



**Designation: A484/A484M – 21**

# Standard Specification for General Requirements for Stainless Steel Bars, Billets, and Forgings<sup>1</sup>

This standard is issued under the fixed designation A484/A484M; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

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

## 1. Scope\*

1.1 This specification<sup>2</sup> covers general requirements that shall apply to wrought stainless steel bars, shapes, forgings, and billets or other semi-finished material (except wire) for forging, under each of the following specifications issued by ASTM: Specifications [A276/A276M](#), [A314](#), [A458](#), [A477](#), [A479/A479M](#), [A564/A564M](#), [A565/A565M](#), [A582/A582M](#), [A638/A638M](#), [A705/A705M](#), and [A831/A831M](#).

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 requirements for introduction of new materials in specifications referencing this specification are given in [Annex A1](#).

1.4 General requirements for flat-rolled stainless steel products other than bar are covered in Specification [A480/A480M](#).

1.5 General requirements for wire products in coils are covered in Specification [A555/A555M](#).

1.6 The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system are not necessarily exact equivalents; therefore, to ensure conformance with the standard, each system shall be used independently of the other, and values from the two systems shall not be combined

1.7 Unless the order specifies an “M” designation, the material shall be furnished to inch-pound units.

1.8 *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:<sup>3</sup>

[A262 Practices for Detecting Susceptibility to Intergranular Attack in Austenitic Stainless Steels](#)

[A276/A276M Specification for Stainless Steel Bars and Shapes](#)

[A314 Specification for Stainless Steel Billets and Bars for Forging](#)

[A370 Test Methods and Definitions for Mechanical Testing of Steel Products](#)

[A458 Specification for Hot-Worked, Hot-Cold-Worked, and Cold-Worked Alloy Steel Bars for High Strength at Elevated Temperatures \(Withdrawn 1988\)<sup>4</sup>](#)

[A477 Specification for Hot-Worked, Hot-Cold Worked and Cold-Worked Alloy Steel Forgings and Forging Billets for High Strength at Elevated Temperatures \(Withdrawn 1988\)<sup>4</sup>](#)

[A479/A479M Specification for Stainless Steel Bars and Shapes for Use in Boilers and Other Pressure Vessels](#)

[A480/A480M Specification for General Requirements for Flat-Rolled Stainless and Heat-Resisting Steel Plate, Sheet, and Strip](#)

[A555/A555M Specification for General Requirements for Stainless Steel Wire and Wire Rods](#)

[A564/A564M Specification for Hot-Rolled and Cold-Finished Age-Hardening Stainless Steel Bars and Shapes](#)

<sup>1</sup> This specification is under the jurisdiction of ASTM Committee [A01](#) on Steel, Stainless Steel and Related Alloys and is the direct responsibility of Subcommittee [A01.17](#) on Flat-Rolled and Wrought Stainless Steel.

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<sup>2</sup> For ASME Boiler and Pressure Vessel Code Applications, see related Specification SA-484/SA-484M in Section II of that code.

<sup>3</sup> For referenced ASTM standards, visit the ASTM website, [www.astm.org](http://www.astm.org), or contact ASTM Customer Service at [service@astm.org](mailto:service@astm.org). For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

<sup>4</sup> The last approved version of this historical standard is referenced on [www.astm.org](http://www.astm.org).

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

**A565/A565M** Specification for Martensitic Stainless Steel Bars for High-Temperature Service

**A582/A582M** Specification for Free-Machining Stainless Steel Bars

**A638/A638M** Specification for Precipitation Hardening Iron Base Superalloy Bars, Forgings, and Forging Stock for High-Temperature Service

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

**A705/A705M** Specification for Age-Hardening Stainless Steel Forgings

**A751** Test Methods and Practices for Chemical Analysis of Steel Products

**A831/A831M** Specification for Austenitic and Martensitic Stainless Steel Bars, Billets, and Forgings for Liquid Metal Cooled Reactor Core Components (Withdrawn 2005)<sup>4</sup>

**E112** Test Methods for Determining Average Grain Size

**E139** Test Methods for Conducting Creep, Creep-Rupture, and Stress-Rupture Tests of Metallic Materials

2.2 *Federal Standards:*<sup>5</sup>

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

Fed Std. No. 183 Continuous Marking of Iron and Steel Products

2.3 *Military Standards:*<sup>5</sup>

MIL-STD-129 Marking for Shipment and Storage

MIL-STD-163 Preservation of Steel Products for Shipment (Storage and Overseas Shipment)

