Designation: A480/A480M – 19

Standard Specification for General Requirements for Flat-Rolled Stainless and Heat-Resisting Steel Plate, Sheet, and Strip[1]

This standard is issued under the fixed designation A480/A480M; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

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

1. Scope*

1.1 This specification[2] covers a group of general requirements that, unless otherwise specified in the purchase order or in an individual specification, shall apply to rolled steel plate, sheet, and strip, under each of the following specifications issued by ASTM: Specifications A240/A240M, A263, A264, A265, A666, A693, A793, and A895.

1.2 In the case of conflict between a requirement of a product specification and a requirement of this specification, the product specification shall prevail. In the case of conflict between a requirement of the product specification or a requirement of this specification and a more stringent requirement of the purchase order, the purchase order shall prevail. The purchase order requirements shall not take precedence if they, in any way, violate the requirements of the product specification or this specification; for example, by waiving a test requirement or by making a test requirement less stringent.

1.3 The values stated in either inch-pound units or SI units are to be regarded separately as standard. Within the text, the SI units are shown in brackets, except that when A480M is specified, Annex A3 shall apply for the dimensional tolerances and not the bracketed SI values in Annex A2. The values stated in each system are not exact equivalents; therefore, each system must be used independently of the other. Combining values from the two systems may result in nonconformance with the specification.

1.4 This specification and the applicable material specifications are expressed in both inch-pound and SI units. However, unless the order specifies the applicable "M" specification designation [SI units], the material shall be furnished in inch-pound units.

1.5 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[3]

A240/A240M Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications

A262 Practices for Detecting Susceptibility to Intergranular Attack in Austenitic Stainless Steels

A263 Specification for Stainless Chromium Steel-Clad Plate

A264 Specification for Stainless Chromium-Nickel Steel-Clad Plate

A265 Specification for Nickel and Nickel-Base Alloy-Clad Steel Plate

A342/A342M Test Methods for Permeability of Weakly Magnetic Materials

A370 Test Methods and Definitions for Mechanical Testing of Steel Products

A666 Specification for Annealed or Cold-Worked Austenitic Stainless Steel Sheet, Strip, Plate, and Flat Bar

A693 Specification for Precipitation-Hardening Stainless and Heat-Resisting Steel Plate, Sheet, and Strip

A700 Guide for Packaging, Marking, and Loading Methods for Steel Products for Shipment

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

A763 Practices for Detecting Susceptibility to Intergranular Attack in Ferritic Stainless Steels

A793 Specification for Rolled Floor Plate, Stainless Steel

A895 Specification for Free-Machining Stainless Steel Plate, Sheet, and Strip

[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 A01.17 on Flat-Rolled and Wrought Stainless Steel.

Current edition approved Sept. 1, 2019. Published October 2019.. Originally approved in 1962. Last previous edition approved in 2018 as A480/A480M – 18a. DOI: 10.1520/A0480_A0480M-19.

[2] For ASME Boiler and Pressure Vessel Code applications see related Specification SA – 480 in Section II of that Code.

[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.

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

A923 Test Methods for Detecting Detrimental Intermetallic Phase in Duplex Austenitic/Ferritic Stainless Steels

E140 Hardness Conversion Tables for Metals Relationship Among Brinell Hardness, Vickers Hardness, Rockwell Hardness, Superficial Hardness, Knoop Hardness, Scleroscope Hardness, and Leeb Hardness

2.2 *AIAG Standard:*[4]

B-5 Primary Metals Identification Tag Application Standard

2.3 *ANSI Standard:*[5]

Accredited Standards Committee X12 (ANSI ASC X12)

2.4 *Federal Standard:*[6]

Fed. Std. No. 123 Marking for Shipment (Civil Agencies)

2.5 *Military Standards:*[6]

MIL-STD-129 Marking for Shipment and Storage

MIL-STD-163 Steel Mill Products, Preparation for Shipment and Storage

3. Terminology

3.1 *Definitions:*

3.1.1 Plate, sheet, strip, and cold work as used in this specification apply to the following:

3.1.2 *cold work, n*—the changing of mechanical properties by work hardening.

3.1.3 *plate, n*—material 3/16 in. [5.00 mm] and over in thickness and over 10 in. [250 mm] in width. Finishes for *plate* are actually shown in Section 13.

3.1.4 *sheet, n*—material under 3/16 in. [5.00 mm] in thickness and 24 in. [600 mm] and over in width. Finishes for *sheet* are actually shown in Section 11.

3.1.5 *strip, n*—cold-rolled material under 3/16 in. [5.00 mm] in thickness and under 24 in. [600 mm] in width. Finishes are detailed in Section 12 for *strip*, and strip edges in Section 14 for Cold-Rolled Strip.

4. Ordering Information

4.1 It is the responsibility of the purchaser to specify all requirements that are necessary for material ordered under this specification. Such requirements may include, but are not limited to, the following:

4.1.1 Quantity (weight and number of pieces),

4.1.2 Name of material (stainless steel),

4.1.3 Condition (hot-rolled, cold-rolled, annealed, heat-treated),

4.1.4 Finish (see Section 11 for Sheet, Section 12 for Strip, and Section 13 for Plates). In the case of polished finishes, specify whether one or both sides are to be polished,

4.1.5 Temper (if the applicable material specification requires this detail),

4.1.6 Form (plate, sheet, or strip),

4.1.7 Dimensions (thickness, width, length),

4.1.7.1 Thickness shall be ordered to decimal or fractional thickness. The use of the gauge number is discouraged as being an archaic term of limited usefulness not having general agreement on meaning. The gauge number shall not be a basis for rejection.

4.1.7.2 Thickness, width, and length, when applicable, should be ordered in the same units, for example, 0.060 by 48 by 120 in. [1.52 by 1219 by 3048 mm].

