Designation: A988/A988M – 23

Standard Specification for Hot Isostatically-Pressed Stainless Steel Flanges, Fittings, Valves, and Parts for High Temperature Service[1]

This standard is issued under the fixed designation A988/A988M; 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.

1. Scope*

1.1 This specification covers hot isostatically-pressed, powder metallurgy, stainless steel piping components for use in pressure systems. Included are flanges, fittings, valves, and similar parts made to specified dimensions or to dimensional standards, such as in ASME specification B16.5.

1.2 Several grades of martensitic, austenitic, age hardening, and austenitic-ferritic stainless steels are included in this specification.

1.3 Supplementary requirements are provided for use when additional testing or inspection is desired. These shall apply only when specified individually by the purchaser in the order.

1.4 This specification is expressed in both inch-pound units and in SI units. Unless the order specifies the applicable "M" specification designation (SI units), however, the material shall be furnished to inch-pound units.

1.5 The values stated in either inch-pound units or SI units are to be regarded separately as the standard. Within the text, the SI units are shown in brackets. 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.

1.6 The following safety hazards caveat pertains only to test methods portions 8.1, 8.2, 9.5 – 9.7, and Section 10 of this specification: *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.7 *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:*[2]

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

A275/A275M Practice for Magnetic Particle Examination of Steel Forgings

A745/A745M Practice for Ultrasonic Examination of Austenitic Steel Forgings

A751 Test Methods and Practices for Chemical Analysis of Steel Products

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

A941 Terminology Relating to Steel, Stainless Steel, Related Alloys, and Ferroalloys

A961/A961M Specification for Common Requirements for Steel Flanges, Forged Fittings, Valves, and Parts for Piping Applications

B311 Test Method for Density of Powder Metallurgy (PM) Materials Containing Less Than Two Percent Porosity

E112 Test Methods for Determining Average Grain Size

E165/E165M Practice for Liquid Penetrant Testing for General Industry

E340 Practice for Macroetching Metals and Alloys

E606/E606M Test Method for Strain-Controlled Fatigue Testing

G48 Test Methods for Pitting and Crevice Corrosion Resistance of Stainless Steels and Related Alloys by Use of Ferric Chloride Solution

2.2 *MSS Standard:*

SP 25 Standard Marking System for Valves, Fittings, Flanges, and Unions[3]

[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 A01.22 onSteel Forgings and Wrought Fittings for Piping Applications and Bolting Materials for Piping and Special Purpose Applications.

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[2] 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.

[3] Available from Manufacturers Standardization Society of the Valve and Fittings Industry (MSS), 127 Park St., NE, Vienna, VA 22180-4602, http://www.mss-hq.com.

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

2.3 *ASME Specifications and Boiler and Pressure Vessel Codes:*

B16.5 Dimensional Standards for Steel Pipe Flanges and Flanged Fittings [4]

2.4 *ASME Specification IX Welding Qualifications:*

SFA-5.4 Specification for Corrosion-Resisting Chromium and Chromium-Nickel Steel Covered Welding Electrodes[4]

SFA-5.9 Specification for Corrosion-Resisting Chromium and Chromium-Nickel Steel Welding Rods and Bare Electrodes[4]

SFA-5.11 Specification for Nickel and Nickel-Alloy Covered Welding Electrodes[4]

SFA-5.14 Specification for Nickel and Nickel Alloy Bare Welding Electrodes and Rods[4]

2.5 *AWS Standard:*[5]

A5.11 Specification for Nickel and Nickel Alloy Welding Electrodes for Shielded Metal Arc Welding

A5.14 Specification for Nickel and Nickel Alloy Bare Welding Electrodes and Rods

3. Terminology

3.1 *Definitions*—For definitions of terms used in this standard, refer to Terminology A941.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *can, n*—the container used to encapsulate the powder during the pressure consolidation process; it is partially or fully removed from the final part.

3.2.2 *compact, n*—the consolidated powder from one can. It may be used to make one or more parts.

3.2.3 *consolidation, n*—the bonding of adjacent powder particles in a compact under pressure by heating to a temperature below the melting point of the powder.

3.2.4 *fill stem, n*—the part of the compact used to fill the can. It is not usually integral to the part produced.

3.2.5 *hot isostatic-pressing, n*—a process for simultaneously heating and forming a compact in which the powder is contained in a sealed formable enclosure usually made from metal and the so-contained powder is subjected to equal pressure from all directions at a temperature high enough to permit plastic deformation and consolidation of the powder particles to take place.