2.4 *Other Standard:*<sup>6</sup>

Primary Metals Bar Code Standard

### 3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *bars, n*—straight lengths that are produced by processing that includes hot deformation, such as rolling, forging, or extrusion; the permitted cross-sections include round, rectangular, and complex shapes; shall include shapes with all dimensions under 5 in. [125 mm]; shall include hot-rolled flats with width of 10 in. [250 mm] or less, and with thickness 0.125 in. [3.00 mm] or greater; shall include flats with width of 10 in. [250 mm] or less, and with thickness 0.125 in. [3.00 mm] or greater, cut from strip or plate provided that the long direction of the cut bar is parallel to the final rolling direction of the strip or plate.

3.1.1.1 *Discussion*—All cold-reduced flat material with thickness less than 0.1875 in. [5.00 mm] and width 0.375 in. [9.50 mm] and over is classified as strip.

3.1.2 *billets, n*—semi-finished products, typically produced by rolling, forging, or continuous casting, that require subsequent hot working by rolling, forging, or extrusion; typically have a cross-section area of 36 in.<sup>2</sup> [230 cm<sup>2</sup>] or less and shape that is square or rectangular with width less than twice the

thickness; rectangular cross sections with width equal to or greater than twice the thickness are classified as slabs or sheet bars.

3.1.3 *blooms, n*—semi-finished products, typically produced by rolling or continuous casting, that require subsequent hot working by rolling or forging; typically have a cross section area of greater than 36 in.<sup>2</sup> [230 cm<sup>2</sup>] and shape that is square or rectangular with width less than twice the thickness; rectangular cross sections with width equal to or greater than twice the thickness are classified as slabs or sheet bars.

3.1.4 *condition, n*—identification of the final step or steps thermomechanical processing as required to describe the metallurgical state of the material as delivered (examples include hot-worked; hot-worked and annealed; hot-worked, annealed, and cold-worked for increased mechanical properties; and hot-worked, quenched, and tempered).

3.1.5 *dead lengths or exact lengths, n*—bars, typically hot-sheared, hot-sawed, or machine-cut after machine-straightening, meeting the permitted variations in length as listed in the tolerance tables of this specification.

3.1.6 *finish, n*—description of the surface finish and applicable dimensional tolerances of the product as delivered, most typically by identification of the process applied to the product, and identification of the applicable category of product dimensional tolerances; examples of finishing operations include blasting, pickling, rough turning, machine straightening, centerless grinding, polishing, and light cold drawing for surface finish but not for increased mechanical properties; see also 8.1.1 for *hot-finished* bars and 8.1.3 for *cold-finished* bars.

3.1.7 *forgings, n*—parts, including bars, billets, semi-finished products, or complex shapes, produced by hot mechanical working using hammers, presses, or forging machines.

3.1.8 *multiple lengths, n*—lengths that are specified as containing a predetermined number of units of length associated with production of a particular part, commonly including an allowance of ¼ in. [6.5 mm] per unit for cutting to insure obtaining the required number of pieces.

3.1.9 *random lengths, n*—a length range not less than 24 in. [1 m]; for example, 10 to 12 ft [3 to 4 m], 14 to 17 ft [4 to 5 m], or 15 to 20 ft [5 to 6 m].

3.1.10 *shapes, n*—bar having a cross section other than circular, rectangular, or hexagonal.

3.1.11 *slabs or sheet bars, n*—products, typically produced by blooming, slabbing, or sheet bar mills or by continuous casting, that are shipped without further hot working to be further processed into plate, sheet, or strip; it is permitted to heat treat, cut to shape, or surface condition a slab or sheet bar.

### 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 to be considered include, but are not limited to, the following:

4.1.1 Quantity (weight or number of pieces),

<sup>5</sup> Available from Standardization Document Order Desk, 700 Robbins Avenue, Building 4D, Philadelphia, PA 19111-5094 or from <http://assist.daps.dla.mil>.

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

4.1.2 Dimensions, including shape or form with diameter or width and thickness as applicable, length, and prints or sketches as applicable,

4.1.3 Type or UNS designation,

4.1.4 ASTM specification designation and edition year if other than the latest edition,

4.1.5 Condition,

4.1.6 Finish,

4.1.7 Supplementary Requirements when invoked,

4.1.8 Whether bars are to be rolled as bars or cut from strip or plate, when applicable,

4.1.9 Preparation for delivery,

4.1.10 Marking requirements,

4.1.11 Surface preparation, for shapes, and

4.1.12 Special requirements.

NOTE 1—A typical ordering description is as follows: 5000 lb [2000 kg]; 1.000 in. [25 mm] round bar by 10 to 12 ft [3 to 4 m]; Type 304 or S30400; Specification **A479/A479M**; annealed, centerless ground; plus optional requirements, such as special marking instructions.