4.1.8 Edge, strip only (see Section 14 for Cold-Rolled Strip),

4.1.9 Type or UNS designation, refer to the applicable material specification,

4.1.10 Specification designation and date of issue,

4.1.11 Additions to specification or special requirements,

4.1.12 Restrictions (if desired) on methods for determining yield strength (see appropriate footnote to mechanical properties table of the basic material specification),

4.1.13 Marking requirements (see Section 25),

4.1.14 Preparation for delivery (see Section 25), and

4.1.15 Magnetic permeability test (when required). Refer to Section 19.

5. Process

5.1 The steel shall be manufactured/produced by the following or as specified in the applicable material specification.

5.1.1 The steel shall be made by one of the following processes: electric-arc, electric-induction, or other suitable processes.

5.1.2 If a specific type of melting is required by the purchaser, it shall be so specified on the purchase order.

6. Heat Analysis

6.1 Methods and practices relating to chemical analysis shall be in accordance with Test Methods, Practices, and Terminology A751.

6.2 An analysis of each heat shall be made by the steel producer to determine the percentages of the elements specified in the applicable material specification. This analysis shall be made from a test sample taken during the pouring of the melt, or from the in-process product later in the manufacturing flow.

6.2.1 The heat analysis shall conform to the chemical requirements for each of the specified elements for the grade ordered, as listed in the applicable product specification.

6.2.2 All commercial metals contain small amounts of elements other than those which are specified. It is neither practical nor necessary to specify limits for unspecified elements that can be present. The producer is permitted to analyze for unspecified elements and is permitted to report such analyses. The presence of an unspecified element and the reporting of an analysis for that element shall not be a basis for rejection, unless the presence of that element causes the loss of a property typically expected for that metal, for the type and quality ordered.

6.2.3 The purchaser is permitted to require in the purchase order a maximum limit for an individual element not specified in the product specification. Such a requirement for an element not listed in the product specification, when acknowledged in

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

[5] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, http://www.ansi.org.

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

the order acceptance, shall be treated as a specified element, with determination of chemical analysis and reporting of that analysis.

6.2.4 The purchaser is permitted to make the requirements for any element more stringent, that is, require higher minimums for elements having minimum requirements or ranges with minimum requirements, or requiring lower maximums for elements having specified maximums, or ranges with maximums. The purchaser is not permitted to make chemical requirements less stringent.

6.2.5 Analysis limits shall be established for specific elements rather than groups of elements, including but not limited to *all others*, *rare earths*, and *balance*, unless all elements in such a group are similar in technical effect and are associated in typical methods of chemical analysis.

6.3 Except as permitted in 6.3.1, the steel shall not contain an unspecified element for the ordered grade to the extent that the steel conforms to the requirements of another grade for which that element is a specified element having a required minimum content. For this requirement, a grade is defined as an alloy described individually and identified by its own UNS designation in a table of chemical requirements within this specification or any specification listed within the scope as being covered by the specification.

6.3.1 Unless otherwise specified to lower maximum limits on the purchase order, maximum allowances for unspecified elements will be established for Cu, Mo, Ti, and Nb for the specified grade if the amount of that element present in the material conforms with composition limits for that element in another grade. These allowances are: Cu, 0.75 %; Mo, 0.75 %; Ti, 0.10 %; and Nb, 0.10 %.

6.3.2 If any allowance in 6.3.1 is used to demonstrate non-substitution, then the element involved shall be reported as if it were a specified element.

6.4 The producer is not permitted to certify that material is in compliance with an ASTM product specification when the purchase order has required that the material contain as a minimum or range an element that is neither a specified element nor an intentionally added unspecified element for the ordered grade in accordance with the definitions of Test Methods, Practices, and Terminology A751.

6.5 The names Columbium (Cb) and Niobium (Nb) both refer to element 41. The name Niobium is preferred, but either is acceptable for reporting composition.

7. Product Analysis

7.1 The purchaser is permitted to perform a product analysis (formerly check analysis) to verify the identity of the finished material representing each heat or lot. Such analysis shall be made by any of the commonly accepted methods that will positively identify the material.

7.2 The chemical composition determined in accordance with 7.1 shall conform to the limits of the material specification within the tolerances of Table A1.1, unless otherwise specified in the applicable material specification or the purchase order. The allowable variation of a particular element in a single sample for product analysis is permitted to be either above or below the specified range. However, percentages must exhibit the same tendencies in all samples; that is, the several determinations of any individual element in a heat shall not vary both above and below the specified range.

8. Material Test Report and Certification

8.1 A report of the results of all tests required by the product specification shall be supplied to the purchaser. This material test report shall reference the product specification designation and year date indicating that the material was manufactured, sampled, tested, and inspected in accordance with requirements of the product specification and has been found to meet those requirements. The material test report shall report the melting process when the purchase order requires either a specific type of melting or requires that the melting process used is to be reported.

8.1.1 The report shall indicate the type of steel. If certifying that the material conforms to the requirements for more than one type of steel, the manufacturer may indicate each type of steel on the report, or may issue a separate report for each type of steel.

8.2 A signature is not required on the report. However, the document shall clearly identify the organization submitting the report. Not withstanding the absence of a signature, the organization submitting the document is responsible for its content.

8.3 A material test report, certificate of inspection, 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 certifiers' 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.

8.4 When finished material is supplied to a purchase order specifying the product specification, the organization supplying that material shall provide the purchaser with a copy of the original manufacturer's test report.

NOTE 1—Notwithstanding the absence of a signature, the organization submitting the report is responsible for the content of the report.

NOTE 2—The industry definition as invoked here is: EDI is the computer-to-computer exchange of business information in a standard format such as ANSI ASC X12.