3.2.6 *lot, n*—a number of parts made from a single powder blend following the same manufacturing practice.

3.2.7 *part, n*—a single item coming from a compact, either prior to or after machining.

3.2.8 *powder blend, n*—a homogeneous mixture of powder from one or more heats of the same grade.

3.2.9 *rough part, n*—the part prior to final machining.

4. Ordering Information

4.1 It is the responsibility of the purchaser to specify in the purchase order 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 or number of parts),

4.1.2 Name of material or UNS number,

4.1.3 ASTM designation and year of issue,

4.1.4 Dimensions (tolerances and surface finishes should be included),

4.1.5 Microstructure examination if required (5.1.4),

4.1.6 Inspection (15.1),

4.1.7 Whether rough part or finished machined part (8.2.2),

4.1.8 Supplementary requirements, if any,

4.1.9 Additional requirements (See 7.2 and 17.1), and

4.1.10 Requirement, if any, that the manufacturer shall submit drawings for approval showing the shape of the rough part before machining and the exact location of test specimen material (See 9.3).

5. Materials and Manufacture

5.1 *Manufacturing Practice:*

5.1.1 Compacts shall be manufactured by placing a single powder blend into a can, evacuating the can, and sealing it. The can material shall be selected to ensure that it has no deleterious effect on the final product. The entire assembly shall be heated and placed under sufficient pressure for a sufficient period of time to ensure that the final consolidated part meets the density requirements of 8.1.1.1. One or more parts shall be machined from a single compact.

5.1.2 The powder shall be prealloyed and made by a melting method capable of producing the specified chemical composition, such as but not limited to, air or vacuum induction melting, followed by gas atomization.

5.1.3 When powder from more than one heat of the same grade is used to make a blend, the heats shall be mixed thoroughly to ensure homogeneity.

5.1.4 The compact shall be sectioned and the microstructure examined to check for porosity and other internal imperfections. It shall meet the requirements of 8.1.2. The sample shall be taken from the fill stem or from a location in a part as agreed upon by the manufacturer and purchaser.

5.1.5 Unless otherwise specified in the purchase order, the manufacturer shall remove the can material from the surfaces of the consolidated compacts by chemical or mechanical methods such as by pickling or machining. This removal shall be done before or after heat treatment at the option of the manufacturer (See Note 1).

NOTE 1—Often, it is advantageous to leave the can material in place until after heat treatment or further thermal processing of the consolidated compact.

6. Chemical Composition

6.1 The steel, both as a blend and as a part, shall conform to the requirements for chemical composition prescribed in Table 1. Test Methods, Practices, and Terminology of A751 shall apply.

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

[5] Available from American Welding Society (AWS), 8669 NW 36 St., #130, Miami, FL 33166-6672, http://www.aws.org.

