	over 8 to 60, excl	3/8	3/4	1/2	7/8	5/8	1	3/4	1 1/8
	60 to 84, excl	1/2	3/4	5/8	7/8	3/4	1	7/8	1 1/4
	84 to 108, excl	9/16	7/8	11/16	15/16	13/16	1 1/8	1	1 3/8
	108 and over	5/8	1	3/4	1 1/8	7/8	1 1/4	1 1/8	1 3/8
240 to 360, excl	over 8 to 60, excl	3/8	1	1/2	1 1/8	5/8	1 1/4	3/4	1 1/2
	60 to 84, excl	1/2	1	5/8	1 1/8	3/4	1 1/4	7/8	1 1/2
	84 to 108, excl	9/16	1	11/16	1 1/8	7/8	1 3/8	1	1 1/2
	108 and over	11/16	1 1/8	7/8	1 1/4	1	1 3/8	1 1/4	1 3/4
360 to 480, excl	over 8 to 60, excl	7/16	1 1/8	1/2	1 1/4	5/8	1 3/8	3/4	1 5/8
	60 to 84, excl	1/2	1 1/4	5/8	1 3/8	3/4	1 1/2	7/8	1 5/8
	84 to 108, excl	9/16	1 1/4	3/4	1 3/8	7/8	1 1/2	1	1 7/8
	108 and over	3/4	1 3/8	7/8	1 1/2	1	1 5/8	1 1/4	1 7/8
480 to 600, excl	over 8 to 60, excl	7/16	1 1/4	1/2	1 1/2	5/8	1 5/8	3/4	1 7/8
	60 to 84, excl	1/2	1 3/8	5/8	1 1/2	3/4	1 5/8	7/8	1 7/8
	84 to 108, excl	5/8	1 3/8	3/4	1 1/2	7/8	1 5/8	1	1 7/8
	108 and over	3/4	1 1/2	7/8	1 5/8	1	1 3/4	1 1/4	1 7/8
600 to 720, excl	over 8 to 60, excl	1/2	1 3/4	5/8	1 7/8	3/4	1 7/8	7/8	2 1/4
	60 to 84, excl	5/8	1 3/4	3/4	1 7/8	7/8	1 7/8	1	2 1/4
	84 to 108, excl	5/8	1 3/4	3/4	1 7/8	7/8	1 7/8	1 1/8	2 1/4
	108 and over	7/8	1 3/4	1	2	1 1/8	2 1/4	1 1/4	2 1/2
720 and over	over 8 to 60, excl	9/16	2	3/4	2 1/8	7/8	2 1/4	1	2 3/4
	60 to 84, excl	3/4	2	7/8	2 1/8	1	2 1/4	1 1/8	2 3/4
	84 to 108, excl	3/4	2	7/8	2 1/8	1	2 1/4	1 1/4	2 3/4
	108 and over	1	2	1 1/8	2 3/8	1 1/4	2 1/2	1 3/8	3

[A]Permissible variation under specified width and length: 1/4 in.

[B]Permissible variations in length apply also to Universal Mill plates up to 12 in. in width for thicknesses over 2 to 2½ in., incl, except for alloy steel up to 2 in. thick.

TABLE A1.3 Permissible Variations in Rolled Width for Universal Mill Carbon Steel, High-Strength Low-Alloy Steel, and Alloy-Steel Plates 15 in. and under in Thickness

NOTE 1—Permissible variation under specified width shall be 1/8 in.

Specified Width, in.	Variations Over Specified Width for Thicknesses Given, in.					
	To 3/8 , excl	3/8 to 5/8 , excl	5/8 to 1, excl	1 to 2, incl	Over 2 to 10, incl	Over 10 to 15, incl
Over 8 to 20, excl	1/8	1/8	3/16	1/4	3/8	1/2
20 to 36, excl	3/16	1/4	5/16	3/8	7/16	9/16
36 and over	5/16	3/8	7/16	1/2	9/16	5/8

TABLE A1.4 Permissible Variations in Diameter for Sheared Circular Carbon Steel, High-Strength Low-Alloy Steel, and Alloy Steel Plates 1 in. and under in Thickness

NOTE 1—No permissible variations under specified diameter.

Specified Diameter, in.	Permissible Variations Over Specified Diameter for Thicknesses Given, in.		
	To 3/8 , excl	3/8 to 5/8 , excl	5/8 to 1, incl
To 32, excl	1/4	3/8	1/2
32 to 84, excl	5/16	7/16	9/16
84 to 108, excl	3/8	1/2	5/8
108 to 130, incl	7/16	9/16	11/16

TABLE A1.5 Permissible Variations in Width and Length for Rectangular Carbon Steel and High-Strength Low-Alloy Steel Plates when Gas Cutting is Specified or Required

NOTE 1— These variations may be taken all under or divided over and under, if so specified.

NOTE 2—Plates with universal rolled edges will be gas cut to length only.

Specified Thickness, in.	Variations Over for All Specified Widths or Lengths, in.
To 2, excl	1/2
2 to 4, excl	5/8
4 to 6, excl	3/4
6 to 8, excl	7/8
8 to 15, incl	1

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TABLE A1.6 Permissible Variations in Diameter for Gas-Cut Circular Carbon Steel and High-Strength Low-Alloy Steel Plates

NOTE 1—No permissible variations under specified diameter

Specified Diameter, in.	Variations Over Specified Diameter for Thicknesses Given, in.					
	To 1, excl	1 to 2, excl	2 to 4, excl	4 to 6, excl	6 to 8, excl	8 to 15, incl
To 32, excl	3/8	3/8	1/2	1/2	5/8	3/4
32 to 84, excl	3/8	1/2	1/2	5/8	3/4	7/8
84 to 108, excl	1/2	9/16	5/8	3/4	7/8	1
108 to 130, excl	1/2	9/16	11/16	7/8	1	1 1/8
130 and over	5/8	3/4	7/8	1	1 1/8	1 1/4

TABLE A1.7 Permissible Camber for Carbon Steel Sheared or Gas-Cut Rectangular Plates all Thicknesses

NOTE 1—Camber, as it relates to plates, is the horizontal edge curvature in the length, measured over the entire length of the plate in the flat position.

Maximum permissible camber, in. = 1/8 in. × (number of feet of length/5)

TABLE A1.8 Permissible Camber for Carbon Steel, High-Strength Low-Alloy Steel, and Alloy Steel Universal Mill Plates and High-Strength Low-Alloy Steel and Alloy Steel Sheared or Gas-Cut Rectangular Plates

Dimension, in.		Camber for Thickness and Widths Given
Thickness	Width	
To 2, incl	all	1/8 in. × (number of feet of length/5)
Over 2 to 15, incl	to 30, incl	3/16 in. × (number of feet of length/5)
Over 2 to 15, incl	over 30	1/4 in. × (number of feet of length/5)

TABLE A1.9 Permissible Variations from Flatness for Carbon Steel Plates

NOTE 1—*Flatness Variations for Length*—The longer dimension specified is considered the length, and variation in flatness along the length shall not exceed the tabular amount for the specified width in plates up to 12 ft in length, or in any 12 ft of longer plates.