8.4.1 When the original manufacturer's test report was provided by EDI to the organization supplying the finished material to the purchaser, the organization supplying the finished material shall provide to the purchaser a printed form of the original test report or shall retransmit the test report by EDI to the purchaser. In either case, the test report shall be complete with the full identification of the original manufacturer and with all data provided on the test report of the original manufacturer.

9. Permitted Variations in Dimensions and Weight

9.1 Sheet, strip, and plate shall conform to the permitted variations in thickness, width, length and flatness, and other

properties when specified, as listed in Annex A2 and Annex A3 for A480 and A480M respectively, for the ordered product form, or as agreed upon by seller and user and specified in the purchase order.

10. Workmanship

10.1 The material shall be of uniform quality consistent with good manufacturing and inspection practices. The steel shall have no imperfections of a nature or degree, for the type and quality ordered, that will adversely affect the stamping, forming, machining, or fabrication of finished parts.

10.2 *Sheet, Strip, and Plate*—For sheet and strip, restricted only to material ordered to have a No. 1 finish in accordance with 11.1.1 and 12.1.1 respectively, and for plate restricted to material ordered to hot-rolled and annealed or hot-rolled, annealed, and pickle finish in accordance with 13.1.1 and 13.1.2 respectively, it is permitted to grind to remove surface imperfections, provided such grinding does not reduce the thickness or width at any point beyond the permissible variations in dimensions. An iron free abrasive wheel shall be used for such grinding and shall be operated at a speed ample to ensure that defective areas are cleanly cut out.

11. Finish for Sheet

11.1 The types of finish available on sheet products are:

11.1.1 *No. 1 Finish*—Hot-rolled, annealed, and descaled.

11.1.2 *No. 2D Finish*—Cold-rolled, dull finish.

11.1.3 *No. 2B Finish*—Cold-rolled, bright finish.

11.1.3.1 *Bright Annealed Finish*—A bright cold-rolled finish retained by final annealing in a controlled atmosphere furnace.

11.1.4 *No. 3 Finish*—Intermediate polished finish, one or both sides.

11.1.5 *No. 4 Finish*—General purpose polished finish, one or both sides.

11.1.6 *No. 6 Finish*—Dull satin finish, Tampico brushed, one or both sides.

11.1.7 *No. 7 Finish*—High luster finish.

11.1.8 *No. 8 Finish*—Mirror finish.

11.1.9 *TR Finish*—Cold-worked to obtain specified properties.

NOTE 3—*Explanation of Sheet Finishes:*

No. 1—Commonly referred to as hot-rolled annealed and pickled or descaled. This is a dull, nonreflective finish.

No. 2D—A smooth, nonreflective cold-rolled annealed and pickled or descaled finish. This nondirectional finish is favorable for retention of lubricants in deep drawing applications.

No. 2B—A smooth, moderately reflective cold-rolled annealed and pickled or descaled finish typically produced by imparting a final light cold-rolled pass using polished rolls. This general-purpose finish is more readily polished than No. 1 or 2D finishes. Product with 2B finish is normally supplied in the annealed plus lightly cold-rolled condition unless a tensile-rolled product is specified.

Bright Annealed Finish—A smooth, bright, reflective finish typically produced by cold rolling followed by annealing in a protective atmosphere so as to prevent oxidation and scaling during annealing.

No. 3—A linearly textured finish that may be produced by either mechanical polishing or rolling. Average surface roughness (R_a) may generally be up to 40 µin. A skilled operator can generally blend this finish. Surface roughness measurements differ with different instruments, laboratories, and operators. There may also be overlap in measurements of surface roughness for both No. 3 and No. 4 finishes.

No. 4—A linearly textured finish that may be produced by either mechanical polishing or rolling. Average surface roughness (R_a) may generally be up to 25 µin. A skilled operator can generally blend this finish. Surface roughness measurements differ with different instruments, laboratories, and operators. There may also be overlap in measurements of surface roughness for both No. 3 and No. 4 finishes.

No. 6—This finish has a soft, satin appearance typically produced by tampico brushing a No. 4 finish.

No. 7—Has a high degree of reflectivity. It is produced by buffing a finely ground surface, but the grit lines are not removed. It is chiefly used for architectural or ornamental purposes.

No. 8—This is a highly reflective, smooth finish typically produced by polishing with successively finer grit abrasives, then buffing. Typically, very faint buff of polish lines may still be visible on the final product. Blending after part assembly may be done with buffing.

TR Finish—The finish resulting from the cold-rolling of an annealed and descaled or bright annealed product to obtain mechanical properties higher than that of the annealed condition. Appearance will vary depending upon the starting finish, amount of cold work, and the alloy.

Architectural Finishes—Sometimes described as a No. 5 finish, these are a separate category and may be negotiated between buyer and seller, as there are many techniques and finish variations available throughout the world.

11.1.10 Architectural finish, No. 5, or other proprietary names are special finishes.

11.1.11 Note 3 is not meant to be restrictive or to be used as a basis for rejection but is intended to give general guidelines. Various production methods may be used to obtain these finishes.

11.1.12 Sheets can be produced with one or two sides polished. When polished on one side only, it is permitted to rough grind the other side in order to obtain the necessary flatness.

12. Finish for Strip

12.1 The various types of finish procurable on cold-rolled strip products are:

12.1.1 *No. 1 Finish*—Cold-rolled to specified thickness, annealed, and descaled.

12.1.2 *No. 2 Finish*—Same as No. 1 Finish, followed by a final light cold-roll pass, generally on highly polished rolls.

12.1.3 *Bright Annealed Finish*—A bright cold-rolled finish retained by final annealing in a controlled atmosphere furnace.

12.1.4 *TR Finish*—Cold-worked to obtain specified properties.

12.1.5 *Polished Finish*—Stainless steel strip is also available in polished finishes such as No. 3 and No. 4, which are explained in Note 3.