## 5. Materials and Manufacture

5.1 The material shall be made by any process.

5.2 The material shall be furnished in one of the conditions detailed in the applicable product specification, for example, hot-worked; hot-worked and annealed; hot-worked, annealed, and cold-worked; or hot-worked, annealed, and heat-treated.

5.3 The material shall be furnished in one of the finishes as detailed in Section 8 or further described in the applicable product specification, for example, hot-finished or cold-finished.

## 6. Chemical Composition

6.1 *Heat or Cast Analysis*—The chemical analysis of each heat shall be determined in accordance with the applicable materials specification and Test Methods, Practices, and Terminology **A751**.

6.1.1 The analysis of each heat 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.

6.1.2 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.

6.1.3 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 cause the loss of a property typically expected for that metal, for the type and quality ordered.

6.1.4 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

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

6.1.5 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.

6.1.6 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.

6.2 *Product Analysis*—When required, a product analysis shall be determined in accordance with Test Methods, Practices, and Terminology **A751**. The chemical composition thus determined shall conform to the tolerances shown in **Table 1**.

6.2.1 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.

6.3 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 in the referencing product specification, and any of the product specifications within the scope of this general requirements specification, for which that element has a specified minimum.

## 7. Heat Treatment

7.1 The heat treatments shown in this section are to be followed unless otherwise specified in the applicable product specification.

### 7.2 Austenitic Grades:

7.2.1 Except for strain-hardened grades (see **7.2.4**), hot-rolled grades (see **7.2.5**), and UNS N08020 (see **7.2.6**), all austenitic stainless steels shall be furnished in the solution annealed condition in accordance with **Table 2**, with subsequent light cold drawing for cold finishing and straightening permitted.

7.2.2 Except as indicated in **Table 2**, the austenitic grades shall be annealed, at the option of the manufacturer, by a separate annealing treatment or by process annealing.

7.2.2.1 The separate annealing treatment shall consist of heating the material to the minimum annealing temperature for the grade as listed in **Table 2**, holding for a sufficient time to permit grain boundary carbides to enter into solution, and cooling rapidly enough to prevent unacceptable grain boundary carbide precipitation. Except as indicated in **Table 2**, austenitic stainless steels solution annealed by a separate annealing treatment shall be capable of meeting the requirements of Practice E of Practices **A262**. Practice E of Practices **A262** is not required unless specified on the purchase order.

7.2.2.2 Process annealing shall consist of completing hot working above the minimum annealing temperature required

**TABLE 1 Product Analysis Tolerances**

NOTE 1—This table specifies tolerances over the maximum limits or under the minimum limits of the chemical requirements of the applicable material specification (see 1.1); it does not apply to heat analysis.