NOTE 2—*Flatness Variations for Width*—The flatness variation across the width shall not exceed the tabular amount for the specified width.

NOTE 3—When the longer dimension is under 36 in., the variation in flatness along the length and across the width shall not exceed 1/4 in. in each direction. When the longer dimension is from 36 to 72 in., inclusive, the flatness variation shall not exceed 75 % of the tabular amount for the specified width, but in no case less than 1/4 in.

NOTE 4—The tolerances given in this table apply to plates that have a minimum specified tensile strength not over 60 ksi or comparable chemistry or hardness. For plates specified to a higher minimum tensile strength or comparable chemistry or hardness, the limits given in the table are increased to 1 1/2 times the amounts in the above table.

NOTE 5—This table and notes cover the flatness tolerances of circular and sketch plates, based on the maximum dimensions of those plates.

NOTE 6—Plates shall be in a horizontal position on a flat surface when flatness is measured.

Specified Thickness, in.	Variations from a Flat Surface for Specified Widths, in.										
	Over 8 to 36, excl	36 to 48, excl	48 to 60, excl	60 to 72, excl	72 to 84, excl	84 to 96, excl	96 to 108, excl	108 to 120, excl	120 to 144, excl	144 to 168, excl	168 and over
To 1/4 , excl	9/16	3/4	15/16	1 1/4	1 3/8	1 1/2	1 5/8	1 3/4	1 7/8	...	...
1/4 to 3/8 , excl	1/2	5/8	3/4	15/16	1 1/8	1 1/4	1 3/8	1 1/2	1 5/8	...	...
3/8 to 1/2 , excl	1/2	9/16	5/8	5/8	3/4	7/8	1	1 1/8	1 1/4	1 7/8	2 1/8
1/2 to 3/4 , excl	7/16	1/2	9/16	5/8	5/8	3/4	1	1	1 1/8	1 1/2	2
3/4 to 1, excl	7/16	1/2	9/16	5/8	5/8	5/8	3/4	7/8	1	1 3/8	1 3/4
1 to 2, excl	3/8	1/2	1/2	9/16	9/16	5/8	5/8	5/8	11/16	1 1/8	1 1/2
2 to 4 excl	5/16	3/8	7/16	1/2	1/2	1/2	1/2	9/16	5/8	7/8	1 1/8
4 to 6, excl	3/8	7/16	1/2	1/2	9/16	9/16	5/8	3/4	7/8	7/8	1
6 to 8, excl	7/16	1/2	1/2	5/8	11/16	3/4	7/8	7/8	1	1	1
8 to 10 excl	1/2	1/2	5/8	11/16	3/4	13/16	7/8	15/16	1	1	1
10 to 12, excl	1/2	5/8	3/4	13/16	7/8	15/16	1	1	1	1	1
12 to 15, incl	5/8	3/4	13/16	7/8	15/16	1	1	1	1	1	...

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TABLE A1.10 Permissible Variations in Width and Length for Rectangular Alloy Steel Plates when Gas Cutting is Specified or Required

NOTE 1—These variations may be taken all under or divided over and under, if so specified.

NOTE 2— Plates with universal rolled edges will be gas cut to length only.

Specified Thickness, in.	Variations Over for All Specified Widths and Lengths, in.
To 2, excl	¾
2 to 4, excl	1
4 to 6, excl	1⅛
6 to 8, excl	1 5/16
8 to 15, incl	1½

TABLE A1.11 Permissible Variations in Diameter for Gas-Cut Circular Alloy Steel Plates

NOTE 1—No permissible variations under specified diameter.

Specified Diameter, in.	Variations Over Specified Diameter for Thicknesses Given, in.					
	To 1, excl	1 to 2, excl	2 to 4, excl	4 to 6, excl	6 to 8, excl	8 to 15 incl
To 32, excl	½	¾	¾	¾	1	1
32 to 84, excl	½	⅝	⅞	1	1⅛	1¼
84 to 108, excl	⅝	¾	1	1⅛	1¼	1⅜
108 to 130, incl	⅞	1	1⅛	1¼	1⅜	1½

TABLE A1.12 Permissible Variations from Flatness for High-Strength Low-Alloy Steel and Alloy Steel Plates

NOTE 1—*Flatness Tolerances for Length*—The longer dimension specified is considered the length and variations from a flat surface along the length shall not exceed the tabular amount for the specified width in plates up to 12 ft in length, or in any 12 ft of longer plates.

NOTE 2—*Flatness Tolerances for Width*—The flatness variation across the width shall not exceed the tabular amount for the specified width.

NOTE 3—When the longer dimension is under 36 in., the variation shall not exceed ⅜ in. When the larger dimension is from 36 to 72 in., incl, the variation shall not exceed 75 % of the tabular amount for the specified width.

NOTE 4—This table and notes cover the tolerances for flatness of circular and sketch plates, based on the maximum dimensions of those plates.

NOTE 5—Plates shall be in a horizontal position on a flat surface when flatness is measured.

Specified Thickness, in.	Variations from a Flat Surface for Specified Widths, in.										
	Over 8 to 36, excl	36 to 48, excl	48 to 60, excl	60 to 72, excl	72 to 84, excl	84 to 96, excl	96 to 108, excl	108 to 120, excl	120 to 144, excl	144 to 168, excl	168 and Over
To ¼ , excl	13/16	1⅛	1⅜	1⅞	2	2¼	2⅜	2⅝	2¾	...	...
¼ to ⅜ , excl	¾	15/16	1⅛	1⅜	1¾	1⅞	2	2¼	2⅜	...	...
⅜ to ½ , excl	¾	⅞	15/16	15/16	1⅛	1 5/16	1½	1⅝	1⅞	2¾	3⅛
½ to ¾ , excl	⅝	¾	13/16	⅞	1	1⅛	1¼	1⅜	1⅝	2¼	3
¾ to 1, excl	⅝	¾	⅞	⅞	15/16	1	1⅛	1 5/16	1½	2	2⅝
1 to 2, excl	9/16	⅝	¾	13/16	⅞	15/16	1	1	1	1⅝	2¼
2 to 4, excl	½	9/16	11/16	¾	¾	¾	¾	⅞	1	1¼	1⅝
4 to 6, excl	9/16	11/16	¾	¾	⅞	⅞	15/16	1⅛	1¼	1¼	1½
6 to 8, excl	⅝	¾	¾	15/16	1	1⅛	1¼	1 5/16	1½	1½	1½
8 to 10, excl	¾	13/16	15/16	1	1⅛	1¼	1 5/16	1⅜	1½	1½	1½
10 to 12, excl	¾	15/16	1⅛	1¼	1 5/16	1⅜	1½	1½	1½	1½	1½
12 to 15, incl	⅞	1	1 3/16	1 5/16	1⅜	1½	1½	1½	1½	1½	1½

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TABLE A1.13 Waviness Tolerances for Rectangular Plates, Universal Mill Plates, Circular Plates, and Sketch Plates

NOTE 1—Waviness denotes the deviation of the top or bottom surface from a horizontal line, when the plate is resting on a flat surface, as measured in an increment of less than 12 ft of length. The waviness tolerance is a function of the flatness tolerance as obtained from Tables A1.9 and A1.12.

