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

This standard is issued under the fixed designation A20/A20M; 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, Nickel	A203/A203M
Pressure Vessel Plates, Alloy Steel, Molybdenum	A204/A204M
Pressure Vessel Plates, Alloy Steel, Manganese-Vanadium	A225/A225M
Pressure Vessel Plates, Carbon Steel, Low- and Intermediate-Tensile Strength	A285/A285M
Pressure Vessel Plates, Carbon Steel, Manganese-Silicon	A299/A299M
Pressure Vessel Plates, Alloy Steel, Manganese-Molybdenum and Manganese-Molybdenum-Nickel	A302/A302M
Pressure Vessel Plates, Alloy Steel, 9 Percent Nickel Double-Normalized and Tempered	A353/A353M
Pressure Vessel Plates, Alloy Steel, Chromium-Molybdenum	A387/A387M
Pressure Vessel Plates, Carbon Steel, High Strength Manganese	A455/A455M
Pressure Vessel Plates, Carbon Steel, for Intermediate- and Higher-Temperature Service	A515/A515M
Pressure Vessel Plates, Carbon Steel, Moderate- and Lower-Temperature Service	A516/A516M
Pressure Vessel Plates, Alloy Steel, High-Strength, Quenched and Tempered	A517/A517M
Pressure Vessel Plates, Alloy Steel, Quenched and Tempered Manganese-Molybdenum and Manganese-Molybdenum- Nickel	A533/A533M
Pressure Vessel Plates, Heat-Treated, Carbon-Manganese-Silicon Steel	A537/A537M
Pressure Vessel Plates, Alloy Steel, Quenched and Tempered Chromium-Molybdenum	A542/A542M
Pressure Vessel Plates, Alloy Steel, Quenched and Tempered Nickel-Chromium-Molybdenum	A543/A543M
Pressure Vessel Plates, Alloy Steel, Quenched and Tempered 8 and 9 Percent Nickel	A553/A553M

Title of Specification	ASTM Designation[A]
Pressure Vessel Plates, Carbon Steel, Manganese-Titanium for Glass or Diffused Metallic Coatings	A562/A562M
Pressure Vessel Plates, Carbon Steel, High Strength, for Moderate and Lower Temperature Service	A612/A612M
Pressure Vessel Plates, Five Percent Nickel Alloy Steel, Specially Heat Treated	A645/A645M
Pressure Vessel Plates, Carbon-Manganese, for Moderate and Lower Temperature Service	A662/A662M
Pressure Vessel Plates, Carbon Steel, Quenched and Tempered, for Welded Layered Pressure Vessels	A724/A724M

[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.**

Pressure Vessel Plates, Alloy Steel and High-Strength Low-Alloy Steel, Quenched and Tempered	A734/A734M
Pressure Vessel Plates, Low-Carbon Manganese-Molybdenum-Columbium Alloy Steel, for Moderate and Lower Temperature Service	A735/A735M
Pressure Vessel Plates, Low-Carbon Age-Hardening Nickel-Copper-Chromium-Molybdenum-Columbium Alloy Steel	A736/A736M
Pressure Vessel Plates, High-Strength Low-Alloy Steel	A737/A737M
Pressure Vessel Plates, Heat-Treated, Carbon-Manganese-Silicon Steel, for Moderate and Lower Temperature Service	A738/A738M
Pressure Vessel Plates, Alloy Steel, Chromium-Molybdenum-Vanadium	A832/A832M
Pressure Vessel Plates, Produced by the Thermo-Mechanical Control Process (TMCP)	A841/A841M
Pressure Vessel Plates, 9 % Nickel Alloy, Produced by the Direct-Quenching Process	A844/A844M
Pressure Vessel Plates, 9 % Nickel Alloy, Produced by the Direct-Quenching Process	A844/A844M
Pressure Vessel Plates, 9 % Nickel Alloy, Produced by the Direct-Quenching Process	A844/A844M
Pressure Vessel Plates, Alloy Steel, Chromium-Molybdenum-Tungsten	A1017/A1017M
Pressure Vessel Plates, Alloy Steel, Higher Strength Chromium-Molybdenum-Tungsten	A1041/A1041M

[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.

1.6 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 E29.