NOTE 4—*Explanation of Strip Finishes:*

No. 1—Appearance of this finish varies from dull gray matte finish to a fairly reflective surface, depending largely upon composition. This finish is used for severely drawn or formed parts, as well as for applications where the brighter No. 2 Finish is not required, such as parts for heat resistance.

No. 2—This finish has a smoother and more reflective surface, the appearance of which varies with composition. This is a general purpose finish, widely used for household and automotive trim, tableware, utensils, trays, and so forth.

Bright Annealed Finish—See Note 3.

TR Finish—See Note 3.

13. Finish for Plates

13.1 The types of finish available on plates are:

13.1.1 *Hot-Rolled or Cold-Rolled, and Annealed or Heat Treated*—Scale not removed, an intermediate finish. Use of plates in this condition is generally confined to heat-resisting applications. Scale impairs corrosion resistance.

13.1.2 *Hot-Rolled or Cold-Rolled, and Annealed or Heat Treated, and Blast Cleaned or Pickled*—Condition and finish commonly preferred for corrosion-resisting and most heat-resisting applications, essentially a No. 1 Finish.

13.1.3 *Hot-Rolled or Cold-Rolled, and Annealed or Heat Treated, and Surface Cleaned and Polished*—Polish finish is generally No. 4 Finish.

13.1.4 *Hot-Rolled or Cold-Rolled, and Annealed or Heat Treated, and Descaled, and Temper Passed*—Smoother finish for specialized applications.

13.1.5 *Hot-Rolled or Cold-Rolled, and Annealed or Heat Treated, and Descaled; and Cold-Rolled, and Annealed or Heat Treated, and Descaled, and Optionally Temper Passed*—Smooth finish with greater freedom from surface imperfections than in 13.1.4.

14. Edges for Cold-Rolled Strip

14.1 The types of edges available on strip products are:

14.1.1 *No. 1 Edge*—A rolled edge, either round or square as specified.

14.1.2 *No. 3 Edge*—An edge produced by slitting.

14.1.3 *No. 5 Edge*—An approximately square edge produced by rolling or filing after slitting.

15. Heat Treatment

15.1 The heat treatments shown in this section are to be followed unless otherwise specified in the applicable material specification. Heat treatment thermal cycles shall be separate from other thermal processing cycles; for example, in-process thermal cycles are not permitted as a substitute for the separate annealing cycle.

15.2 *Austenitic Types:*

15.2.1 The austenitic types shall be annealed in accordance with Table A1.2.

15.2.2 The material shall be annealed to meet the mechanical property requirements of the applicable material specification unless otherwise stated in the material specification.

15.2.3 Except as indicated in Table A1.2, Series 300, XM-15, N08800, S30415, S30815, S31725, S31726, and S32615 austenitic chromium-nickel steels, when specified on the purchase order, shall be capable of meeting the test for resistance to intergranular corrosion specified in 18.2.

15.2.4 For grades stabilized with titanium or niobium, refer to Note 5.

NOTE 5—Solution-annealing temperatures above 1950 °F [1066 °C] can impair the resistance to intergranular corrosion after subsequent exposure to sensitizing conditions in the stabilized grades, Types 309Cb, 309HCb, 310Cb, 310HCb, 316Ti, 316Cb, 321, 321H, 347, 347H, 348, 348H, S21640, S33425, S35140, S35135, and S35125. When intergranular corrosion is of concern, the purchaser should specify the corrosion test of 18.2 (to be conducted on sensitized specimens). The manufacturer is permitted, if necessary, use a lower temperature resolution anneal or a stabilization anneal after a high temperature solution anneal in order to meet corrosion test requirements. Consideration should be given to the corrosive media before using a stabilization anneal at less than 1800 °F [982 °C], as such treatment is not equally effective for all media.

15.2.5 For the stabilized H types, it is noted that the heat treatment requirements shown in Table A1.2 differ as a function of whether the material was cold worked or hot finished.

15.2.6 The chromium-manganese-nickel types (201, 202, S20103, S20400, S20153, S21800, S21640, XM-11, XM-17, XM-18, XM-19, XM-29, and XM-31) shall be solution annealed to meet the mechanical property requirements of the applicable material specification and to exhibit adequate resistance to intergranular corrosion (see 18.2). For S20161, the heat treatment is specified in Table A1.2. For S21640, see Note 5.

15.2.6.1 Note that some of these types contain high carbon content that can adversely affect resistance to intergranular corrosion.

15.3 *Duplex Types*—The duplex types shall be solution annealed in accordance with Table A1.2.

15.4 *Martensitic and Ferritic Types:*

15.4.1 The chromium steels (S32803, 400 Series, S40945, S41045, S41050, S41500, S43932, S44400, S44537, S44635, S44660, S44700, S44735, S44800, XM-27, and XM-33) shall be heat treated in such a manner as to satisfy all the requirements for mechanical and bending properties specified in the applicable material specification and (except for 400 Series, S41050, and S41500) to provide for adequate resistance to intergranular attack.

15.4.2 For S41500, heat to 1750 °F [955 °C] minimum, air cool to 200 °F [93 °C] or lower prior to any optional intermediate temper and prior to final temper. The final temper shall be between 1050 °F [566 °C] and 1150 °F [621 °C].

16. Number of Tests

16.1 Unless otherwise specified by the applicable material specification or by agreement between the seller and the purchaser to perform a greater number of tests, the following number of tests are to be performed.

16.1.1 In the case of plate, sheet, and strip produced in coil form, two or more hardness tests (one from each end of the coil); one bend test, when required; one permeability test, when required; and one or more tension tests shall be made on specimens taken from each coil. If the hardness difference between the two ends of the coil exceeds 5 HRB, or equivalent, or if the material is temper rolled, tensile properties must be determined on both coil ends.