Flatness Tolerance from Tables A1.9 and A1.12	When Number of Waves in 12 ft is:						
	1	2	3	4	5	6	7
5/16	5/16	1/4	3/16	1/8	1/8	1/16	1/16
3/8	3/8	5/16	3/16	3/16	1/8	1/16	1/16
7/16	7/16	5/16	1/4	3/16	1/8	1/8	1/16
1/2	1/2	3/8	5/16	3/16	3/16	1/8	1/16
9/16	9/16	7/16	5/16	1/4	3/16	1/8	1/8
5/8	5/8	1/2	3/8	1/4	3/16	1/8	1/8
11/16	11/16	1/2	3/8	5/16	3/16	3/16	1/8
3/4	3/4	9/16	7/16	5/16	1/4	3/16	1/8
13/16	13/16	5/8	7/16	5/16	1/4	3/16	1/8
7/8	7/8	11/16	1/2	3/8	1/4	3/16	1/8
15/16	15/16	11/16	1/2	3/8	5/16	1/4	3/16
1	1	3/4	9/16	7/16	5/16	1/4	3/16
1 1/8	1 1/8	7/8	5/8	1/2	3/8	1/4	3/16
1 1/4	1 1/4	15/16	11/16	1/2	3/8	5/16	1/4
1 3/8	1 3/8	1 1/16	3/4	9/16	7/16	5/16	1/4
1 1/2	1 1/2	1 1/8	7/8	5/8	1/2	3/8	1/4
1 5/8	1 5/8	1 1/4	15/16	11/16	1/2	3/8	5/16
1 3/4	1 3/4	1 5/16	1	3/4	9/16	7/16	5/16
1 7/8	1 7/8	1 7/16	1 1/16	13/16	9/16	7/16	5/16
2	2	1 1/2	1 1/8	7/8	5/8	1/2	3/8
2 1/8	2 1/8	1 5/8	1 3/16	7/8	11/16	1/2	3/8
2 1/4	2 1/4	1 11/16	1 1/4	15/16	11/16	9/16	3/8
2 3/8	2 3/8	1 13/16	1 5/16	1	3/4	9/16	7/16
2 1/2	2 1/2	1 7/8	1 7/16	1 1/16	13/16	9/16	7/16
2 5/8	2 5/8	2	1 1/2	1 1/8	13/16	5/8	7/16
2 3/4	2 3/4	2 1/16	1 9/16	1 1/8	7/8	5/8	1/2
2 7/8	2 7/8	2 3/16	1 5/8	1 3/16	15/16	11/16	1/2
3	3	2 1/4	1 11/16	1 1/4	15/16	11/16	9/16
3 1/8	3 1/8	2 3/8	1 3/4	1 5/16	1	3/4	9/16

TABLE A1.14 Visible Edge Indications Extending Approximately Parallel to Rolled Surfaces

Plate Specification and Thickness	Acceptable		Remove by Grinding		Acceptable on Edges Cut in Fabrication	
	Depth	Length[A]	Depth	Length[A]	Depth	Length[A]
Column	1	2	3	4	5	6
Other than killed,[B] to 2 in., incl	1/8 in. max	any	over 1/8 in. to 1/4 in., incl	over 1 in.	1/4 in. max	any
Killed,[C] to 6 in., incl	1/16 in. max	any	over 1/16 in. to 1/8 in., incl	over 1 in.	1/8 in. max	any
Killed,[C] over 6 in.	1/8 in. max	any	over 1/8 in. to 1/2 in., incl	over 1 in.	1/2 in. max	any

[A] Laminar-type discontinuities 1 in. and less in length are acceptable and do not require exploration.
[B] Specifications: A 285; A 433; A 442 in thicknesses to 1 in., incl; or A 455.
[C] The specification in 1.1 of this standard, other than those listed in the above Footnote *B*.

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TABLE A1.15 Generally Available Grade-Thickness-Minimum Test Temperature Combinations Meeting Charpy V-Notch Requirements Indicated (Normalized or Quenched and Tempered Condition)

NOTE 1— The minimum temperatures listed are for longitudinal tests. For transverse tests, the available minimum temperature may be somewhat higher.

Acceptance Criteria Charpy V-Notch			Specification and Grade[A]	Test Temperature, °F for Plate Thicknesses (Unless Otherwise Agreed Upon)			
Energy Absorption							
Class[B]	MinimumAverage For 3 Specimens[C] ft·lbf	Minimum For 1 Specimen[C] ft·lbf		1 in. and Under	Over 1 in. to 2 in., incl.	Over 2 in. to 3 in., incl.	Over 3 in. to 5 in., incl.
I	10	7	A 285 Grade A	+40	+60	. . .	. . .
			A 285 Grade B	+50	+70	. . .	. . .
			A 285 Grade C	+60	+80	. . .	. . .
II	13	10	A 455	+25	. . .	. . .	. . .
III	13	10	A 203 Grade A	–90	–90	–75	. . .
			A 203 Grade D	–150	–150	–125	. . .
			A 442 Grade 55 (1½ in. max thickness	. . .	–20	. . .	. . .
			A 442 Grade 60 (1½ in. max thickness)	. . .	–15	. . .	. . .
			A 516 Grade 55	–60	–60	–50	–50
			A 516 Grade 60	–60	–50	–50	–50
			A 516 Grade 65	–60	–50	–40	–25
			A 537 Class 1 (Over 2½ –4 in.)	. . .	. . .	–75	–50
			A 662 Grade A	–75	–75	. . .	. . .
			A 662 Grade B	–60	–60	. . .	. . .
IV	15	12	A 203 Grade B	–90	–90	–75	. . .
			A 203 Grade E	–150	–150	–125	. . .
			A 203 Grade F (4 in. max)	. . .	. . .	–160	–160
			A 299	+20	+30	+30	+40
			A 516 Grade 70	–50	–40	–30	–20
			A 537 Class 1 (2½ in. max)	–80	–75	–75	. . .
			A 537 Class 2 (Over 2½ –4 in.)	. . .	. . .	–75	–50
			A 662 Grade C	–50	–50	. . .	. . .
V	20	15	A 203 Grade F	–160	–160	. . .	. . .
			A 537 Class 2 (2½ in. max)	–90	–90	–90	. . .
			A 612	–50	. . .	. . .	. . .
			A 724 Grade A	–50	. . .	. . .	. . .
	Lateral Expansion Mils. Minimum Each Specimen Transverse Test						
VI		15	A 353	–320	–320	. . .	. . .
			A 553 Type I	–320	–320	. . .	. . .
			A 553 Type II	–275	–275	. . .	. . .
			A 645	–275	–275	. . .	. . .
			A 517 all (2½ in. max thickness)	[A]	[A]	. . .	. . .
			A 724 Grade B	–50	. . .	. . .	. . .

[A] Testing temperature as specified in the purchase order, but no higher than 32 °F.