TABLE 1 Chemical Requirements

UNS Designation	Grade	Composition, %[A] Carbon	Manganese	Phosphorus	Sulfur	Silicon	Nickel	Chromium	Molybdenum	Copper	Niobium[D]	Nitrogen	Other Elements
					Martensitic Stainless Steels								
S41000	13 chromium	0.15	1.00	0.040	0.030	1.00	. . .	11.5–13.5	. . .	. . .	. . .	. . .	
S41026	13 chromium 0.5 molybdenum	0.15	1.00	0.020	0.020	1.00	1.00–2.00	11.5–13.5	0.40–0.60	0.50	. . .	. . .	
S41500	13 chromium, 4 nickel	0.05	0.50–1.00	0.030	0.030	0.60	3.5–5.5	11.5–14.0	0.50–1.00	. . .	. . .	. . .	
S42390	12 chromium, 1.0 molybdenum, modified with vanadium	0.18–0.25	1.00	0.030	0.030	1.00	0.30–0.80	11.5–12.5	0.80–1.20	. . .	0.08–0.15	0.03–0.08	V 0.25–0.35
					Austenitic Stainless Steels								
N08028	32 nickel, 27 chromium, 3.5 molybdenum	0.030	2.50	0.030	0.030	1.0	30.0–34.0	26.0–28.0	3.0–4.0	0.60–1.4	. . .	. . .	
N08029	32 nickel, 27 chromium, 4.5 molybdenum	0.020	2.0	0.025	0.015	0.6	30.0–34.0	26.0–28.0	4.0–5.0	0.60–1.4	. . .	. . .	
S30400	18 chromium, 8 nickel	0.08	2.00	0.045	0.030	1.00	8.0–11.0	18.0–20.0	. . .	. . .	. . .	0.10	
S30403	18 chromium, 8 nickel, low carbon	0.035	2.00	0.045	0.030	1.00	8.0–13.0	18.0–20.0	. . .	. . .	. . .	0.10	
S30451	18 chromium, 8 nickel, modified with nitrogen	0.08	2.00	0.045	0.030	1.00	8.0–11.0	18.0–20.0	. . .	. . .	. . .	0.10–0.16	
S30453	18 chromium, 8 nickel, modified with nitrogen	0.030	2.00	0.045	0.030	1.00	8.0–11.0	18.0–20.0	. . .	. . .	. . .	0.10–0.16	
S31600	18 chromium, 8 nickel, modified with molybdenum	0.08	2.00	0.045	0.030	1.00	10.0–14.0	16.0–18.0	2.00–3.00	. . .	. . .	0.10	
S31603	18 chromium, 8 nickel, modified with molybdenum, low carbon	0.030	2.00	0.045	0.030	1.00	10.0–14.0	16.0–18.0	2.00–3.00	. . .	. . .	0.10	
S31651	18 chromium, 8 nickel, modified with molybdenum and nitrogen	0.08	2.00	0.045	0.030	1.00	10.0–13.0	16.0–18.0	2.00–3.00	. . .	. . .	0.10–0.16	
S31653	18 chromium, 8 nickel, modified with molybdenum and nitrogen	0.030	2.00	0.045	0.030	1.00	10.0–13.0	16.0–18.0	2.00–3.00	. . .	. . .	0.10–0.16	
S31700	19 chromium, 13 nickel 3.5 molybdenum	0.08	2.00	0.045	0.030	1.00	11.0–15.0	18.0–20.0	3.0–4.0	. . .	. . .	. . .	
S31703	19 chromium, 13 nickel, 3.5 molybdenum	0.030	2.00	0.045	0.030	1.00	11.0–15.0	18.0–20.0	3.0–4.0	. . .	. . .	. . .	

TABLE 1 *Continued*

UNS Designation	Grade	Composition, %[A] Carbon	Manganese	Phosphorus	Sulfur	Silicon	Nickel	Chromium	Molybdenum	Copper	Niobium[D]	Nitrogen	Other Elements
S21904	20 chromium, 6 nickel, 9 manganese	0.04	8.0–10.0	0.045	0.030	1.00	5.5–7.5	19.0–21.5	. . .	. . .	. . .	0.15–0.40	
S31254	20 chromium, 18 nickel, 6 molybdenum, low carbon	0.020	1.00	0.030	0.010	0.80	17.5–18.5	19.5–20.5	6.0–6.5	0.50–1.00	. . .	0.18–0.22	
S31725	19 chromium, 15 nickel, 4 molybdenum	0.030	2.00	0.045	0.030	1.00	13.5–17.5	18.0–20.0	4.0–5.0	. . .	. . .	0.20	
S31726	19 chromium, 15 nickel, 4 molybdenum	0.030	2.00	0.045	0.030	1.00	14.5–17.5	17.0–20.0	4.0–5.0	. . .	. . .	0.10–0.20	
N08367	22 chromium, 25 nickel, 6.5 molybdenum, low carbon	0.030	2.00	0.040	0.030	1.00	23.50–25.50	20.0–22.0	6.0–7.0	0.75	. . .	0.18–0.25	
S32654	25 chromium, 22 nickel, 7 molybdenum, low carbon	0.020	2.0–4.0	0.030	0.005	0.50	21.0–23.0	24.0–25.0	7.0–8.0	0.30–0.60	. . .	0.45–0.55	
Age-Hardening Stainless Steels													
S17400	17 chromium, 4 nickel, 3 copper	0.07	1.00	0.040	0.030	1.00	3.0–5.0	15.0–17.5	. . .	3.0–5.0	0.15–0.45	. . .	
Austenitic-Ferritic Stainless Steels													
S31803	22 chromium, 5.5 nickel, modified with nitrogen	0.030	2.00	0.030	0.020	1.00	4.5–6.5	21.0–23.0	2.5–3.5	. . .	. . .	0.08–0.20	
S32205	22 chromium, 5.5 nickel, modified with high nitrogen	0.030	2.00	0.030	0.020	1.00	4.5–6.5	22.0–23.0	3.0–3.5	0.75	. . .	0.14–0.20	
S32906	29 chromium, 6.5 nickel, 2.0 molybdenum, modified with high nitrogen	0.030	0.80–1.50	0.030	0.030	0.50	5.8–7.5	28.0–30.0	1.50–2.60	0.80	. . .	0.30–0.40	
S32950	26 chromium, 3.5 nickel, 1.0 molybdenum	0.030	2.00	0.035	0.010	0.60	3.5–5.2	26.0–29.0	1.00–2.50	. . .	. . .	0.15–0.35	
S32750[B]	25 chromium, 7 nickel, 4 molybdenum, modified with nitrogen	0.030	1.20	0.035	0.020	0.80	6.0–8.0	24.0–26.0	3.0-5.0	0.50	. . .	0.24–0.32	
S39274	25 chromium, 7 nickel, modified with nitrogen and tungsten	0.030	1.0	0.030	0.020	0.80	6.0–8.0	24.0–26.0	2.5–3.5	0.20–0.80	. . .	0.24–0.32	W 1.50–2.50