16.1.2 In the case of plate, sheet, or strip produced in cut lengths, one tension test; two tension tests if the material is temper rolled (one tension test for single piece lots); one bend test when required, and one or more hardness tests shall be made on each 100 or less pieces of the same heat and nominal thickness rolled separately or continuously and heat treated within the same operating period, either as a lot or continuously.

NOTE 6—The term continuously, as applied to heat treatment, is meant to describe a heat-treating operation in which one cut length follows another through the furnace. Interspersement of different melts is permissible if they are of approximately the same nominal thickness and are heat treated in the same operating period and under the same conditions (time and temperature).

16.1.3 One intergranular corrosion test, when required, shall be selected from each heat and thickness subjected to the same heat treatment practice. It is permitted to obtain such specimens from specimens selected for mechanical testing.

17. Test Specimens

17.1 *Tension Test:*

17.1.1 Tension test specimens shall be taken from finished material and shall be selected in either or both longitudinal and transverse direction. The tension test specimen shall conform to the appropriate sections of Test Methods and Definitions A370, unless otherwise specified in the applicable material specification or agreed upon by the seller and the purchaser.

17.1.2 The testing speed between the yield strength and the fracture of the specimen, shall be conducted at a constant strain rate between ⅛ in. [3.18 mm] and ½ in. [12.70 mm] inclusive, per inch [25.40 mm] of gauge length per minute, or at a crosshead speed that will give a strain rate within this range. For the purposes of this specification, the rate of strain shall be determined by a strain-rate pacer, indicator, or controller, or by dividing the unit elongation by the elapsed time from yield strength to fracture.

17.2 *Hardness Test*—It is permitted to perform hardness tests on the grip ends of the tension specimens before they are subjected to the tension test.

17.2.1 Unless otherwise specified in the purchase order, the manufacturer may use an alternate hardness test procedure when material size or form dictates. Hardness conversion shall be done using the applicable tables in Test Methods and Definitions A370. When the material is too thin to allow hardness testing using any of the Rockwell superficial hardness tests, the hardness requirement is waived.

17.3 *Bend Test:*

17.3.1 Bend test specimens (when required) shall be taken from finished material and shall be selected in the transverse direction or as indicated in the applicable material specification or as agreed upon by the seller and the purchaser. In the case of transverse bend test specimens, the axis of bend shall be parallel to the direction of rolling.

17.3.2 Bend test specimens from sheet and strip product shall be the full thickness of the material and approximately 1 in. [25.4 mm] in width. It is permitted to round the edges of the test specimen to a radius equal to one half the specimen thickness.

17.3.3 The width of strip for which bend tests can be made is subject to practical limitations on the length of the bend test specimen. For narrow strip, the following widths can be tested:

Strip thickness, in. [mm]	Minimum Strip Width and Minimum Specimen Length for Bend Tests, in. [mm]
0.100 [2.5] and under	½ [12.7]
Over 0.100 [2.5] to 0.140 [3.5], excl.	1 [25.4]
0.140 [3.5] and over	1½ [38.1]

Bend test specimens shall be of any suitable length over the specified minimum length.

17.3.4 Bend test specimens taken from plates shall be in full thickness of the material up to and including ½ in. [12.7 mm] in thickness, of suitable length, and between 1 and 2 in. [25.4 and 50.8 mm] in width. It is permitted to remove the sheared edges to a depth of at least ⅛ in. [3.2 mm] and it is permitted to smooth the sides with a file. It is permitted to break the corners of the cross section of the specimen with a file, but no appreciable rounding of the corners is permitted.

17.3.5 In the case of plates over ½ in. [12.7 mm] in thickness, it is permitted to use bend test specimens, machined to 1 in. [25.4 mm] nominal width by ½ in. [12.7 mm] nominal thickness and at least 6 in. [152.4 mm] in length. One surface, to be the outside surface in bending, shall be the original surface of the plate; however, surface preparation by light grinding is permitted. It is permitted to round the edges to a 1/16 in. [1.6 mm] radius. When agreed by the seller and the purchaser, it is permitted to modify the cross section to ½ in. [12.7 mm] nominal square.

17.3.6 In the case of plates over 1 in. [25.4 mm] in thickness, bend tests must be agreed upon between the seller and the purchaser.

17.3.7 The bend test specimen shall withstand cold bending through the angle specified in the applicable material specification without cracking on the outside of the bent portion.

17.4 The bend shall be made over a diameter equal to the number of thicknesses of flat stock shown in the applicable material specification or over a single piece of flat stock equal to the number of thicknesses shown in the applicable material specification; or as follows:

17.4.1 Material up to and including ⅜ in. [9.5 mm] in thickness shall be bent over a piece (or pieces) of flat stock that has the same nominal thickness of the material being tested (1T), allowing the test material to form its natural curvature.

17.4.2 Material over ⅜ in. [9.5 mm] and up to and including 1 in. [25.4 mm] in thickness shall be bent over a piece (or pieces) of flat stock equalling two times the thickness of the material being tested (2T), allowing the test material to form its natural curvature.

18. Special Tests

18.1 If other tests are required, the methods and acceptance criteria shall be agreed upon between the seller and the purchaser and specified on the purchase order.

18.2 *Resistance to Intergranular Corrosion:*

18.2.1 The intergranular corrosion test, Practice E of Practices A262, is not required unless it is specified on the purchase order. All austenitic chromium-nickel types except the H types are expected to be capable of passing this test. However, it is not necessary to actually run the test unless it is specified on the purchase order. Note that Practices A262 requires the test to be performed on sensitized specimens in the low-carbon and stabilized types and on specimens representative of the as-shipped condition for other types. In the case of low-carbon types containing 3 % or more molybdenum in their specified composition, the applicability of the sensitizing treatment prior to testing shall be a matter for negotiation between the seller and the purchaser. When specified, all flat rolled products of the chromium-nickel series (300 series) in thickness up to and including 2 in. [50.8 mm] nominal size shall be capable of passing the intergranular corrosion test in the as shipped condition. In the case of heavier plates of types other than

304L, 304LN, 309Cb, 310Cb, 316Cb, 316L, 316LN, 316Ti, 317L, 321, 347, 348, S31725, and S31726, the applicability of this test shall be a matter for negotiation between the seller and the purchaser.

