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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 and health 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, Practices, and Terminology for Chemical Analysis of Steel Products

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

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 Examination 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 of Terms Specific to This Standard:*

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

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

3.1.3 *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.

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

3.1.5 *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.

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

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

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

3.1.9 *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.

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.

[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[E]	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 chormium, 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[B]	18 chromium, 8 nickel	0.08	2.00	0.045	0.030	1.00	8.0–11.0	18.0–20.0	. . .	. . .	. . .	. . .	
S30403[B]	18 chromium, 8 nickel, low carbon	0.035	2.00	0.045	0.030	1.00	8.0–13.0	18.0–20.0	. . .	. . .	. . .	. . .	
S30451[C]	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	. . .	. . .	. . .	. . .	
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	. . .	. . .	. . .	. . .	
S31600[B]	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	. . .	. . .	. . .	
S31603[B]	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	. . .	. . .	. . .	
S31651[C]	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	. . .	. . .	. . .	
S31653[C]	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	. . .	. . .	. . .	
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[E]	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	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*

		Composition, %[A]											
UNS Designation	Grade	Carbon	Manganese	Phosphorus	Sulfur	Silicon	Nickel	Chromium	Molybdenum	Copper	Niobium[E]	Nitrogen	Other Elements
S32760[D]	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] S30400, S30403, S31600, and S31603 shall have a maximum nitrogen content of 0.10 %.
[C] S30451, S31651, S30453, S31653 shall have a nitrogen content of 0.10 to 0.16 %.
[D] % Cr + 3.3 × % Mo + 16 × % N > 40 min.
[E] The terms Niobium (Nb) and Columbium (Cb) are alternate names for the same element.

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 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

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.

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 test specimen shall be at least *T* from any second heat treated surface. When the section thickness does not permit this positioning, the test specimen shall be positioned as near as possible to the prescribed location, as agreed to by the purchaser and the supplier.

9.4 For all annealed stainless steels, the test specimen may be taken from any convenient location.

TABLE 3 Tensile and Hardness Requirements

UNS Designation	Tensile Strength, min, ksi [MPa]	Yield Strength, min, ksi [MPa][A]	Elongation in 2 in. [50 mm] or 4*D*, min, %	Reduction of Area, min, %	Brinell Hardness Number
Martensitic Stainless Steels					
S41000 Class 1	70 [485]	40 [275]	18	35.0	143–187
S41000 Class 2	85 [585]	55 [380]	18	35.0	167–229
S41000 Class 3	110 [760]	85 [585]	15	35.0	235–302
S41000 Class 4	130 [895]	110 [760]	12	35.0	263–321
S41026	110–135 [760–930]	90 [620]	16	45.0	235–285
S41500	115 [790]	90 [620]	15	45.0	295 max
S42390	100–125 [690–862]	75 [517]	14.0	. . .	. . .
Austenitic Stainless Steels					
N08028	73 [500]	31 [214]	40	50	. . .
N08029	73 [500]	31 [214]	40	50	. . .
S30400	75 [515][B]	30 [205]	30	50	. . .
S30403	70 [485][C]	25 [170]	30	50	. . .
S30451	80 [550]	35 [240]	30	50	. . .
S30453	75 [515][B]	30 [205]	30	50	. . .
S31600	75 [515][B]	30 [205]	30	50	. . .
S31603	70 [485][C]	25 [170]	30	50	. . .
S31651	80 [550]	35 [240]	30	50	. . .
S31653	75 [515][B]	30 [205]	30	50	. . .
S31700	75 [515][B]	30 [205]	30	50	. . .
S31703	70 [485][C]	25 [170]	30	50	. . .
S21904	90 [620]	50 [345]	45	60	. . .
S31254	94 [650]	44 [300]	35	50	. . .
S31725	75 [525]	30 [205]	40.0	50.0	. . .
S31726	80 [550]	35 [240]	40.0	50.0	. . .
N08367	95 [655]	45 [310]	30.0	50.0	
S32654	109 [750]	62 [430]	40.0	. . .	250 max
Age-Hardening Stainless Steels					
UNS Designation, condition					
S17400, A	. . .	. . .	. . .	. . .	363 max
S17400, H900	190 [1310]	170 [1170]	6	15	388 min
S17400, H925	170 [1170]	155 [1070]	7	20	375 min
S17400, H1025	155 [1070]	145 [1000]	8	27	331 min
S17400, H1075	145 [1000]	125 [860]	9	28	311 min
S17400, H1100	140 [965]	115 [795]	10	29	302 min
S17400, H1150	135 [930]	105 [725]	11	30	277 min
S17400, H1150M	115 [795]	75 [520]	14	35	255 min
Austenitic-Ferritic Stainless Steels					
S31803	90 [620]	65 [450]	25	45	. . .
S32205	95 [655]	65 [450]	25.0	. . .	293 max
S32906	109 [750]	80 [550]	25	. . .	310 max
S32950	100 [690]	70 [485]	15	. . .	. . .
S32750	116 [800]	80 [550]	15	. . .	310 max
S39274	116 [800]	80 [550]	15	30	310 max
S32760	109–130 [750–895]	80 [550]	25.0	45	. . .
S39277	118 [820]	85 [585]	25.0	50	. . .
S32505	116 [800]	80 [550]	25	50	310 max