TABLE 1 *Continued*

UNS Designation	Grade	Composition, %[A]											
		Carbon	Manganese	Phosphorus	Sulfur	Silicon	Nickel	Chromium	Molybdenum	Copper	Niobium[D]	Nitrogen	Other Elements
S32760[C]	25 chromium, 7 nickel, 3.5 molybdenum, modified with nitrogen and tungsten	0.030	1.00	0.030	0.010	1.00	6.0–8.0	24.0–26.0	3.0–4.0	0.50–1.00	. . .	0.20–0.30	W 0.50–1.00
S39277	25 chromium, 7 nickel, 3.7 molybdenum	0.025	0.80	0.025	0.002	0.80	6.5–8.0	24.0–26.0	3.0–4.0	1.20–2.00	. . .	0.23–0.33	W 0.80–1.20
S32505	27 chromium, 7 nickel, 3 molybdenum, modified with nitrogen and copper	0.030	1.50	0.030	0.020	1.00	4.5–7.0	24.0–27.0	2.9–3.9	1.50–2.50	. . .	0.25–0.30	

[A] Maximum, unless otherwise specified. Where ellipses (. . .) appear in this table, there is no requirement, and analysis for the element need not be determined or reported.
[B] % Cr + 3.3 × % Mo + 16 × % N ≥ 41.
[C] % Cr + 3.3 × (% Mo + 1/2 %W) + 16 × % N ≥ 41.
[D] The terms Niobium (Nb) and Columbium (Cb) are alternate names for the same element.

6.1.1 A representative sample of each blend of powder shall be analyzed by the manufacturer to determine the percentage of elements prescribed in Table 1. The blend shall conform to the chemical composition requirements prescribed in Table 1.

6.1.2 When required by the purchaser, the chemical composition of a sample from one part from each lot of parts shall be determined by the manufacturer. The composition of the sample shall conform to the chemical requirements prescribed in Table 1.

6.2 Addition of lead, selenium, or other unspecified elements for the purpose of improving the machinability of the compact shall not be permitted.

6.3 The steel shall not contain an unspecified element other than nitrogen, 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.

7. Heat Treatment

7.1 Except as provided in 7.2, the final heat treatment of all parts shall be in compliance with the requirements of Table 2. After hot isostatic-pressing and prior to final heat treatment, the compacts are permitted to be annealed, at the option of the producer, either as a part of the consolidation process or as a separate operation.

7.2 When agreed upon by the purchaser, liquid quenching may be applied to the martensitic stainless steels in place of the furnace cool or air cool specified in Table 2, provided that such quenching is followed by tempering in the temperature ranges as required in Table 2. Martensitic parts that are liquid quenched and tempered shall be marked "QT."

7.3 The final heat treatment shall be performed before or after machining at the option of the producer.

7.4 See Section S16 if a particular heat treatment method is specified by the purchaser in the purchase order.

8. Structural Integrity Requirements

8.1 *Microporosity*—The parts shall be free of microporosity as demonstrated by measurement of density as provided in 8.1.1 or by microstructural examination as provided in 8.1.2.

8.1.1 *Density Measurement:*

8.1.1.1 The density measurement shall be used for acceptance of material but not for rejection of material. The measured density for each production lot shall exceed 99 % of the density typical of that grade when wrought and in the same heat treated condition as the sample. A production lot that fails to meet this acceptance criterion is permitted to be tested at the option of the producer, for microporosity in accordance with the microstructural examination as provided in 8.1.2.