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]

A203/A203M Specification for Pressure Vessel Plates, Alloy Steel, Nickel

A204/A204M Specification for Pressure Vessel Plates, Alloy Steel, Molybdenum

A225/A225M Specification for Pressure Vessel Plates, Alloy Steel, Manganese-Vanadium-Nickel

A285/A285M Specification for Pressure Vessel Plates, Carbon Steel, Low- and Intermediate-Tensile Strength

A299/A299M Specification for Pressure Vessel Plates, Carbon Steel, Manganese-Silicon

A302/A302M Specification for Pressure Vessel Plates, Alloy Steel, Manganese-Molybdenum and Manganese-Molybdenum-Nickel

[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.

A353/A353M Specification for Pressure Vessel Plates, Alloy Steel, Double-Normalized and Tempered 9 % Nickel
A370 Test Methods and Definitions for Mechanical Testing of Steel Products
A387/A387M Specification for Pressure Vessel Plates, Alloy Steel, Chromium-Molybdenum
A435/A435M Specification for Straight-Beam Ultrasonic Examination of Steel Plates
A455/A455M Specification for Pressure Vessel Plates, Carbon Steel, High-Strength Manganese
A515/A515M Specification for Pressure Vessel Plates, Carbon Steel, for Intermediate- and Higher-Temperature Service
A516/A516M Specification for Pressure Vessel Plates, Carbon Steel, for Moderate- and Lower-Temperature Service
A517/A517M Specification for Pressure Vessel Plates, Alloy Steel, High-Strength, Quenched and Tempered
A533/A533M Specification for Pressure Vessel Plates, Alloy Steel, Quenched and Tempered, Manganese-Molybdenum and Manganese-Molybdenum-Nickel
A537/A537M Specification for Pressure Vessel Plates, Heat-Treated, Carbon-Manganese-Silicon Steel
A542/A542M Specification for Pressure Vessel Plates, Alloy Steel, Quenched-and-Tempered, Chromium-Molybdenum, and Chromium-Molybdenum-Vanadium
A543/A543M Specification for Pressure Vessel Plates, Alloy Steel, Quenched and Tempered Nickel-Chromium-Molybdenum
A553/A553M Specification for Pressure Vessel Plates, Alloy Steel, Quenched and Tempered 8 and 9 % Nickel
A562/A562M Specification for Pressure Vessel Plates, Carbon Steel, Manganese-Titanium for Glass or Diffused Metallic Coatings
A577/A577M Specification for Ultrasonic Angle-Beam Examination of Steel Plates
A578/A578M Specification for Straight-Beam Ultrasonic Examination of Rolled Steel Plates for Special Applications
A612/A612M Specification for Pressure Vessel Plates, Carbon Steel, High Strength, for Moderate and Lower Temperature Service
A645/A645M Specification for Pressure Vessel Plates, 5 % and 51 2 % Nickel Alloy Steels, Specially Heat Treated
A662/A662M Specification for Pressure Vessel Plates, Carbon-Manganese-Silicon Steel, for Moderate and Lower Temperature Service
A700 Practices for Packaging, Marking, and Loading Methods for Steel Products for Shipment
A724/A724M Specification for Pressure Vessel Plates, Carbon-Manganese-Silicon Steel, Quenched and Tempered, for Welded Pressure Vessels
A734/A734M Specification for Pressure Vessel Plates, Alloy Steel and High-Strength Low-Alloy Steel, Quenched-and-Tempered
A735/A735M Specification for Pressure Vessel Plates, Low-Carbon Manganese-Molybdenum-Columbium Alloy Steel, for Moderate and Lower Temperature Service
A736/A736M Specification for Pressure Vessel Plates, Low-Carbon Age-Hardening Nickel-Copper-Chromium-Molybdenum-Columbium and Nickel-Copper-Manganese-Molybdenum-Columbium Alloy Steel
A737/A737M Specification for Pressure Vessel Plates, High-Strength, Low-Alloy Steel
A738/A738M Specification for Pressure Vessel Plates, Heat-Treated, Carbon-Manganese-Silicon Steel, for Moderate and Lower Temperature Service
A751 Test Methods, Practices, and Terminology for Chemical Analysis of Steel Products
A770/A770M Specification for Through-Thickness Tension Testing of Steel Plates for Special Applications
A832/A832M Specification for Pressure Vessel Plates, Alloy Steel, Chromium-Molybdenum-Vanadium
A841/A841M Specification for Steel Plates for Pressure Vessels, Produced by Thermo-Mechanical Control Process (TMCP)
A844/A844M Specification for Steel Plates, 9 % Nickel Alloy, for Pressure Vessels, Produced by the Direct-Quenching Process
A941 Terminology Relating to Steel, Stainless Steel, Related Alloys, and Ferroalloys
A1017/A1017M Specification for Pressure Vessel Plates, Alloy Steel, Chromium-Molybdenum-Tungsten
A1041/A1041M Specification for Pressure Vessel Plates, Alloy Steel, Higher Strength Chromium-Molybdenum-Tungsten
E21 Test Methods for Elevated Temperature Tension Tests of Metallic Materials
E29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications
E112 Test Methods for Determining Average Grain Size
E208 Test Method for Conducting Drop-Weight Test to Determine Nil-Ductility Transition Temperature of Ferritic Steels
E709 Guide for Magnetic Particle Testing