[A] Determined by the 0.2 % offset method.
[B] For sections over 5 in. [130 mm] in thickness, the minimum tensile strength shall be 70 ksi [485 MPa].
[C] For sections over 5 in. [130 mm] in thickness, the minimum tensile strength shall be 65 ksi [450 MPa].

9.5 *Tension Tests:*

9.5.1 *Age-Hardening and Martensitic Stainless Steels*—One tension test shall be made for each production lot in each heat treatment charge. When the heat treating cycles are the same and the furnaces (either batch or continuous type) are controlled within ±25 °F [±14 °C] and equipped with recording pyrometers so that complete records of heat treatment are available, then only one tension test from each production lot of each type of part (See Note 3) and section size is required instead of one test from each production lot in each heat-treatment charge.

NOTE 3—"Type" in this case is used to describe the shape of the part such as a flange, elbow, tee, and so forth.

9.5.2 *Austenitic and Austenitic-Ferritic Stainless Steels*—One tension test shall be made for each production lot. The tension test specimen shall be made from material accompanying the parts in final heat treatment.

9.5.3 Testing shall be performed as specified in Specification A961/A961M using the largest feasible of the round specimens.

9.6 *Hardness Tests:*

9.6.1 When two or more parts are produced, a minimum of two pieces per batch or continuous run as defined in 9.6.2 shall be hardness tested as specified in Specification A961/A961M

to ensure that the parts are within the hardness limits given for each grade in Table 3. When only one part is produced, it shall be hardness tested as required. The purchaser is permitted to verify that the requirement has been met by testing at any location on any part provided such testing does not render the part useless.

9.6.2 When the reduced number of tension tests permitted by 9.5.1 is applied, additional hardness tests shall be made on parts or samples as defined in 9.2 distributed throughout the charge. At least eight samples shall be checked from each batch load and a least one check/h shall be made from a continuous run. When the furnace charge is less than eight parts, each part shall be checked. If any hardness test result falls outside the prescribed limits, the entire lot of parts shall be reheat treated and the requirements of 9.5.1 shall apply.

9.7 *Fatigue Tests*—When specified in the order, the fatigue strength of austenitic stainless steel components intended for service above 1000 °F [540 °C] shall be determined in accordance with Section S18.

10. Corrosion Testing

10.1 Corrosion testing is not required by this specification.

10.2 Austenitic stainless steels shall be capable of meeting the intergranular corrosion test requirements described in Section S11.

10.3 When required by the purchaser, the stainless steels shall be tested in the final heat treated condition for pitting or crevice corrosion resistance according to the procedures described in Section S12.