8.1.1.2 Density shall be determined for one sample from each production lot by measuring the difference in mass of the sample when weighed in air and when weighed in water and multiplying this difference by the density of water (Archimede's principle). The equipment used shall be capable of determining density within ±0.004 lb/in.^{3} [0.10 g/cm^3]. Alternatively, at the option of the producer, it is permitted to use Test Method B311 to determine the density.

8.1.1.3 At the option of the producer, the density shall be compared to the room temperature density typical of wrought steels of the same class of grades, 0.28 lb/in.^{3} [7.8 g/cm^3] for age-hardening, martensitic, and austenitic-ferritic grades, and 0.29 lb/in.^{3} [8.0 g/cm^3] for austenitic grades, or to the density of a wrought reference sample of the same grade heat treated in accordance with the requirements of Table 2 (See Note 2).

NOTE 2—The actual density of stainless steel varies slightly with composition and heat treatment. For this reason, small differences in the measured density from the typical density for a class of grades may be the result of differences in alloy content, heat treatment, or microporosity. When density values are measured that are less than the density typical of a class of grades, it is appropriate to examine the sample for microporosity by the more specific metallographic examination procedures.

8.1.2 *Microstructural Examination:*

8.1.2.1 The microstructure shall be examined at 20-50×, 100-200×, and 1000-2000× and shall be reasonably uniform and shall be free of voids, laps, cracks, and porosity.

8.1.2.2 One sample from each production lot shall be examined. The sample shall be taken after hot-isostatic pressing or after final heat treatment. The sample shall be taken from the component, stem, protrusion, or test part made from a single powder blend consolidated in the same hot isostatic press using the same pressure, temperature, and time parameters and heat-treated in the same final heat-treatment charge. The microstructure shall meet the requirements of 8.1.2.1.

8.1.2.3 If the sample fails to meet the requirements for acceptance, each part in the lot is permitted to be retested and those that pass shall be accepted.

8.2 *Hydrostatic Tests*—After they have been machined, pressure-containing parts shall be tested to the hydrostatic shell test pressures prescribed in ASME B16.5 for the applicable steel rating for which the part is designed and shall show no leaks. Parts ordered under these specifications for working pressures other than those listed in the ASME B16.5 ratings shall be tested to such pressures as may be agreed upon between the manufacturer and purchaser.

8.2.1 No hydrostatic test is required for weld neck or other flanges.

8.2.2 The compact manufacturer is not required to perform pressure tests on rough parts that are to be finish machined by others. The fabricator of the finished part is not required to pressure test parts that are designed to be pressure containing only after assembly by welding into a larger structure. The manufacturer of the compacts, however, shall be responsible, as required in 16.1 for the satisfactory performance of the parts under the final test required in 8.2.

8.3 *Ultrasonic Tests*—When specified in the order, austenitic-ferritic stainless steel parts made from S32505 shall be ultrasonic tested according to the procedures described in Section S7.