2.2 *American Society of Mechanical Engineers Code:*[4]
ASME Boiler and Pressure Vessel Code Section IX, Welding Qualifications

2.3 *U.S. Federal Standard:*[5]
Fed. Std. No. 123 Marking for Shipment (Civil Agencies)

[4] Available from American Society of Mechanical Engineers (ASME), ASME International Headquarters, Three Park Ave., New York, NY 10016-5990, http://www.asme.org.
[5] Available from Standardization Documents Order Desk, DODSSP, Bldg. 4, Section D, 700 Robbins Ave., Philadelphia, PA 19111-5098, http://dodssp.daps.dla.mil.

2.4 *Automotive Industry Action Group Standard:*[6]
B 1 Bar Code Symbology Standard

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 A941.

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 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 A941 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.)

[6] Available from Automotive Industry Action Group (AIAG), 26200 Lahser Rd., Suite 200, Southfield, MI 48033, http://www.aiag.org.

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 A299/A299M, A515/A515M, A516/A516M, A537/A537M, A662/A662M, or A737/A737M.

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 A578/A578M, 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 A770/A770M.

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.

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 A751.

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~~8.3.2.1); 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 A751.

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 A751 shall be used.

8. Metallurgical Structure

~~8.1If 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~~

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
Boron, max %	Heat analysis	0.0010
	Product analysis	0.0015

[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 %.

8.1 Where austenitic grain size testing is required, such testing shall be a McQuaid Ehn test in accordance with Test Methods E112 ~~, 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.~~ and at least 70 % of the grains in the area examined shall meet the specified grain size requirement.

8.2 *Coarse Austenitic Grain Size*—Where coarse austenitic grain size is specified one austenitic grain size test per heat shall be made and the grain size number so determined shall be in the range of 1 to 5 inclusive.

8.3 *Fine Austenitic Grain Size*:

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

~~8.2.2If 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 Test Methods E112, Plate IV. One test per heat shall be made.~~

~~8.2.2.1If 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.~~

~~8.2.3If 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.~~

~~8.2.4By 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 specified in the purchase order. In addition, the McQuaid-Ehn test of 8.2.3 shall be required.~~

8.3.1 Except as allowed in 8.3.2, and when fine austenitic grain size is specified, or when the producer elects to determine the grain size, one McQuaid Ehn test per heat shall be made and the austenitic grain size number so determined shall be 5 or higher, and the chemical requirements of 8.3.2 do not apply.

NOTE 1—Such austenitic grain size numbers may be achieved with lower contents of austenitic grain refining elements than 8.3.2 requires for austenitic grain size testing to be waived.

8.3.2 Unless testing for fine austenitic grain size is specified in the purchase order or the producer elects to test for fine austenitic grain size, the austenitic grain size test need not be made for any heat that has, by heat analysis, one or more of the following:

8.3.2.1 A total aluminum content of 0.020 % or more.

8.3.2.2 An acid soluble aluminum content of 0.015 % or more.

8.3.2.3 A content for an austenitic grain refining element that exceeds the minimum value agreed to by the purchaser as being sufficient for austenitic grain size testing to be waived.

8.3.2.4 Contents for the combination of two or more austenitic grain refining elements that exceed the applicable minimum values agreed to by the purchaser as being sufficient for austenitic grain size testing to be waived.

8.3.2.5 The analysis for the elements mentioned in 8.3.2.1, 8.3.2.2, 8.3.2.3, or 8.3.2.4 shall be included in the test report.

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 Boiler and Pressure Vessel Code and repair welding shall be done by welders or welding operators meeting the qualification requirements of 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 Boiler and Pressure Vessel 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 A370.

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 E29.

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 A941 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 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 Test Methods and Definitions A370. 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 Test Methods and Definitions A370 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 Test Methods and Definitions A370. 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
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 A20/20M 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 A20/A20M 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 A20/A20M 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 A370 using Charpy V-notch (Type A) specimens as shown in Test Methods and Definitions A370. 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.

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 E208.

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~~ 2—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