10.4 Austenitic-ferritic stainless steels shall be capable of meeting the test requirements described in Section S13.

11. Product Analysis

11.1 The purchaser is permitted to make a product analysis on parts supplied to this specification. Samples for analysis shall be taken from midway between the center and surface of solid parts, midway between the inner and outer surfaces of hollow parts, midway between the center and surface of full-size prolongations, or from broken mechanical test specimens. The chemical composition thus determined shall conform to Table 1 with the tolerances as stated in Table 4.

TABLE 4 Product Analysis Tolerances for Stainless Steels[A]

Elements	Limit or Maximum of Specified Range, %	Tolerance Over the Maximum Limit or Under the Minimum Limit
Carbon	0.030, incl	0.005
	over 0.030 to 0.20 incl	0.01
Manganese	to 1.00, incl	0.03
	over 1.00 to 3.00, incl	0.04
	over 3.00 to 6.00	0.05
	over 6.00 to 10.00	0.06
Phosphorus	to 0.040, incl	0.005
Sulfur	to 0.030, incl	0.005
Silicon	to 1.00, incl	0.05
	over 1.00 to 5.00, incl	0.10
Chromium	over 10.00 to 15.00, incl	0.15
	over 15.00 to 20.00, incl	0.20
	over 20.00 to 30.00, incl	0.25
Nickel	to 1.00, incl	0.03
	over 1.00 to 5.00, incl	0.07
	over 5.00 to 10.00, incl	0.10
	over 10.00 to 20.00, incl	0.15
	over 20.00 to 30.00, incl	0.20
	over 30.00 to 40,00, incl	0.25
Molybdenum	to 0.20 incl	0.01
	over 0.20 to 0.60, incl	0.03
	over 0.60 to 2.00, incl	0.05
	over 2.00 to 7.00, incl	0.10
Titanium	all ranges	0.05
Columbium+tantalum	all ranges	0.05
Tantalum	to 0.10, incl	0.02
Cobalt	0.05 to 0.20, incl	0.01[B]
Nitrogen	to 0.19 incl	0.01
	over 0.19 to 0.25	0.02
	over 0.25 to 0.35	0.03
	over 0.35 to 0.45	0.04
	over 0.45 to 0.60	0.05
Columbium[C]	0.05 to 0.20, incl	0.01
Aluminum	to 0.05 incl	0.01
Vanadium	to 0.10 incl	0.01
	over 0.10 to 0.25 incl	0.02
Cerium	0.03 to 0.08	-0.005
		+0.01
Tungsten	to 1.00, incl	0.04
Copper	to 0.50, incl	0.03
	Over 0.50 to 1.00, incl	0.05
	Over 1.00 to 3.00, incl	0.10
	Over 3.00 to 5.00, incl	0.15

[A] This table does not apply to heat analysis.
[B] Product analysis limits for cobalt under 0.05 % have not been established and the producer should be consulted for those limits.
[C] The terms Niobium (Nb) and Columbium (Cb) are alternate names for the same element.

12. Reheat Treatment

12.1 If the results of the mechanical tests do not conform to the requirements specified, the manufacturer is permitted to reheat treat the parts and repeat the tests specified in Section 9, but not more than twice.

13. Surface Finish, Appearance, and Corrosion Protection

13.1 The requirements of Specification A961/A961M apply to hot isostatically pressed finished parts.

13.2 In addition to the requirements of Specification A961/A961M, the following requirements apply:

13.2.1 The parts shall be free of machining burrs, and machined surfaces, other than surfaces having special requirements, shall have a surface finish not to exceed R_a 250 microinch [6.3 micrometre] (arithmetic average) roughness height.

14. Repair by Welding

14.1 Weld repairs shall be permitted (See Section S8) only with prior approval of the purchaser and with the following limitations and requirements:

14.1.1 The welding procedure and welders shall be qualified in accordance with Section IX of the ASME Boiler and Pressure Vessel Code.