Element	Upper Limit of Maximum of Specified Range, %	Tolerances over the Maximum (Upper Limit) or Under the Minimum (Lower Limit)	Element	Upper Limit or Maximum of Specified Range, %	Tolerances over the Maximum (Upper Limit) or Under the Minimum (Lower Limit)
Carbon	to 0.010, incl	0.002	Cobalt	over 0.05 to 0.50, incl	0.01
	over 0.010 to 0.030, incl	0.005		over 0.50 to 2.00, incl	0.02
	over 0.030 to 0.20, incl	0.01		over 2.00 to 5.00, incl	0.05
	over 0.20 to 0.60, incl	0.02		over 5.00 to 10.00, incl	0.10
	over 0.60 to 1.20, incl	0.03		over 10.00 to 15.00, incl	0.15
Manganese	to 1.00, incl	0.03	over 15.00 to 22.00, incl	0.20	
	over 1.00 to 3.00, incl	0.04	over 22.00 to 30.00, incl	0.25	
	over 3.00 to 6.00, incl	0.05	Columbium <sup>A</sup> + Tantalum	to 1.50, incl	0.05
	over 6.00 to 10.00, incl	0.06		over 1.50 to 5.00, incl	0.10
	over 10.00 to 15.00, incl	0.10		over 5.00	0.15
Phosphorus	over 15.00 to 20.00, incl	0.15	Tantalum	to 0.10, incl	0.02
	to 0.040, incl	0.005	Copper	to 0.50, incl	0.03
over 0.040 to 0.20, incl	0.010	over 0.50 to 1.00, incl		0.05	
Sulfur	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
Silicon	over 0.20 to 0.50, incl	0.020	over 5.00 to 10.00, incl	0.20	
	to 1.00, incl	0.05	Aluminum	to 0.15, incl	-0.005, +0.01
	over 1.00 to 3.00, incl	0.10		over 0.15 to 0.50, incl	0.05
over 3.00 to 7.00 incl	0.15	over 0.50 to 2.00, incl		0.10	
Chromium	over 4.00 to 10.00, incl	0.10		over 2.00 to 5.00, incl	0.20
	over 10.00 to 15.00, incl	0.15		over 5.00 to 10.00, incl	0.35
	over 15.00 to 20.00, incl	0.20	Nitrogen	to 0.02, incl	0.005
over 20.00 to 30.00, incl	0.25	over 0.02 to 0.19, incl		0.01	
Nickel	to 1.00, incl	0.03		over 0.19 to 0.25, incl	0.02
	over 1.00 to 5.00, incl	0.07		over 0.25 to 0.35, incl	0.03
	over 5.00 to 10.00, incl	0.10		over 0.35 to 0.45, incl	0.04
	over 10.00 to 20.00, incl	0.15	over 0.45	0.05	
	over 20.00 to 30.00, incl	0.20	Tungsten	to 1.00, incl	0.03
over 30.00 to 40.00, incl	0.25	over 1.00 to 2.00, incl		0.05	
over 40.00	0.30	over 2.00 to 5.00, incl		0.07	
Molybdenum	over 0.20 to 0.60, incl	0.03		over 5.00 to 10.00, incl	0.10
	over 0.60 to 2.00, incl	0.05		over 10.00 to 20.00, incl	0.15
	over 2.00 to 7.00, incl	0.10	Vanadium	to 0.50, incl	0.03
	over 7.00 to 15.00, incl	0.15		over 0.50 to 1.50, incl	0.05
over 15.00 to 30.00, incl	0.20	Selenium	all	0.03	
Titanium	to 1.00, incl		0.05		
	over 1.00 to 3.00, incl		0.07		
	over 3.00	0.10			

<sup>A</sup> Columbium (Cb) and niobium (Nb) are considered interchangeable names for element 41 in the periodic table and both names are acceptable for use.

for each grade as indicated in Table 2, and cooling rapidly enough to prevent unacceptable grain boundary carbide precipitation. Except as indicated in Table 2, austenitic stainless steels solution annealed by process annealing shall be capable of meeting the requirements of Practice E of Practices A262. Practice E of Practices A262 is not required unless specified on the purchase order.

7.2.3 For the stabilized grades, Types 321, 321H, 347, 347H, 348, and 348H, the manufacturer is permitted, if necessary, to use a lower temperature resolution anneal or a stabilization anneal after a high temperature anneal in order to maximize resistance to intergranular corrosion.

NOTE 2—Solution annealing temperatures above 1950 °F [1065 °C] may impair the resistance to intergranular corrosion after subsequent exposure to sensitizing conditions for the stabilized grades. When inter-

granular corrosion is of concern, the purchaser should specify Practice E of Practices A262 (to be conducted on specimens exposed to a sensitizing treatment). Consideration should be given to the corrosive media before using a stabilization anneal at less than 1800 °F [980 °C], as such a treatment may not be fully effective for all media.

7.2.4 *Strain-hardened Austenitic Grades*—When a particular austenitic grade is desired with increased mechanical properties, the purchaser is permitted to specify a strain hardened condition. This condition is produced by solution annealing the product in accordance with Table 2, followed by strain hardening sufficient to meet the required mechanical properties. Annealing in accordance with Table 2 is permitted between strain hardening steps. The solution annealed and strain hardened material shall be capable of meeting the intergranular corrosion test requirements of Practice E of