[B] Class I is *Other Than Killed* with a specified minimum tensile strength of 65 ksi or lower.
Class II is *Other Than Killed* with a specified minimum tensile strength of over 65 ksi to 75 ksi.
Class III is *Killed* with a specified minimum tensile strength of 65 ksi or lower.
Class IV is *Killed* with a specified minimum tensile strength of over 65 ksi to 75 ksi.
Class V is *Killed* with a specified minimum tensile strength of over 75 ksi to but not including 95 ksi.
Class VI is *Killed* with a specified minimum tensile strength of 95 ksi or over.

[C] Full size (10 by 10 mm) specimens.

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TABLE A1.16 Charpy V-Notch Test Acceptance Criteria for Various Subsize Specimens[A]

Full Size, 10 by 10 mm		¾ Size, 10 by 7.5 mm		⅔ Size, 10 by 6.7 mm		½ Size, 10 by 5 mm		⅓ Size, 10 by 3.3 mm		¼ Size, 10 by 2.5 mm	
ft·lbf	[J]	ft·lbf	[J]	ft·lbf	[J]	ft·lbf	[J]	ft·lbf	[J]	ft·lbf	[J]
40	[54]	30	[41]	27	[37]	20	[27]	13	[18]	10	[14]
35	[48]	26	[35]	23	[31]	18	[24]	12	[16]	9	[12]
30	[41]	22	[30]	20	[27]	15	[20]	10	[14]	8	[11]
25	[34]	19	[26]	17	[23]	12	[16]	8	[11]	6	[8]
20	[27]	15	[20]	13	[18]	10	[14]	7	[10]	5	[7]
16	[22]	12	[16]	11	[15]	8	[11]	5	[7]	4	[5]
15	[20]	11	[15]	10	[14]	8	[11]	5	[7]	4	[5]
13	[18]	10	[14]	9	[12]	6	[8]	4	[5]	3	[4]
12	[16]	9	[12]	8	[11]	6	[8]	4	[5]	3	[4]
10	[14]	8	[11]	7	[10]	5	[7]	3	[4]	2	[3]
7	[10]	5	[7]	5	[7]	4	[5]	2	[3]	2	[3]

[A]Interpolation shall be made for specimens with widths intermediate of those listed. Interpolated values shall be rounded to the nearest whole number as prescribed in Practice E 29.

TABLE A1.17 Permissible Variations in Width for Mill Edge Carbon Steel and High-Strength Low-Alloy Steel Plates Produced on Strip Mills

NOTE 1— Applies to plates produced from coil and plates produced from plate-as-rolled.

Specified Width, in.	Variations over SpecifiedWidth, in[A]
To 14, excl	7/16
14 to 17, excl	½
17 to 19, excl	9/16
19 to 21, excl	⅝
21 to 24, excl	11/16
24 to 26, excl	13/16
26 to 28, excl	15/16
28 to 35, excl	1⅛
35 to 50, excl	1¼
50 to 60, excl	1½
60 to 65, excl	1⅝
65 to 70, excl	1¾
70 to 80, excl	1⅞
80 and over	2

[A]No permissible variation under specified width.

A2. PERMISSIBLE VARIATIONS IN DIMENSIONS, ETC.—SI UNITS

A2.1 Listed herein are permissible variations in dimensions, and notch toughness information, expressed in SI units.

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TABLE A2.1 Permissible Variations in Thickness for Rectangular Plates

NOTE 1—Permissible variation under specified thickness, 0.3 mm.
NOTE 2—Thickness shall be measured 10 to 20 mm from the longitudinal edge.
NOTE 3—For specified thicknesses other than those shown, the tolerances for the next higher thickness shall apply.
NOTE 4—For thickness measured at any location other than that specified in Note 2, the permissible maximum over tolerance shall be increased by 75 %, rounded to the nearest 0.1 mm.

Specified Thickness, mm	Tolerance Over Specified Thickness for Widths Given in Millimetres, mm										
	1200 and Under	Over 1200 to 1500, excl	1500 to 1800, excl	1800 to 2100, excl	2100 to 2400, excl	2400 to 2700, excl	2700 to 3000, excl	3000 to 3300, excl	3300 to 3600, excl	3600 to 4200, excl	4200 and Over
5.0	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.9	1.0		
5.5	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.9	1.0		
6.0	0.8	0.8	0.8	0.8	0.8	0.8	0.9	1.0	1.1		
7.0	0.8	0.8	0.8	0.8	0.8	0.8	0.9	1.0	1.2	1.4	
8.0	0.8	0.8	0.8	0.8	0.8	0.8	0.9	1.0	1.2	1.4	
9.0	0.8	0.8	0.8	0.8	0.8	0.8	1.0	1.0	1.3	1.5	
10.0	0.8	0.8	0.8	0.8	0.8	0.8	1.0	1.0	1.3	1.5	1.7
11.0	0.8	0.8	0.8	0.8	0.8	0.8	1.0	1.0	1.3	1.5	1.7
12.0	0.8	0.8	0.8	0.8	0.8	0.9	1.0	1.0	1.3	1.5	1.8
14.0	0.8	0.8	0.8	0.8	0.9	0.9	1.0	1.1	1.3	1.5	1.8
16.0	0.8	0.8	0.8	0.8	0.9	0.9	1.0	1.1	1.3	1.5	1.8
18.0	0.8	0.8	0.8	0.8	0.9	1.0	1.1	1.2	1.4	1.6	2.0
20.0	0.8	0.8	0.8	0.8	0.9	1.0	1.2	1.2	1.4	1.6	2.0
22.0	0.8	0.9	0.9	0.9	1.0	1.1	1.3	1.3	1.5	1.8	2.0
25.0	0.9	0.9	1.0	1.0	1.0	1.2	1.3	1.5	1.5	1.8	2.2
28.0	1.0	1.0	1.1	1.1	1.1	1.3	1.4	1.8	1.8	2.0	2.2
30.0	1.1	1.1	1.2	1.2	1.2	1.4	1.5	1.8	1.8	2.1	2.4
32.0	1.2	1.2	1.3	1.3	1.3	1.5	1.6	2.0	2.0	2.3	2.6
35.0	1.3	1.3	1.4	1.4	1.4	1.6	1.7	2.3	2.3	2.5	2.8
38.0	1.4	1.4	1.5	1.5	1.5	1.7	1.8	2.3	2.3	2.7	3.0
40.0	1.5	1.5	1.6	1.6	1.6	1.8	2.0	2.5	2.5	2.8	3.3
45.0	1.6	1.6	1.7	1.8	1.8	2.0	2.3	2.8	2.8	3.0	3.5
50.0	1.8	1.8	1.8	2.0	2.0	2.3	2.5	3.0	3.0	3.3	3.8
55.0	2.0	2.0	2.0	2.2	2.2	2.5	2.8	3.3	3.3	3.5	3.8
60.0	2.3	2.3	2.3	2.4	2.4	2.8	3.0	3.4	3.4	3.8	4.0
70.0	2.5	2.5	2.5	2.6	2.6	3.0	3.3	3.5	3.6	4.0	4.0
80.0	2.8	2.8	2.8	2.8	2.8	3.3	3.5	3.5	3.6	4.0	4.0
90.0	3.0	3.0	3.0	3.0	3.0	3.5	3.5	3.5	3.6	4.0	4.4
100.0	3.3	3.3	3.3	3.3	3.5	3.8	3.8	3.8	3.8	4.4	4.4
110.0	3.5	3.5	3.5	3.5	3.5	3.8	3.8	3.8	3.8	4.4	4.4
120.0	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	4.8	4.8
130.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	5.2	5.2
140.0	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	5.6	5.6
150.0	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	5.6	5.6
160.0	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	5.6	5.6
180.0	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	6.3	6.3
200.0	5.8	5.8	6.0	6.0	6.0	6.0	6.0	6.0	6.0	7.0	7.0
250.0	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	8.8
300.0	7.5	7.5	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0