14.1.2 The weld metal shall be deposited using the electrodes specified in Table 5 except as otherwise provided in Section S14. The electrodes shall be purchased in accordance with ASME Specifications SFA-5.4, SFA-5.9, or SFA-5.11. The submerged arc process with neutral flux, the gas metal-arc welding and gas tungsten-arc welding processes are permitted to be used.

14.1.3 Defects shall be removed completely prior to welding by chipping or grinding to sound metal as verified by magnetic particle inspection in accordance with Test Method A275/A275M for the age-hardening, martensitic, or austenitic-ferritic stainless steels, or by liquid penetrant inspection in accordance with Test Method E165/E165M for all grades.

14.1.4 After repair welding, the welded area shall be ground smooth to the original contour and shall be completely free of defects as verified by magnetic-particle or liquid-penetrant inspection, as applicable.

14.1.5 The preheat, interpass temperature, and post-weld heat treatment requirements given in Table 5 shall be met.

14.1.6 Repair by welding shall not exceed 10 % of the surface area of the part. Repair by welding shall not exceed 33⅓ % of the wall thickness of the finished part or ⅜ in. [9.5 mm], whichever is less.

14.1.7 No weld repairs are permitted for S41000 Classes 3 and 4.

15. Inspection

15.1 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 purchase order. Inspection by the purchaser shall not interfere unnecessarily with the manufacturer's operations. All tests and inspections shall be made at the place of manufacture unless otherwise agreed upon.

TABLE 5 Repair Welding Requirements

UNS Designation	Electrodes[A]	Preheat and Interpass Temperature Range, °F [°C][B]	Minimum Post-Weld Heat Treatment Temperature °F [°C][C]
	Age-Hardening Stainless Steels		
S17400	17 Cr, 4 Ni, 3 Cu	NR	1875-1925 [1025-1055], air cool, plus 900-1150 [480-620]
	Martensitic Stainless Steels		
S41000 Class 1	E 410-15 or 16	400-700 [205-370]	1250 [675]
S41000 Class 2	E 410-15 or 16	400-700 [205-370]	1250 [675]
S41026	13 % Cr, 1½ % Ni, ½ % Mo	400-700 [205-370]	1150 [620]
S41500	13 % Cr, 4 % Ni	300-700 [150-370]	1050 [565]
S42390		400-750 [205-400]	1350-1440 [730-780]
	Austenitic Stainless Steels		
N08028	ER383	NR	2010–2120 [1100–1160] + WQ
N08029	ERNiCrMo-3[E] ERNiCrMo-13[E]	NR	1975–2100 [1080–1150] + WQ
S30400	E 308-15 or 16	NR	1900 [1040] + WQ
S30403	E 308L-15 or 16	NR	1900 [1040] + WQ
S30451	E 308-15 or 16	NR	1900 [1040] + WQ
S30453	E 308L-15 or 16	NR	1900 [1040] + WQ
S31600	E 316-15 or 16	NR	1900 [1040] + WQ
S31603	E 316L-15 or 16	NR	1900 [1040] + WQ
S31651	E 316-15 or 16	NR	1900 [1040] + WQ
S31653	E 316L-15 or 16	NR	1900 [1040] + WQ
S31700	E 317-15 or 16	NR	1900 [1040] + WQ
S31703	E 317L-15 or 16	NR	1900 [1040] + WQ
S21904	XM-10W	NR	NR
S31254	E NiCrMo-3	NR	2100 [1150] + WQ
S31725	[D]	. . .	2100 [1150] + WQ
S31726	[D]	. . .	2100 [1150] + WQ
N08367	E NiCrMo-3	NR	2025 [1105] + WQ
S32654	25 % Cr, 61 % Ni, 14 % Mo	NR	2100 [1150] + WQ
	Austenitic-Ferritic Stainless Steels		
S31803	22 % Cr, 5.5 % Ni, 3 % Mo	NR	NR
S32205	22 % Cr, 5.5 % Ni, 3 % Mo	NR	NR
S32906	29 % Cr, 8 % Ni, 2 % Mo	NR	NR
S32950	26 % Cr, 8 % Ni, 2 % Mo	NR	NR
S32750	25 % Cr, 7 %, Ni, 4 % Mo	NR	NR
S39274	25 % Cr, 7 % Ni, 3 % Mo, W	NR	NR
S32760	25 % Cr, 7 % Ni, 3.5 Mo	NR	NR
S39277	25 % Cr, 7 % Ni, 3 % Mo, 1.5 % Cu, 1 % W	NR	NR
S32505	27 % Cr, 7 % Ni, 3 % Mo, 2 % Cu	NR	NR