18.2.2 The H types are not normally subject to intergranular corrosion tests. However, it is permitted to specify Practice E of Practices A262 for Type 321H when intergranular corrosion is of concern. In this case, the purchaser shall inform the seller and agree upon the requirements and these requirements shall be so stated on the purchase order.

18.2.3 Austenitic chromium-manganese-nickel types (201, 202, XM-17, XM-18, XM-19, XM-29, XM-31, S20400, S21640, and S21800) are to be heat treated for intergranular corrosion resistance. When intergranular corrosion tests are required, they shall be as agreed upon between the seller and the purchaser.

18.2.4 N08800 shall be heat treated for intergranular corrosion resistance. When intergranular corrosion tests are required, they shall be as agreed upon between the seller and purchaser.

18.2.5 Corrosion tests are not normally required for the 400 series types. Lower-carbon corrosion-resistant types (S44400, S44635, S44660, S44700, S44800, S44735, XM-27, and XM-33) are heat treated for resistance to corrosion. For S44400, S44635, S44660, S44700, S44800, S44735, XM-27, and XM-33, intergranular corrosion testing of Practices A763, Practice X, Y, or Z shall be specified as agreed upon between the seller and the purchaser.

18.3 *Detrimental Intermetallic Phases in Duplex Stainless Steels*—The tests for detrimental intermetallic phases in wrought duplex stainless steels, Methods A, B, or C of Test Methods A923, are not required unless it is specified on the purchase order. All duplex (austenitic-ferritic) types that are listed in Test Methods A923 are expected to be capable of passing these tests. However, it is not necessary to actually run the tests unless specified on the purchase order. The applicability of these tests to duplex stainless steels not listed in Test Methods A923 shall be a matter for negotiation between the seller and the purchaser.

19. Test Methods

19.1 The properties enumerated in applicable specifications shall be determined in accordance with the following ASTM standards.

19.1.1 *Tension Tests*—Test Methods and Definitions A370.

19.1.2 *Brinell Tests*—Test Methods and Definitions A370.

19.1.3 *Rockwell Hardness*—Test Methods and Definitions A370.

19.1.4 *Hardness Equivalents*—Tables E140.

19.1.5 *Intergranular Corrosion* (*when specified*)—Practices A262, Practices A763.

19.1.6 *Permeability Test* (*when required*)—Test Methods A342/A342M.

19.1.7 *Charpy Impact Testing (when required)*—Test Methods and Definitions A370.

19.1.8 *Intermetallic Phases (when specified)*—Test Methods A923.

20. Retests and Retreatment

20.1 Retests are permitted in accordance with the provisions of Test Methods and Definitions A370.

20.2 If any test specimen shows defective machining or develops flaws, it is permitted to discard the flawed specimen and substitute another specimen.

20.2.1 If the percentage of elongation of any tension specimen is less than that specified and any part of the fracture is more than ¾ in. [19.1 mm] from the center of the gauge length of the 2 in. [50.8 mm] specimen or is outside the middle half of the gauge length of an 8-in. [203.2-mm] specimen, as indicated by scribe marks placed on the specimen before testing, a retest shall be allowed.

20.3 If a bend test specimen fails, due to conditions of bending more severe than required by the specification, a retest shall be permitted, either on a duplicate specimen or on a remaining portion of the failed specimen.

20.4 If the results of any test lot are not in conformance with the requirements of the applicable material specification, the producer is permitted the option of retreating such lots. The material shall be accepted if the results of retests on retreated material are within the specified requirements.

20.5 If any specimens selected to represent any heat fail to meet any of the test requirements as specified in the applicable material specification, it is permitted to reheat treat the material represented and resubmit it for testing.

20.6 If the product analysis fails to conform to the specified limits, analysis shall be made on a new sample. The results of this retest shall be within the specified requirements.

21. Repair of Plate by Welding

21.1 Repair of surface defects of plate, by welding, is permitted unless prohibited by other specifications or purchase order requirements.

21.2 Defect depth shall not exceed ⅓ of the nominal thickness, and the total area shall not exceed 1 % of the plate surface area, unless prior approval from the purchaser is obtained.

21.3 Unacceptable imperfections shall be suitably prepared for welding by grinding or machining. Open clean defects, such as pits or impressions, will not necessarily require preparation.

21.4 The welding procedure and the welders or welding operators shall be qualified in accordance with Section IX of the ASME Code.[2]

21.5 The welding consumables shall be suitable with the plate.

21.6 After repair welding, the welded area shall be ground smooth and blended uniformly to the surrounding surface.

22. Inspection

22.1 Inspection of the material by the purchaser's representative at the producing plant shall be made as agreed upon between the purchaser and the seller as part of the purchase order.

22.2 Unless otherwise specified in the contract or purchase order: (*1*) the seller is responsible for the performance of all the inspection and test requirements in this specification, (*2*) the seller is permitted to use own or other suitable facilities for the performance of the inspection and testing, and (*3*) the purchaser shall have the right to perform any of the inspection and tests set forth in this specification. The manufacturer shall afford the purchaser's inspector all reasonable facilities necessary to satisfy the inspector that the material is being furnished in accordance with the specification. Inspection by the purchaser shall not interfere unnecessarily with the manufacturer.

23. Rejection

23.1 Unless otherwise specified, any rejection based on tests made in accordance with this specification shall be reported to the seller within 60 working days from the receipt of the material by the purchaser.