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TABLE A2.2 Permissible Variations in Width and Length for Sheared Plates 40 mm and Under in Thickness; Length only for Universal Mill Plates 65 mm and Under in Thickness

Specified Dimensions, mm		Permissible Variations over Specified Width and Length[A] for Thicknesses Given in millimetres, mm							
Length	Width	To 10, excl		10 to 16, excl		16 to 25, excl		25 to 50, incl[B]	
		Width	Length	Width	Length	Width	Length	Width	Length
To 3 000 excl	to 1500 excl	10	13	11	16	13	19	16	25
	1500 to 2100 excl	11	16	13	17	16	22	19	25
	2100 to 2700 excl	13	19	16	22	19	25	25	29
	2700 and over	16	22	19	25	22	29	29	32
3 000 to 6 000 excl	to 1500 excl	10	19	13	22	16	25	19	29
	1500 to 2100 excl	13	19	16	22	19	25	22	32
	2100 to 2700 excl	14	22	17	24	21	29	25	35
	2700 and over	16	25	19	29	22	32	29	35
6 000 to 9 000 excl	to 1500 excl	10	25	13	29	16	32	19	38
	1500 to 2100 excl	13	25	16	29	19	32	22	38
	2100 to 2700 excl	14	25	17	32	22	35	25	38
	2700 and over	17	29	22	32	25	35	32	44
9 000 to 12 000 excl	to 1500 excl	11	29	13	32	16	35	19	41
	1500 to 2100 excl	13	32	16	35	19	38	22	41
	2100 to 2700 excl	14	32	19	35	22	38	25	48
	2700 and over	19	35	22	38	25	41	32	48
12 000 to 15 000 excl	to 1500 excl	11	32	13	38	16	41	19	48
	1500 to 2100 excl	13	35	16	38	19	41	22	48
	2100 to 2700 excl	16	35	19	38	22	41	25	48
	2700 and over	19	38	22	41	25	44	32	48
15 000 to 18 000 excl	to 1500 excl	13	44	16	48	19	48	22	57
	1500 to 2100 excl	16	44	19	48	22	48	25	57
	2100 to 2700 excl	16	44	19	48	22	48	29	57
	2700 and over	22	44	25	51	29	57	32	64
18 000 and over	to 1500 excl	14	51	19	54	22	57	25	70
	1500 to 2100 excl	19	51	22	54	25	57	29	70
	2100 to 2700 excl	19	51	22	54	25	57	32	70
	2700 and over	25	51	29	60	32	64	35	76

[A]Permissible variation under specified width and length: 6 mm.

[B]Permissible variations in length apply also to Universal Mill plates up to 300 mm in width for thicknesses over 50 to 65 mm, incl, except for alloy steel up to 50 mm thick.

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TABLE A2.3 Permissible Variations in Rolled Width for Universal Mill Carbon Steel, High-Strength Low-Alloy Steel Plates, and Alloy Steel Plates 400 mm and under in Thickness

NOTE 1— Permissible variation under specified width shall be 3 mm.

Specified Width, mm	Variations Over Specified Width for Thickness Given, mm					
	To 10, excl	10 to 16, excl	16 to 25, excl	25 to 50, excl	Over 50 to 250, incl	Over 250 to 400, incl
Over 200 to 500, excl	3	3	5	6	10	13
500 to 900, excl	5	6	8	10	11	14
900 and over	8	10	11	13	14	16

TABLE A2.4 Permissible Variations in Diameter for Sheared Circular Carbon Steel, High-Strength Low-Alloy Steel, and Alloy Steel Plates 25 mm and under in Thickness

NOTE 1— No permissible variations under specified diameter.

Specified Diameters, mm	Permissible Variations Over Specified Diameter for Thicknesses Given, mm		
	To 10, excl	10 to 16, excl	16 to 25, incl
To 800, excl	6	10	13
800 to 2100, excl	8	11	14
2100 to 2700, excl	10	13	16
2700 to 3300, excl	11	14	17
3300 and over	13	16	19

TABLE A2.5 Permissible Variations in Width and Length for Rectangular Carbon Steel and High-Strength Low-Alloy Steel Plates when Gas Cutting is Specified or Required

NOTE 1—These variations may be taken all under or divided over and under, if so specified.

NOTE 2— Plates with universal rolled edges will be gas cut to length only.

Specified Thickness, mm	Variations Over for All Specified Widths or Lengths, mm
To 50, excl	13
50 to 100, excl	16
100 to 150, excl	19
150 to 200, excl	22
200 to 400, incl	25

TABLE A2.6 Permissible Variations in Diameter for Gas-Cut Circular Carbon Steel and High-Strength Low-Alloy Steel Plates

NOTE 1— No permissible variations under specified diameter.

Specified Diameters, mm	Variations Over Specified Diameter for Thicknesses Given, mm					
	To 25, excl	25 to 50, excl	50 to 100, excl	100 to 150, excl	150 to 200, excl	200 to 400, excl
To 800, excl	10	10	13	13	16	19
800 to 2100, excl	10	13	13	16	19	22
2100 to 2700, excl	13	14	16	19	22	25
2700 to 3300, excl	13	14	17	22	25	29
3300 and over	16	19	22	25	29	32

TABLE A2.7 Permissible Camber for Carbon Steel Sheared or Gas-Cut Rectangular Plates all Thicknesses

NOTE 1— Camber, as it relates to plates, is the horizontal edge curvature in the length, measured over the entire length of the plate in the flat position.

Maximum permissible camber, mm = length in millimetres/500

TABLE A2.8 Permissible Camber for Carbon Steel, High-Strength Low-Alloy Steel, and Alloy Steel Universal Mill Plates and High-Strength Low-Alloy Steel and Alloy Steel Sheared or Gas-Cut Rectangular Plates

NOTE 1— Camber, as it relates to plates, is the horizontal edge curvature in the length, measured over the entire length of the plate in the flat position.

Width, mm	Camber for Width Given, mm
To 750, incl	Length/300
Over 750 to 1500	Length/250

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TABLE A2.9 Permissible Variations from Flatness for Carbon Steel Plates

NOTE 1—*Flatness Variations for Length*—The longer dimension specified is considered the length, and variation in flatness along the length shall not exceed the tabular amount for the specified width in plates up to 4000 mm in length, or in any 4000 mm of longer plates.