**TABLE 2 Annealing Requirements**

Designation/Type	Temperature <sup>A</sup>	Cooling/Testing Requirements	Permitted Annealing <sup>B</sup>	
			Separate	Process
Austenitic (Chromium-Nickel) (Chromium-Nickel-Manganese)				
All austenitic grades except as listed below	1900 °F [1040 °C]	C	x	x <sup>D</sup>
All Cr-Ni-Mn grades, 302, S30215, S30452, S30600, S30615, 308, S30815, S30880, 309, 309S, 310, 310S, 314, 317, S31725, S31726, S32615, S38100	1900 °F [1040 °C]	E	x	x <sup>D</sup>
309Cb, 310Cb, 316Cb, 316Ti, 321, 347, 348	1900 °F [1040 °C]	E	x	
304H, 309H, 310H, 316H 321H, 347H, 348H	1900 °F [1040 °C]	E	x	
Hot-worked	1925 °F [1050 °C]	E	x	
Cold-worked	2000 °F [1095 °C]	E	x	
S31254, S32050	2100 °F [1150 °C]	E	x	
S31727, S32053	1975 to 2155 °F [1080° to 1180 °C]	E	x	
S33228	2050 to 2140 °F [1120° to 1170 °C]	E	x	
S34565	2050 to 2140 °F [1120° to 1170 °C]	E	x	
S34752	1940 to 2140 °F [1060° to 1170 °C]	E	x	
S35315	2010 °F [1100 °C]	E	x	
N08367	2025 °F [1105 °C]	E	x	
N08700	2000 °F [1095 °C]	E	x	
N08020	1700 to 1850 °F [930 to 1010 °C]	E	x	
N08810	2050 °F [1120 °C]	E	x	
N08811	2100 °F [1150 °C]	E	x	
N08904	2000 °F [1095 °C]	E	x	
N08925, N08926	2010 to 2100 °F [1100 to 1150 °C]	E	x	
Austenitic-Ferritic (Duplex)				
S32100	1900 °F [1040 °C]	E	x	x <sup>F</sup>
S31260	1870° to 2010 °F [1020° to 1100 °C]	E	x	x <sup>F</sup>
S31266	2100 °F [1150 °C]	E	x	
S31803	1900 °F [1040 °C]	E	x	x <sup>F</sup>
S32101	1870 °F [1020 °C]	E	x	x <sup>F</sup>
S32202	1800 to 1975 °F [980 to 1080 °C]	E	x	x <sup>F</sup>
S32205	1900 °F [1040 °C]	G	x	x <sup>F</sup>
S32304	1800 °F [980 °C]	E	x	x <sup>F</sup>
S32506	1870° to 2050 °F [1020° to 1120 °C]	E	x	x <sup>F</sup>
S32550	1900 °F [1040 °C]	E	x	x <sup>F</sup>
S32750	1880 °F [1025 °C]	E	x	x <sup>F</sup>
S32760	2010 °F [1100 °C]	E	x	x <sup>F</sup>
S32808	1925 to 2100 °F [1050 to 1150 °C]	E	x	x <sup>F</sup>
S32900	1750° ± 25 °F [955° ± 15 °C]	E	x	x <sup>F</sup>
S32906	1830° to 2100 °F [1000° to 1150 °C]	E	x	x <sup>F</sup>
S32950	1850° ± 25 °F [1010° ± 15 °C]	E	x	x <sup>F</sup>
S82441	1830 °F [1000 °C]	E	x	x <sup>F</sup>

<sup>A</sup> Minimum annealing temperature unless otherwise specified.

<sup>B</sup> Permitted annealing procedure, see 7.2.2.

<sup>C</sup> 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 Practice E of Practices A262. Performance of the test is not required unless specified in the purchase order.

<sup>D</sup> Minimum temperature at which hot rolling is completed shall be 1850 °F [1010 °C].

<sup>E</sup> Quenched in water or rapidly cooled by other means.

<sup>F</sup> Minimum temperature at which hot rolling is completed shall be the minimum temperature for separate annealing.

<sup>G</sup> Quenched in water.

Practices A262. Practice E of Practices A262 is not required unless specified on the purchase order.

7.2.4.1 Individual product specifications are permitted to define particular strain hardened conditions as functions of grade, size, and degree of strain hardening.

7.2.5 Hot-rolled Austenitic Grades—Individual product specifications are permitted to define requirements for particular hot-rolled austenitic grades without annealing.

7.2.6 Except when strain-hardened (see 7.2.4), UNS N08020 shall be furnished in the stabilized annealed condition in accordance with Table 2, with subsequent light cold drawing for cold finishing and straightening permitted.

### 7.3 Austenitic-Ferritic (Duplex) Grades:

7.3.1 The austenitic-ferritic (duplex) grades shall be furnished in the solution annealed condition in accordance with Table 2, with subsequent light cold drawing for cold finishing and straightening permitted.

7.3.2 Except as indicated in Table 2, the duplex grades shall be annealed, at the option of the manufacturer, by a separate annealing treatment or by process annealing.