23.2 Material that shows injurious imperfections as described in Section 10 subsequent to its acceptance at the purchaser's works will be rejected and the seller shall be notified.

24. Rehearing

24.1 Samples tested in accordance with this specification that represent rejected material shall be retained for three weeks from the date of the notification to the seller of the rejection. In case of dissatisfaction with the results of the test, the seller is permitted to make claim for a rehearing within that time.

25. Packaging, Marking, and Loading

25.1 *For Commercial Procurement:*

25.1.1 *Marking*—Unless otherwise specified in the applicable material specification or the purchase order, marking shall be conducted as follows:

25.1.1.1 Sheet, strip, and plate shall be marked on one face, in the location indicated below with the specification designation number, type of steel (type or UNS designation), material identification number, and the name or mark of the manufacturer. For sheet, strip, and plate whose length and width dimensions are both less than 24 in., each piece shall be marked with the type of steel and material identification number. The specification and designation number, and name or mark of the manufacturer shall be marked on the piece(s) or attached to the item or bundle. The characters shall be of such size as to be clearly legible. The marking shall be sufficiently stable to withstand normal handling. Unless otherwise specified by the purchaser, the marking, at the producers option, is permitted to be done with *(a)* marking fluid (if a specific maximum impurity limit of designated elements in the marking fluid is required by the purchaser, it shall be so stated on the purchase order), *(b)* low-stress blunt-nosed continuous or low-stress blunt-nosed-interrupted-dot die stamp, *(c)* a vibratory tool with a minimum tip radius of 0.005 in. [0.1 mm], or *(d)* electrochemical etching.

25.1.1.2 Flat sheet, strip in cut lengths, and plate shall be marked in two places near the ends or shall be continuously line marked along one edge. For flat sheet, strip in cut lengths, and plate whose length and width dimensions are both less than 48 in., it is permitted to mark such pieces in only one place.

25.1.1.3 Sheet, strip, and plate in coil form shall be marked near the outside end of the coil. The inside of the coil shall also be marked or shall have a tag or label attached and marked with the information of 25.1.1.1.

25.1.1.4 Material less than ¼ in. [6.4 mm] in thickness shall not be marked with die stamps.

25.1.1.5 The manufacturer's test identification number shall be legibly stamped on each test specimen, if to be shipped to the customer.

25.1.1.6 Material that conforms completely with the requirements of two types of steel within the ordering specification is permitted to be marked as both types of steel provided that the manufacturer is certifying the material as meeting the requirements of each of the types of steel. Such marking, if used, shall be part of the same marking as used for a single type of steel, or shall be a separate but similar marking immediately adjacent to the marking used for a single type of steel.

25.1.1.7 The AIAG primary metals identification tag (AIAG B-5) is permitted to be used as an auxiliary method of identification in cases where a bar-coded identification tag is desired. Use of this method shall be by agreement between purchaser and supplier.

25.1.2 *Packaging and Loading*—Unless otherwise specified in the applicable material specification or the purchase order, packaging and loading shall be in accordance with the procedures recommended by Practices A700.

25.2 *For U.S. Government Procurement:*

25.2.1 When specified in the contract or order, and for direct procurement by or direct shipment to the government, marking for shipment shall be in accordance with Fed. Std. No. 123 for civil agencies and MIL-STD-129 for military agencies.

25.2.2 When specified in the contract or order, material shall be preserved, packaged, and packed in accordance with the requirements of MIL-STD-163. The applicable levels shall be as specified in the contract or order.

26. Keywords

26.1 austenitic stainless steel; duplex stainless steel; ferritic stainless steel; martensitic stainless steel; stainless steel; stainless steel plate; stainless steel sheet; stainless steel strip

ANNEXES

(Mandatory Information)

A1. PRODUCT ANALYSIS TOLERANCES AND HEAT TREATMENT REQUIREMENTS

A1.1 Listed in Annex A1 are tables showing the permitted variations of composition for product analysis relative to specified chemical requirements (Table A1.1) and the heat treatment requirements for types of stainless steel covered by product specifications that reference Specification A480/A480M (Table A1.2). When the product requirement includes a ratio requirement that is the quotient of two, or more, elements, the minimum required ratio determined from product analysis shall be at least 0.90× the minimum in the product specification.

TABLE A1.1 Chemical Requirements (Product Analysis Tolerances)[A]