NOTE 2—*Flatness Variations for Width*—The flatness variation across the width shall not exceed the tabular amount for the specified width.

NOTE 3—When the longer dimension is under 900 mm, the variation in flatness along the length and across the width shall not exceed 6 mm in each direction. When the longer dimension is from 900 to 1800 mm, inclusive, the flatness variation shall not exceed 75 % of the tabular amount for the specified width, but in no case less than 6 mm.

NOTE 4—The tolerances given in this table apply to plates that have a minimum specified tensile strength not over 415 MPa or comparable chemistry or hardness. For plates specified to a higher minimum tensile strength or comparable chemistry or hardness, the limits given in the table are increased to 1½ times the amounts in the above table.

NOTE 5—This table and notes cover the flatness tolerances of circular and sketch plates, based on the maximum dimensions of those plates.

NOTE 6—Plates shall be in a horizontal position on a flat surface when flatness is measured.

Specified Thickness, mm	Permissible Variations from a Flat Surface for Specified Widths, mm										
	To 900, excl	900 to 1200	1200 to 1500	1500 to 1800	1800 to 2100	2100 to 2400	2400 to 2700	2700 to 3000	3000 to 3600	3600 to 4200	4200 and 0ver
To 6, excl	14	19	24	32	35	38	41	44	48	. . .	. . .
6 to 10, excl	13	16	19	24	29	32	35	38	41	. . .	. . .
10 to 12, excl	13	14	16	16	19	22	25	29	32	48	54
12 to 20, excl	11	13	14	16	16	19	25	25	29	38	51
20 to 25, excl	11	13	14	16	16	16	19	22	25	35	44
25 to 50, excl	10	13	13	14	14	16	16	16	18	29	38
50 to 100, excl	8	10	11	13	13	13	13	14	16	22	29
100 to 150, excl	10	11	13	13	14	14	16	19	22	22	25
150 to 200, excl	11	13	13	16	18	19	22	22	25	25	25
200 to 250, excl	13	13	16	18	19	21	22	24	25	25	25
250 to 300, excl	13	16	19	21	22	24	25	25	25	25	25
300 to 400, incl	16	19	21	22	24	25	25	25	25	25	. . .

TABLE A2.10 Permissible Variations in Width and Length for Rectangular Alloy Steel Plates when Gas Cutting is Specified or Required

NOTE 1— These variations may be taken all under or divided over and under, if so specified.

NOTE 2—Plates with universal rolled edges will be gas cut to length only.

Specified Thickness, mm	Variations Over for All Specified Widths and Lengths, mm
To 50, excl	19
50 to 100, excl	25
100 to 150, excl	29
150 to 200, excl	33
200 to 400, incl	38

TABLE A2.11 Permissible Variations in Diameter for Gas Cut Circular Alloy Steel Plates

NOTE 1— No permissible variations under specified diameter.

Specified Diameter, mm	Variations Over Specified Diameter for Thicknesses Given, mm					
	To 25, excl	25 to 50, excl	50 to 100, excl	100 to 150, excl	150 to 200, excl	200 to 400, incl
To 800, excl	13	13	19	19	25	25
800 to 2100, excl	13	16	22	25	29	32
2100 to 2700, excl	16	19	25	29	32	35
2700 to 3300, incl	22	25	29	32	35	38

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TABLE A2.12 Permissible Variations from Flatness for High-Strength Low-Alloy Steel and Alloy Steel Plates

NOTE 1—*Flatness Tolerances for Length*—The longer dimension specified is considered the length and variations from a flat surface along the length shall not exceed the tabular amount for the specified width in plates up to 4000 mm in length, or in any 4000 mm of longer plates.

NOTE 2—*Flatness Tolerances for Width*—The flatness variation across the width shall not exceed the tabular amount for the specified width.

NOTE 3—When the longer dimension is under 900 mm, the variation shall not exceed 10 mm. When the larger dimension is from 900 to 1800 mm, incl, the variation shall not exceed 75 % of the tabular amount for the specified width.

NOTE 4—This table and notes cover the tolerances for flatness of circular and sketch plates, based on the maximum dimensions of those plates.

NOTE 5—Plates shall be in a horizontal position on a flat surface when flatness is measured.

Specified Thickness, mm	Flatness Tolerances for Specified Widths, mm										
	To 900, excl	900 to 1200	1200 to 1500	1500 to 1800	1800 to 2100	2100 to 2400	2400 to 2700	2700 to 3000	3000 to 3600	3600 to 4200	4200 and over
To 6, excl	21	29	35	48	51	57	60	67	70	. . .	. . .
6 to 10, excl	19	24	29	35	44	48	51	57	60	. . .	. . .
10 to 12, excl	19	22	24	24	29	33	38	41	48	70	79
12 to 20, excl	16	19	21	22	25	29	32	35	41	57	76
20 to 25, excl	16	19	22	22	24	25	29	33	38	51	67
25 to 50, excl	14	16	19	21	22	24	25	25	25	41	57
50 to 100, excl	13	14	18	19	19	19	19	22	25	32	41
100 to 150, excl	14	18	19	19	22	22	24	29	32	32	38
150 to 200, excl	16	19	19	24	25	29	32	33	38	38	38
200 to 250, excl	19	21	24	25	29	32	33	35	38	38	38
250 to 300, excl	19	24	29	32	33	35	38	38	38	38	38
300 to 400, incl	22	25	30	33	35	38	38	38	38	38	38

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TABLE A2.13 Waviness Tolerances for Rectangular Plates, Universal Mill Plates, Circular Plates, and Sketch Plates

NOTE 1— Waviness denotes the deviation of the top or bottom surface from a horizontal line, when the plate is resting on a flat surface, as measured in an increment of less than 4000 mm of length. The waviness tolerance is a function of the flatness tolerance as obtained from Tables A 2.9 and A 2.12.

Flatness Tolerance from Tables A2.9 and A2.12	When Number of Waves in 4000 mm is:						
	1	2	3	4	5	6	7
8	8	6	5	3	3	2	2
10	10	8	5	5	3	2	2
11	11	8	6	5	3	3	2
13	13	10	8	5	5	3	2
14	14	11	8	6	5	3	2
16	16	13	10	6	5	3	2
17	17	13	10	8	5	5	2
19	19	14	11	8	6	5	2
21	21	16	11	8	6	5	2
22	22	17	13	10	6	5	2
24	24	17	13	10	8	6	5
25	25	19	14	11	8	6	5
29	29	22	16	13	10	6	5
32	32	24	17	13	10	8	6
35	35	27	19	14	11	8	6
38	38	29	22	16	13	10	6
41	41	32	24	17	13	10	8
44	44	33	25	19	14	11	8
48	48	37	27	21	14	11	8
51	51	38	29	22	16	13	10
54	54	41	30	22	17	13	10
57	57	43	32	24	17	14	10
60	60	46	33	25	19	14	11
64	64	48	37	27	21	14	11
67	67	51	38	29	21	16	11
70	70	52	40	29	22	16	13
73	73	56	41	30	24	17	13
76	76	57	43	32	24	17	14
79	79	60	44	33	25	19	14