7.3.2.1 The separate annealing treatment shall consist of heating the material to the minimum annealing temperature for the grade as listed in Table 2, holding for a sufficient time to permit dissolution of intermetallic phases, and cooling rapidly enough to prevent unacceptable precipitation of intermetallic phases.

7.3.2.2 Process annealing shall consist of completing hot working above the minimum annealing temperature required for each grade as indicated in **Table 2**, and cooling rapidly enough to prevent unacceptable precipitation of intermetallic phases.

7.4 *Ferritic Grades*—Ferritic grades shall be annealed to meet their respective mechanical testing requirements as shown in the applicable product specification.

#### 7.5 *Martensitic Grades:*

7.5.1 All martensitic grades shall be supplied in either the annealed condition or in the tempered condition as specified by the purchaser. Tempered material shall be normalized, or shall be liquid quenched from 1700 °F [925 °C], minimum, followed by tempering in accordance with **7.5.2**, **7.5.3**, or **7.5.4**.

7.5.2 Types 403 and 410 tempered material shall be held at the tempering temperature for at least 1 h/in. [25.4 mm] of cross section as follows:

7.5.2.1 *Condition 1*—1250 °F [675 °C] minimum, 1400 °F [760 °C] maximum.

7.5.2.2 *Condition 2*—1100 °F [595 °C] minimum, 1400 °F [760 °C] maximum.

7.5.2.3 *Condition 3*—1050 °F [565 °C] minimum, 1400 °F [760 °C] maximum.

7.5.3 Types XM-30, 414, and 431 tempered materials shall be held at 1100 °F [595 °C], minimum for at least 1 h/in. [25 mm] of cross section. Maximum tempering temperature shall be 1400 °F [760 °C].

7.5.4 S41500 shall be heated to 1750 °F [955 °C] minimum, air cooled to 200 °F [95 °C] or lower prior to any optional intermediate temper and prior to the final temper. The final temper shall be between 1050 and 1150 °F [565 and 620 °C].

7.5.5 When the purchaser elects to perform the hardening and tempering heat treatment, martensitic materials shall be supplied by the manufacturer in the annealed condition (see **7.5.1**). In this case the purchaser shall be responsible to apply the proper heat treatment and to conduct the tests deemed necessary to assure that the required properties are obtained.

## 8. Finish

8.1 The following types of finishes are permitted, as applicable to the product ordered:

8.1.1 *Hot-finished Bars*—Hot-finished bars shall have the surface finish that results from hot processing, with or without certain additional surface modification. Hot-finished bars are commonly produced by hot rolling, forging, pressing, extruding, or similar hot working procedures applied to ingots, blooms, or billets. The resulting products are typically subject to various additional operations affecting the surface of the bars, including but not limited to one or more of the following: annealing or other heat treatment; cleaning by blasting, pickling, or other descaling methods; rough turning; and machine straightening. The producer is permitted to use centerless grinding, polishing, or other operations commonly associated with cold finishing in order to provide improved dimensional tolerances or surface condition for the hot-finished bar. The dimensional tolerances applicable to hot-finished bars are less stringent than those applicable to cold-finished bars.

8.1.2 *Bars Cut from Strip or Plate*—Bars cut from flat-rolled stainless steel products shall have two surfaces that are pickled or descaled, and two cut surfaces, except when the bar is heat treated subsequent to cutting, in which case all surfaces shall be descaled or pickled.

8.1.3 *Cold-finished Bar*—Cold-finished bars shall have the surface finish that results from hot-finished bars being further processed by additional mechanical operations on the surface of the bar, including but not limited to light cold drawing, burnishing, centerless grinding, and polishing to provide closer tolerances and improved surface finish. The dimensional tolerances applicable to cold-finished bars are more stringent than those applicable to hot-finished bars.

8.1.4 *Bars and Billets or Other Semi-finished Material for Reforging*—Material intended for reforging shall be delivered in the hot-finished condition or in the cold-drawn condition. The cold-drawn condition alternative is only permitted for austenitic and austenitic-ferritic stainless steel forgings. When delivered in the hot-finished condition, it is permitted to condition the surface by removing surface defects provided that the depth of the conditioning does not exceed that which affects the surface condition or dimensions of the article to be forged from the bar or billet. When delivered in the cold-drawn condition, it is permitted to hot forge forgings from cold-drawn bar provided this bar has been cold-drawn from material in the solution-annealed condition.

8.1.5 *Shapes*—Shapes shall be descaled by machining, grinding, blasting, or pickling.