[A] Electrodes shall comply with ASME SFA-5.4, and corresponding ER grades of SFA-5.9 or SFA-5.11.
[B] NR = not required.
[C] WQ = water quench.
[D] Match filler metal is available. Fabricators also have used AWS A5.14, Class ER, NiCrMo-3 and AWS A5.11, Class E, NiCrMo-3 filter metals.
[E] ASME SFA-5.14 Class.

16. Rejection

16.1 Each part that develops defects during shop working operations or in service shall be rejected and the manufacturer notified.

16.2 Samples representing material rejected by the purchaser shall be preserved until disposition of the claim has been agreed upon between the manufacturer and the purchaser.

17. Certification

17.1 In addition to the certification requirements of Specification A961/A961M, test reports shall be furnished to the purchaser or his representative. Test reports shall provide the following as applicable:

17.1.1 Type of heat treatment, Section 7 (Table 2).

17.1.2 Chemical analysis results, Section 6 (Table 1), reported results shall be to the same number of significant figures as the limits specified in Table 1 for that element.

17.1.3 Product analysis results, Section 11 (Table 4),

17.1.4 Tensile property results, Section 9 (Table 3), report the yield strength and tensile strength, in ksi [MPa], elongation and reduction in area, in percent,

17.1.5 Hardness results, 9.6 (Table 3)

17.1.6 Structural integrity test results, Section 8, and

17.1.7 Any supplementary testing required by the purchase order.

18. Product Marking

18.1 In addition to marking requirements of Specification A961/A961M, the following additional marking requirements shall apply:

18.1.1 Quenched and tempered martensitic stainless steel parts shall be marked with the letters QT following the specification designation.

18.1.2 Hot isostatically-pressed parts repaired by welding shall be marked with the letter “W” following the specification designation.

18.1.3 Hot isostatically-pressed parts meeting all requirements for more than one class or grade are permitted, at the option of the producer, to be marked with more than one class or grade designation, such as S30400/S30409, S30400/S30403, etc.

18.2 *Bar Coding*—In addition to the requirements in 18.1, bar coding is acceptable as a supplemental identification method. The purchaser is permitted to specify in the order that a specific bar coding system be used. The bar coding system, if applied at the discretion of the supplier, should be consistent with one of the published industry standards for bar coding. If used on small parts, the bar code may be applied to the box or a substantially applied tag.

19. Keywords

19.1 age-hardening stainless steel; austenitic stainless steels; austenitic-ferritic stainless steel; gas-atomized powder; hot isostatically-pressed stainless steel parts; martensitic stainless steel; pipe fittings, steel; piping applications; pressure containing parts; stainless steel fittings; stainless steel flanges; steel valves; temperature service applications, elevated; temperature service applications, high

SUPPLEMENTARY REQUIREMENTS

The following supplementary requirements shall apply only when specified by the purchaser in the contract or order.

S1. Macroetch Test

S1.1 A sample part shall be sectioned and etched to show internal imperfections. The test shall be conducted according to Test Method E340. Details of the test shall be agreed upon between the manufacturer and the purchaser.