TABLE A2.14 Visible Edge Indications Extending Approximately Parallel to Rolled Surfaces

Plate Specification and Thickness	Acceptable		Remove by Grinding		Acceptable on Edges Cut in Fabrication	
	Depth	Length[A]	Depth	Length[A]	Depth	Length[A]
Column	1	2	3	4	5	6
Other than killed,[B] to 50 mm, incl	3 mm, max	any	over 3 to 6 mm, incl	over 25 mm	6 mm max	any
Killed,[C] to 150 mm, incl	2 mm, max	any	over 2 to 3 mm, incl	over 25 mm	3 mm max	any
Killed,[C] over 150 mm	3 mm, max	any	over 3 to 13 mm, incl	over 25 mm	13 mm max	any

[A] Laminar-type discontinuities 25 mm and less in length are acceptable and do not require exploration.
[B] Specifications: A 285; A 433; A 442 in thicknesses to 25 mm, incl; or A 455.
[C] The specifications in 1.1 of this standard, other than those listed in the above Footnote *B*.

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TABLE A2.15 Generally Available Grade-Thickness-Minimum Test Temperature Combinations Meeting Charpy V-Notch Requirements Indicated (Normalized or Quenched and Tempered Condition)

NOTE 1— The minimum temperatures listed are for longitudinal tests. For transverse tests, the available minimum temperature may be somewhat higher.

Acceptance Criteria Charpy V-Notch Energy Absorption			Specification and Grade	Test Temperature, °C for Plate Thicknesses (Unless Otherwise Agreed Upon)			
Class[A]	Minimum Average For 3 Specimens[B], J	Minimum For 1 Specimen[B], J		25 mm and Under	Over 25 mm to 50 mm, incl.	Over 50 mm to 75 mm, incl.	Over 75 mm to 125 mm, incl.
I	14	10	A 285 Grade A	+4	+16	. . .	. . .
			A 285 Grade B	+10	+21	. . .	. . .
			A 285 Grade C	+16	+27	. . .	. . .
II	18	14	A 455	–4	. . .	. . .	. . .
III	18	14	A 203 Grade A	–68	–68	–60	. . .
			A 203 Grade D	–101	–101	–87	. . .
			A 442 Grade 55 (38 mm max thickness)	. . .	–29	. . .	. . .
			A 442 Grade 60 (38 mm max thickness)	. . .	–26	. . .	. . .
			A 516 Grade 55	–51	–51	–46	–46
			A 516 Grade 60	–51	–46	–46	–46
			A 516 Grade 65	–51	–46	–40	–32
			A 537 Class 1 (Over 64–100 mm)	. . .	. . .	–60	–46
			A 662 Grade A	–60	–60	. . .	. . .
			A 662 Grade B	–51	–51	. . .	. . .
IV	20	16	A 203 Grade B	–68	–68	–60	. . .
			A 203 Grade E	–101	–101	–87	. . .
			A 203 Grade F (100 mm max)	. . .	. . .	–107	–107
			A 299	–7	–1	–1	+4
			A 516 Grade 70	–46	–40	–35	–29
			A 537 Class 1 (64 mm max)	–62	–60	–60	. . .
			A 537 Class 2 (Over 64–100 mm)	. . .	. . .	–60	–46
			A 662 Grade C	–46	–46	. . .	. . .
V	27	20	A 203 Grade F	–107	–107	. . .	. . .
			A 537 Class 2 (64 mm max)	–68	–68	–68	. . .
			A 612	–46	. . .	. . .	. . .
			A 724 Grade A	–46	. . .	. . .	. . .
Lateral Expansion mm, Minimum Each Specimen Transverse Test							
VI	0.38		A 353	–196	–196	. . .	. . .
			A 553 Type I	–196	–196	. . .	. . .
			A 553 Type II	–170	–170	. . .	. . .
			A 645	–170	–170	. . .	. . .
			A 517 all (64 mm max thickness)	[C]	[C]	. . .	. . .
			A 724 Grade B	–46	. . .	. . .	. . .

[A]Class I is *Other Than Killed* with a specified minimum tensile strength of 450 MPa or lower.
Class II is *Other Than Killed* with a specified minimum tensile strength of over 450 to 520 MPa, incl.
Class III is *Killed* with a specified minimum tensile strength of 450 MPa or lower.
Class IV is *Killed* with a specified minimum tensile strength of over 450 to 520 MPa, incl.
Class V is *Killed* with a specified minimum tensile strength of over 520 MPa to but not including 655 MPa.
Class VI is *Killed* with a specified minimum tensile strength of 655 MPa or over.
[B]Full size (10 by 10 mm) specimens.
[C]Testing temperature as specified in the purchase order, but no higher than 0 °C.

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TABLE A2.16 Permissible Variations in Width for Mill Edge Carbon Steel and High-Strength Low-Alloy Steel Plates Produced on Strip Mills

NOTE 1— Applies to plates produced from coil and plates produced from plate-as-rolled.

Specified Width, mm	Variations Over Specified Width, mm[A]
To 360, excl	11
360 to 430, excl	13
430 to 480, excl	14
480 to 530, excl	16
530 to 610, excl	17
610 to 660, excl	21
660 to 710, excl	24
710 to 890, excl	29
890 to 1270, excl	32
1270 to 1520, excl	38
1520 to 1650, excl	41
1650 to 1780, excl	44
1780 to 2030, excl	47
2030 and over	51

[A]No permissible variation under specified width.

APPENDIXES

(Nonmandatory Information)

X1. COILED STEEL

X1.1 Continuous wide hot strip rolling mills are normally equipped with coilers. Regardless of the different types of systems employed during or following the rolling operations, it is common for the steel to be reeled into the coiler at temperatures in the stress-relieving range. In general, such temperatures are higher as the steel thickness increases. The coils subsequently cool to ambient temperature with outer and inner laps cooling more rapidly than central laps. The difference in cooling rate can result in measurable differences in the mechanical properties throughout a coil. Data confirm reduced yield and tensile strength, and increased percent elongation, for the product with slower cooling rates from the coiling temperature to ambient. Such differences are in addition to the effects on mechanical properties caused by differences in heat analysis and chemical segregation.

X2. VARIATION OF TENSILE PROPERTIES IN PLATE-AS-ROLLED

X2.1 The tension requirements of this general requirements specification are intended only to characterize the tensile properties of a plate-as-rolled for determination of conformance to the requirements of the applicable product specifications. Such testing procedures are not intended to define the upper or lower limits of tensile properties at all possible test locations within a plate-as-rolled. It is well known and documented that tensile properties vary within a plate-as-rolled or individual piece of steel as a function of chemical composition, processing, testing procedure, and other factors. It is, therefore, incumbent on designers and engineers to use sound engineering judgement when using tension test results shown on mill test reports. The testing procedures of this general requirements specification have been found to provide plate adequate for normal pressure vessel design criteria.