8.1.5.1 Shapes shall be subject to either Class A or Class C surface preparation as specified on the purchase order. Class A consists of grinding for the removal of imperfections of a hazardous nature, such as fins, tears, and jagged edges, provided the underweight tolerance is not exceeded and the maximum depth of grinding at any one point does not exceed 10 % of the thickness of the section. Class C consists of grinding for the removal of all visible surface imperfections, provided that the underweight tolerance is not exceeded and the maximum depth of grinding at any point does not exceed 10 % of the thickness of the section.

8.1.6 *Forgings*—Forgings shall be descaled by machining, blasting, or pickling. The selection of the descaling methods shall be at the option of the producer unless a particular descaling method is specified in the purchase order.

## 9. Dimensions, Mass, and Permissible Variations

9.1 Unless otherwise specified on the purchase order, the material shall conform to the permitted variations in dimensions as specified in the following:

9.1.1 *Bars*—**Tables 3-12**.

9.1.2 *Shapes*—**Tables 13-19** and **Figs. 1 and 2**.

9.1.3 *Forgings*—As specified in the purchase order, or in prints or sketches accompanying the purchase order.

9.1.4 *Billets or Other Semi-finished Material for Reforging*—Billets and other semi-finished material shall conform to the shape and dimensions specified by the purchaser within a permitted variation of  $\pm 5\%$ .

**TABLE 3 Permitted Variations in Size of Hot-finished Round, Turned,<sup>A</sup> and Square Bars**

Specified Size, in. [mm]	Permitted Variations from Specified Size, in. [mm]		Out-of-Round <sup>B</sup> or Out-of-Square, <sup>C</sup> in. [mm]
	Over	Under	
5/16 to 7/16 [8.00 to 11.00], incl <sup>D</sup>	0.006 [0.15]	0.006 [0.15]	0.009 [0.23]
Over 7/16 to 5/8 [11.00 to 15.50], incl <sup>D</sup>	0.007 [0.18]	0.007 [0.18]	0.010 [0.26]
Over 5/8 to 7/8 [15.50 to 22.00], incl	0.008 [0.20]	0.008 [0.20]	0.012 [0.30]
Over 7/8 to 1 [22.00 to 25.00], incl	0.009 [0.23]	0.009 [0.23]	0.013 [0.34]
Over 1 to 1 1/8 [25.00 to 28.00], incl	0.010 [0.25]	0.010 [0.25]	0.015 [0.38]
Over 1 1/8 to 1 1/4 [28.00 to 31.50], incl	0.011 [0.28]	0.011 [0.28]	0.016 [0.42]
Over 1 1/4 to 1 3/8 [31.50 to 34.50], incl	0.012 [0.30]	0.012 [0.30]	0.018 [0.46]
Over 1 3/8 to 1 1/2 [34.50 to 38.00], incl	0.014 [0.35]	0.014 [0.35]	0.021 [0.53]
Over 1 1/2 to 2 [38.00 to 50.00], incl	1/64 [0.40]	1/64 [0.40]	0.023 [0.60]
Over 2 to 2 1/2 [50.00 to 63.00], incl	1/32 [0.80]	0	0.023 [0.60]
Over 2 1/2 to 3 1/2 [63.00 to 90.00], incl	3/64 [1.20]	0	0.035 [0.90]
Over 3 1/2 to 4 1/2 [90.00 to 115.00], incl	1/16 [1.60]	0	0.046 [1.20]
Over 4 1/2 to 5 1/2 [115.00 to 140.00], incl	5/64 [2.00]	0	0.058 [1.50]
Over 5 1/2 to 6 1/2 [140.00 to 165.00], incl	1/8 [3.00]	0	0.070 [1.80]
Over 6 1/2 to 8 [165.00 to 200.00], incl	3/32 [4.00]	0	0.085 [2.20]
Over 8 to 12 [200.00 to 300.00], incl <sup>A</sup>	3/16 [4.80]	0	3/32 [2.40]
Over 12 to 15 [300.00 to 400.00], incl <sup>A</sup>	7/32 [5.50]	0	7/64 [2.80]
Over 15 to 25 [400.00 to 625.00], incl <sup>A</sup>	1/4 [6.50]	0	1/8 [3.20]

<sup>A</sup> Turned bars are generally available from 2 to 25 in. [50 to 625 mm] in diameter, over 8 in. [200 mm] only turned bars are available.

<sup>B</sup> Out-of-round is the difference between the maximum and minimum diameters of the bar measured at the same cross section.

<sup>C</sup> Out-of-square section is the difference in the two dimensions at the same cross section of a square bar, each dimension being the distance between opposite faces.