Elements	Limit or Maximum of Specified Range, %	Tolerance Over the Maximum Limit or Under the Minimum Limit	Elements	Limit or Maximum Specified Range, %	Tolerance Over the Maximum Limit or Under the Minimum Limit
Carbon	to 0.010, incl	0.002	Titanium	to 1.00, incl	0.05
	over 0.010 to 0.030, incl	0.005		over 1.00 to 3.00, incl	0.07
	over 0.030 to 0.20, incl	0.01			
	over 0.20 to 0.60, incl	0.02	Cobalt	over 0.05 to 0.50, incl	0.01[B]
	over 0.60 to 1.20, incl	0.03		over 0.50 to 2.00, incl	0.02
				over 2.00 to 5.00, incl	0.05
Manganese	to 1.00, incl	0.03			
	over 1.00 to 3.00, incl	0.04	Niobium	to 1.50, incl	0.05
	over 3.00 to 6.00, incl	0.05			
	over 6.00 to 10.00, incl	0.06	Tantalum	to 0.10, incl	0.02
	over 10.00 to 15.00, incl	0.10			
	over 15.00 to 20.00, incl	0.15	Copper	to 0.50, incl	0.03
				over 0.50 to 1.00, incl	0.05
Phosphorus	to 0.040, incl	0.005		over 1.00 to 3.00, incl	0.10
	over 0.040 to 0.20, incl	0.010		over 3.00 to 5.00, incl	0.15
				over 5.00 to 10.00, incl	0.20
Sulfur	to 0.040, incl	0.005			
	over 0.040 to 0.20, incl	0.010	Aluminum	to 0.15, incl	−0.005, +0.01
	over 0.20 to 0.50, incl	0.020		over 0.15 to 0.50, incl	0.05
				over 0.50 to 2.00, incl	0.10
Silicon	to 1.00, incl	0.05			
	over 1.00 to 3.00, incl	0.10	Nitrogen	to 0.02, incl	0.005
	over 3.00 to 7.00, incl	0.15		over 0.02 to 0.19, incl	0.01
				over 0.19 to 0.25, incl	0.02
Chromium	over 4.00 to 10.00, incl	0.10		over 0.25 to 0.35, incl	0.03
	over 10.00 to 15.00, incl	0.15		over 0.35 to 0.45, incl	0.04
	over 15.00 to 20.00, incl	0.20		over 0.45 to 0.55, incl	0.05
	over 20.00 to 30.00, incl	0.25			
			Tungsten	to 1.00, incl	0.03
Nickel	to 1.00, incl	0.03		over 1.00 to 2.00, incl	0.05
	over 1.00 to 5.00, incl	0.07		over 2.00 to 5.00, incl	0.07
	over 5.00 to 10.00, incl	0.10		over 5.00 to 10.00, incl	0.10
	over 10.00 to 20.00, incl	0.15		over 10.00 to 20.00, incl	0.15
	over 20.00 to 30.00, incl	0.20			
	over 30.00 to 40.00	0.25	Vanadium	to 0.50, incl	0.03
	over 40.00	0.30		over 0.50 to 1.50, incl	0.05
Molybdenum	over 0.20 to 0.60, incl	0.03	Selenium	all	0.03
	over 0.60 to 2.00, incl	0.05			
	over 2.00 to 8.00, incl	0.10			

[A] This table does not apply to heat analysis.
[B] Product analysis limits for cobalt under 0.05 % have not been established, and the manufacturer should be consulted for those limits.

TABLE A1.2 Heat Treatment Requirements

Designation/Type	Temperature[A]	Cooling/Testing Requirements
Austenitic (Chromium-Nickel) (Chromium-Nickel-Manganese)		
All Cr-Ni steels except as listed below	1900 °F [1040 °C]	B
302, 308, 309, 309Cb, 310, 310Cb, S21640, S30215, S30452, S30615, S32615, S33228, S33425, S35140, S38100, S33815	1900 °F [1040 °C]	C
304H, 309H, 310H, 316H	1900 °F [1040 °C]	C
309HCb, 310HCb, 321H, 347H, 348H		
Cold Worked	2000 °F [1095 °C]	C
Hot Finished	1925 °F [1050 °C]	C
N08020	1700 to 1850 °F [925 to 1010 °C]	C
N08367	2025 °F [1105 °C]	C
N08700, N08904, S35115	2000 °F [1095 °C]	C
N08810, S31277	2050 °F [1120 °C]	C
N08811, N08925, S31254, S31266, S32050, S32654	2100 °F [1150 °C]	C
N08926, S35315	2010 °F [1100 °C]	C
S20161	1900 to 2000 °F [1040 to 1095 °C]	C
S20431, S20432, S20433, S30530	1900 to 2010 °F [1040 to 1100 °C]	C
S30600, S30601	2010 to 2140 °F [1100 to 1170 °C]	C
S30616	1920 to 2100 °F [1050 to 1150 °C]	C
S31060	1975 to 2160 °F [1080 to 1180 °C]	C
S31727, S32053	1975 to 2155 °F [1080 to 1180 °C]	C
S33228	2050 to 2160 °F [1120 to 1180 °C]	C
S33550	2065 to 2155 °F [1130 to 1180 °C]	C
S34565	2050 to 2140 °F [1120 to 1170 °C]	C
Duplex (Austenitic-Ferritic)		
S31200, S31803, S32001, S32550	1900 °F [1040 °C]	C
S31260	1870 to 2010 °F [1020 to 1100 °C]	C
S32003, S82011	1850 °F [1010 °C]	C
S32101	1870 °F [1020 °C]	C
S32202	1800 to 1975 °F [980 to 1080 °C]	C
S32205	1900 °F [1040 °C]	D
S32304	1800 °F [980 °C]	C
S32506	1870 to 2050 °F [1020 to 1120 °C]	C
S32520	1975 to 2050 °F [1080 to 1120 °C]	C
S32750[E]	1880 to 2060 °F [1025 to 1125 °C]	C
S32760	2010 °F [1100 °C]	C
S32808, S39274	1925 to 2100 °F [1050 to 1150 °C]	C
S32900	1750 ± 25 °F [955 ± 15 °C]	C
S32906	1900 to 2100 °F [1040 to 1150 °C]	C
S32950	1850 ± 25 °F [1010 ± 15 °C]	C
S44537	1922 °F [1050 °C]	C
S81921	1760 to 2010 °F [960 to 1100 °C]	C
S82012, S82031, S82441	1830 °F [1000 °C]	C
S82013, S82121	1830 to 2010 °F [1000 to 1100 °C]	C
S82122	1725 °F [940 °C]	C

[A] Minimum, unless otherwise indicated.
[B] Quenched in water or rapidly cooled by other means at a rate sufficient to prevent reprecipitation of carbides, as demonstrable by the capability of passing the test for resistance to intergranular corrosion specified in 18.2.
[C] Quenched in water or rapidly cooled by other means.
[D] Quenched in water, except that coiled product heat treated in a continuous annealing line shall be water quenched or rapidly cooled by other means.
[E] Temperatures above 2060 °F are permissible if the resulting microstructure provides the properties required by this specification or any additional requirements of the purchase order.