X2.2 A survey of the variation to be expected in tensile properties obtained from plates and structural shapes was conducted by the American Iron and Steel Institute (AISI).[6] The results of this survey are contained in a *Contributions to the Metallurgy of Steel* entitled "The Variation of Product Analysis and Tensile Properties—Carbon Steel Plates, and Wide Flange Shapes" (SU/18, SU/19, and SU/20), published in September 1974. The data are presented in tables of probability that tensile properties at other than the official location may differ from those of the reported test location.

X2.3 This general requirements specification contains no requirements applicable to product tension tests; conformance to the applicable product specification is determined on the basis of tests performed at the place of manufacture or processing prior to shipment, unless otherwise specified.

X2.4 A Task Group of ASTM Subcommittee A01.11 has determined, based on review of the AISI data [6](SU20), that the variation in tensile properties within a plate-as-rolled can be expressed as a function of specified requirements; one standard deviation equals approximately 3 % of required tensile strength, 5 % of required yield strength, and 3 percentage points of required elongation.

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X3. VARIATION IN CHARPY V-NOTCH TESTS

X3.1 A survey of the variation to be expected in Charpy V-Notch test results obtained from three common fine grain plate steels was conducted by the American Iron and Steel Institute (AISI).[6] The results of the survey are contained in a Contributions to the Metallurgy of Steel entitled, "The Variations of Charpy V-Notch Impact Test Properties in Steel Plates," (SU/24), published January 1979. The survey data consists of test values obtained from six locations in addition to the locations specified in 12.1.3 of this specification. The plate conditions tested involved as-rolled, normalized, and quench and tempered. Sufficient full-size specimens were taken from each sample so that three longitudinal and three transverse specimens could be broken at three test temperatures defined for each grade. The data is presented in tables of probability that impact properties at other than the official location which may differ from those of the reported test location. Additional data of the same type, but utilizing samples from thicker plates, was published by AISI as SU/27.[6]

X4. RADIUS FOR COLD BENDING

X4.1 Suggested minimum inside bend radii for cold forming are referenced to group Designations A through F as defined in Table X4.1. The suggested radii listed in Table X4.2 should be used as minimums in typical shop fabrication. Material that does not form satisfactorily when fabricated in accordance with Table X4.2 may be subject to rejection pending negotiation with the steel supplier. When tighter bends are required, the manufacturer should be consulted.

X4.2 The bend radius and the radius of the male die should be as liberal as the finished part will permit. The width across the shoulders of the female die should be at least 8 times the plate thickness. Higher strength steels require larger die openings. The surface of the dies in the area of radius should be smooth.

X4.3 Since cracks in cold bending commonly originate from the outside edges, shear burrs and gas cut edges should be removed by grinding. Sharp corners on edges and on punched or gas cut holes should be removed by chamfering or grinding to a radius.

X4.4 If possible, parts should be formed such that the bend line is perpendicular to the direction of final rolling. If it is necessary to bend with the bend line parallel to the direction of final rolling, a more generous radius is suggested (1½ times applicable value given in Table X4.2 for bend lines perpendicular to the direction of rolling).

X4.5 References

Holt, G. E., et al. "Minimum Cold Bend Radii Project - Final Report," Concurrent Technologies Corporation, January 27, 1997.

Brockenbrough, R. L., "Fabrication Guidelines for Cold Bending," R. L. Brockenbrough & Associates, June 28, 1998.

Both of these references are available from American Iron and Steel Institute, 1101 17th Street NW, Washington, DC 20036-4700.

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TABLE X4.1 Group Designations for Cold Bending

Specification	Class Where Applicable	Grade Where Applicable	Group Designation[A]
A 202/A 202M		A	D
		B	E
A 203/A 203M		A, D	B
		B, E	C
		F	D
A 204/A 204M		A	B
		B	C
		C	D
A 225/A 225M		C, D	D
A 285/A 285M		A, B, C	A
A 299/A 299M		A, B	D
A 302/A 302M		A, C, D	D
		B	E
A 353/A 353M			D
A 387/A 387M	1, 2	2, 11, 12	C
	1	5, 9, 21, 21L, 22, 22L	E
	2	5, 9, 21, 22, 91	E
A 455/A 455M			C
A 515/A 515M		60 or 65	B
		70	C
A 516/A 516M		55	A
		60, 65	B
		70	C
A 517/A 517M		A, B, C, E, F, H, J, K, M, P, Q, S, T	F
A 533/A 533M	1, 2, 3	A, B, C, D	E
A 537/A 537M	1, 2[B], 3[B]		C
	2[C], 3[C]		D
A 542/A 542M[D]	1, 2		F
	3, 4		D
	4a		E
A 543/A 543M	1, 2, 3	B, C	F
A 553/A 553M[D]			D
A 562/A 562M			A
A 612/A 612M			C
A 645/A 645M			D
A 662/A 662M		A, B	B
		C	C
A 724/A 724M		A, C	D
		B	E
A 734/A 734M[D]			D
A 735/A 735M	1, 2, 3, 4		E
A 736/A 736M	1, 2, 3	A, C	D
A 737/A 737M		B, C	B
A 738/A 738M		A, B	D
		C[B]	C
		C[C]	D
A 782/A 782M	1, 2		E
	3		F
A 832/A 832M		21V, 22V, 23V	E
A 841/A 841M	1, 2	A, B, C	C
	3	D	F
A 844/A 844M			D
A 1017/A 1017M		23, 122	D
		911	E
A 1041/A 1041M		315, 315T	F

[A]Steels in Groups A to E inclusive are grouped on the basis of similar specified values for minimum elongation in 2 in. [50 mm]; Group F includes steels that have a specified minimum elongation in 2 in. [50 mm] of 16 or less, and steels that have a ratio of specified minimum tensile strength to specified minimum yield strength of 1.15 or less.

[B]For thicknesses of 4 in. [100 mm] and less.

[C]For thicknesses over 4 in. [100 mm].

[D]For any type.

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TABLE X4.2 Suggested Minimum Inside Radii for Cold Bending[A]

Group Designation[B]	Thickness (t), in. [mm]			
	Up to ¾ in. [20 mm]	Over ¾ in. [20 mm] to 1 in. [25 mm], incl	Over 1 in. [25 mm] to 2 in. [50 mm], incl	Over 2 in. [50 mm]
A	1.5*t*	1.5*t*	1.5*t*	1.5*t*
B	1.5*t*	1.5*t*	1.5*t*	2.0*t*
C	1.5*t*	1.5*t*	2.0*t*	2.5*t*
D	1.5*t*	1.5*t*	2.5*t*	3.0*t*
E	1.5*t*	1.5*t*	3.0*t*	3.5*t*
F	1.75*t*	2.25*t*	4.5*t*	5.5*t*

[A]Values are for bend lines perpendicular to the direction of final rolling. These radii apply when the precautions listed in X4.2 are followed. If bend lines are parallel to the direction of final rolling, multiply values by 1.5.

[B]Steels specifications included in the group designations may not include the entire thickness range shown in this table.

SUMMARY OF CHANGES

Committee A01 has identified the location of selected changes to this standard since the last issue (A 20/A 20M–06) that may impact the use of this standard.

(*1*) Revised Table A2.1.

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