<sup>D</sup> Size tolerances have not been evolved for round sections in the size range of 5/16 in. [8.00 mm] to approximately 5/8 in. [15.5 mm] in diameter which are produced on rod mills in coils.

**TABLE 4 Permitted Variations in Size of Hot-finished Hexagonal and Octagonal Bar**

Specified Sizes Measured Between Opposite Sides, in. [mm]	Permitted Variations from Specified Size, in. [mm]		Maximum Difference in 3 Measurements for Hexagons Only, in. [mm]
	Over	Under	
1/4 to 1/2 [6.50 to 13.00], incl	0.007 [0.18]	0.007 [0.18]	0.011 [0.28]
Over 1/2 to 1 [13.00 to 25.00], incl	0.010 [0.25]	0.010 [0.25]	0.015 [0.38]
Over 1 to 1 1/2 [25.00 to 38.00], incl	0.021 [0.53]	0.021 [0.53]	0.025 [0.64]
Over 1 1/2 to 2 [38.00 to 50.00], incl	1/32 [0.80]	1/8 [0.80]	1/32 [0.80]
Over 2 to 2 1/2 [50.00 to 63.00], incl	3/64 [1.20]	3/64 [1.20]	3/64 [1.20]
Over 2 1/2 to 3 1/2 [63.00 to 90.00], incl	1/16 [1.60]	1/16 [1.60]	1/16 [1.60]

**TABLE 5 Permitted Variations in Thickness and Width for Hot-finished Flat Bars Rolled as Bars**

Specified Width, in. [mm]	Permitted Variations in Thickness for Thicknesses Given, in. [mm]												Permitted Variations in Width, in. [mm]		
	1/8 to 1/2 [3.2 to 13], incl		Over 1/2 to 1 [13 to 25], incl		Over 1 to 2 [25 to 50], incl		Over 2 to 4 [50 to 100], incl		Over 4 to 6 [100 to 150], incl		Over 6 to 8 [150 to 200], incl				
	Over	Under	Over	Under	Over	Under	Over	Under	Over	Under	Over	Under	Over	Under	
To 1 [25.00], incl	0.008 [0.20]	0.008 [0.20]	0.010 [0.25]	0.010 [0.25]	...	...	...	...	...	...	...	...	...	0.015 [0.40]	0.015 [0.40]
Over 1 to 2 [25.00 to 50.00], incl	0.012 [0.30]	0.012 [0.30]	0.015 [0.40]	0.015 [0.40]	0.031 [0.80]	0.031 [0.80]	...	...	...	...	...	...	...	0.031 [0.80]	0.031 [0.80]
Over 2 to 4 [50.00 to 100.00], incl	0.015 [0.40]	0.015 [0.40]	0.020 [0.50]	0.020 [0.50]	0.031 [0.80]	0.031 [0.80]	0.062 [1.60]	0.031 [0.80]	...	...	...	...	...	0.062 [1.60]	0.031 [0.80]
Over 4 to 6 [100.00 to 150.00], incl	0.015 [0.40]	0.015 [0.40]	0.020 [0.50]	0.020 [0.50]	0.031 [0.80]	0.031 [0.80]	0.062 [1.60]	0.031 [0.80]	0.093 [2.40]	0.062 [1.60]	...	...	...	0.093 [2.40]	0.062 [1.60]
Over 6 to 8 [150.00 to 200.00], incl	0.016 [0.40]	0.016 [0.40]	0.025 [0.65]	0.025 [0.65]	0.031 [0.80]	0.031 [0.80]	0.062 [1.60]	0.031 [0.80]	0.093 [2.40]	0.062 [1.60]	0.125 [3.20]	0.156 [4.00]	0.125 [3.20]	0.156 [4.00]	0.156 [4.00]
Over 8 to 10 [200.00 to 250.00], incl	0.020 [0.50]	0.020 [0.50]	0.031 [0.80]	0.031 [0.80]	0.031 [0.80]	0.031 [0.80]	0.062 [1.60]	0.031 [0.80]	0.093 [2.40]	0.062 [1.60]	0.125 [3.20]	0.156 [4.00]	0.156 [4.00]	0.187 [4.80]	0.187 [4.80]

## 10. Workmanship, Finish, and Appearance

10.1 The material shall be of uniform quality consistent with good manufacturing and inspection practices. Imperfections shall be of such a nature or degree for the type and quality

ordered, that they shall not adversely affect the forming, machining, or fabrication of finished parts.