9. Mechanical Properties

9.1 The material shall conform to the requirements for mechanical properties prescribed in Table 3 at room temperature.

9.2 Sample shall be from the component, stem, protrusion, or test part made from a single powder blend consolidated in

TABLE 2 Heat Treating Requirements

UNS No.	Heat Treat Type	Austenitizing/Solutioning Temperature °F [°C][A]	Cooling Media	Quenching, Cool to Below °F [°C]	Tempering Temperature, min° F [°C]
		Martensitic Stainless Steels			
S41000 Class 1	anneal	not specified	furnace cool	[B]	[B]
	normalize and temper	not specified	air cool	400 [205]	1325 [725]
	temper	not required	[B]	[B]	1325 [725]
S41000 Class 2	anneal	not specified	furnace cool	[B]	[B]
	normalize and temper	not specified	air cool	400 [205]	1250 [675]
	temper	not required	[B]	[B]	1250 [675]
S41000 Class 3	anneal	not specified	furnace cool	[B]	[B]
	normalize and temper	not specified	air cool	400 [205]	1100 [595]
S41000 Class 4	anneal	not specified	furnace cool	[B]	[B]
	normalize and temper	not specified	air cool	400 [205]	1000[540]
S41026	anneal	1750 [955]	furnace cool	[B]	[B]
	normalize and temper	1750 [955]	air cool	400 [205]	1150 [620]
S41500	normalize and temper	1850 [1010]	air cool	200 [95]	1040–1120 [560–600]
S42390	normalize and temper	1860–1960 [1015–1070]	air cool	200 [95]	1350–1440 [730–780]
		Austenitic Stainless Steels			
N08028	solution treat and quench	2000 [1100]	liquid	500 [260]	[B]
N08029	solution treat and quench	2000 [1100]	liquid	500 [260]	[B]
S30400	solution treat and quench	1900 [1040]	liquid	500 [260]	[B]
S30403	solution treat and quench	1900 [1040]	liquid	500 [260]	[B]
S30451	solution treat and quench	1900 [1040]	liquid	500 [260]	[B]
S30453	solution treat and quench	1900 [1040]	liquid	500 [260]	[B]
S31600	solution treat and quench	1900 [1040]	liquid	500 [260]	[B]
S31603	solution treat and quench	1900 [1040]	liquid	500 [260]	[B]
S31651	solution treat and quench	1900 [1040]	liquid	500 [260]	[B]
S31653	solution treat and quench	1900 [1040]	liquid	500 [260]	[B]
S31700	solution treat and quench	1900 [1040]	liquid	500 [260]	[B]
S31703	solution treat and quench	1900 [1040]	liquid	500 [260]	[B]
S21904	solution treat and quench	1900 [1040]	liquid	500 [260]	[B]
S31254	solution treat and quench	2100 [1150]	liquid	500 [260]	[B]
S31725	solution treat and quench	1900 [1040]	liquid	500 [260]	[B]
S31726	solution treat and quench	1900 [1040]	liquid	500 [260]	[B]
N08367	solution treat and quench	2025 [1105]	liquid	500 [260]	[B]
S32654	solution treat and quench	2050–2160 [1120–1180]	liquid	500 [260]	[B]
		Austenitic-Ferritic Stainless Steels			
S31803	solution treat and quench	1870 [1020]	liquid	500 [260]	[B]
S32205	solution treat and quench	1870 [1020]	liquid	500 [260]	[B]
S32906	solution treat and quench	1850–2100 [1010–1150]	liquid	500 [260]	[B]
S32950	solution treat and quench	1825–1875 [995–1025][C]	liquid	500 [260]	[B]
S32750	solution treat and quench	1880 [1025]	liquid	500 [260]	[B]
S39274	solution treat and quench	1920–2060 [1050–1125]	liquid	500 [260]	[B]
S32760	solution treat and quench	2010–2085 [1100–1140]	liquid	500 [260]	[B]
S39277	solution treat and quench	1940 [1060]	liquid	175 [80]	[B]

		Age-Hardening Stainless Steels		
		Solution Heat Treatment		Aging Heat Treatment[D]
	Condition	Temperature °F [°C]	Cool as required to below °F [°C]	Temperature °F [°C], time (h), Required Cooling
S17400	A	1875-1975 [1025-1055]	90 [32]	. . .
	H900	1875-1975 [1025-1055]	90 [32]	900 [480], 1.0, air cool
	H925	1875-1975 [1025-1055]	90 [32]	925 [495], 4.0, air cool
	H1025	1875-1975 [1025-1055]	90 [32]	1025 [550], 4.0, air cool
	H1075	1875-1975 [1025-1055]	90 [32]	1075 [580], 4.0, air cool
	H1100	1875-1975 [1025-1055]	90 [32]	1100 [595], 4.0, air cool
	H1150	1875-1975 [1025-1055]	90 [32]	1150 [620], 4.0, air cool
	H1150M	1875-1975 [1025-1055]	90 [32]	1400 [760], 2.0, air cool plus 1150 [620], 4.0, air cool

[A] Minimum unless temperature range is listed.
[B] Not applicable.
[C] 30 min/in. of thickness.
[D] Unless otherwise noted, it is permitted to vary the aging treatment temperature to obtain the required properties. The listed times are minimum time at temperature and the treatment is permitted to be extended to obtain the required ductility. Material treated at an intermediate temperature must meet the ductility requirements of the next higher hardening or aging temperature, or both.

the same hot isostatic press using the same pressure, temperature, and time parameters and heat-treated in the same final heat-treatment charge. If repair welding is required (See Section 15), the test specimens prior to testing shall accompany the repaired parts if a post weld treatment is done.

9.3 For normalized and tempered parts, or quenched and tempered parts, the central axis of the test specimen shall correspond to the ¼ *T* plane or deeper position, where *T* is the maximum heat treated thickness of the represented part. In addition, for quenched and tempered parts, the midlength of the