S2. Product Analysis

S2.1 A product analysis in accordance with Section 11 shall be made from one randomly selected part representing each size and type (See Note 3) of part on the order. If the analysis fails to comply, each part in that lot, at the option of the manufacturer, shall be checked and accepted if the analysis for the part complies with the requirements, or the lot shall be rejected. All results shall be reported to the purchaser.

S3. Tension Tests

S3.1 In addition to the requirements of Section 9, one tension specimen shall be obtained from a representative part from each production lot at a location agreed upon between the manufacturer and the purchaser. The results of the test shall comply with Table 3 and shall be reported to the purchaser.

S4. Magnetic Particle Examination

S4.1 All accessible surfaces of a finished martensitic, age hardening, or austenitic-ferritic stainless steel part, shall be examined by a magnetic-particle method. The method shall be in accordance with Test Method A275/A275M. Acceptance limits shall be agreed upon between the manufacturer and purchaser.

S5. Liquid Penetrant Examination

S5.1 All accessible surfaces shall be examined by a liquid penetrant method in accordance with Test Method E165/E165M. Acceptance limits shall be agreed upon between the manufacturer and the purchaser.

S6. Hydrostatic Testing

S6.1 A hydrostatic test at a pressure agreed upon between the manufacturer and the purchaser shall be applied by the manufacturer.

S7. Ultrasonic Testing

S7.1 Austenitic-Ferritic stainless steel parts made of S32505 shall be 100 % ultrasonic tested with straight and angle beam probes in accordance with Practice A745/A745M. Acceptance limits shall be agreed upon between the manufacturer and the purchaser.

S8. Repair Welding

S8.1 No repair welding shall be permitted without prior approval of the purchaser. If permitted, the restrictions of Section 14 shall apply.

S9. Heat Treatment Details

S9.1 The manufacturer shall furnish a detailed test report containing the information required in 17.1 and shall include all pertinent details of the heat treating cycle given the parts.

S10. Material for Optimum Resistance to Stress-Corrosion Cracking

S10.1 Austenitic stainless steel parts shall be furnished in the solution-annealed condition as a final operation with no subsequent cold working permitted unless specifically permitted by the purchaser.

S11. Intergranular Corrosion Tests

S11.1 Intergranular corrosion tests shall be performed on specimens of austenitic stainless steel in accordance with Practices A262.

S11.2 For the austenitic stainless steels, details concerning the number of specimens and their source and location are to be a matter of agreement between the manufacturer and the purchaser.

S12. Pitting and Crevice Corrosion Test

S12.1 The stainless steels in the final heat treated condition shall be tested in accordance with Test Method G48. Test procedures and acceptance criteria shall be a matter of agreement between the manufacturer and purchaser.

S13. Detrimental Intermetallic Phase Test

S13.1 The austenitic-ferritic stainless steels shall be tested in accordance with the test methods given in Test Methods A923. Acceptance criteria, if not specified in Test Methods A923, shall be a matter of agreement between the manufacturer and the purchaser.

S14. Special Filler Metal

S14.1 In repair welded S31600, S31603, S31609, and S31651 parts, the deposited weld metal shall conform to E 308 composition wire. Parts repair welded with E 308 weld metal shall be marked S___W308.

S15. Hardness Test

S15.1 Each part shall be hardness tested and shall meet the requirements of Table 3.

S16. Heat Treatment of Austenitic Stainless Parts

S16.1 The purchaser shall specify the heat treatment method in 7.1 that shall be employed.

S16.2 The manufacturer shall provide a test report containing the information required in 17.1 and shall include a statement of the heat treatment method employed.

S17. Grain Size for Austenitic Stainless Steels

S17.1 Hot isostatically-pressed parts made from austenitic stainless steel grades other than H grades shall be tested for average grain size by Test Methods E112. Details of the test shall be agreed upon between the manufacturer and the purchaser.

S18. Fatigue Acceptance Test

S18.1 For austenitic stainless steel components intended for service above 1000 °F [540 °C], a uniaxial fatigue test shall be performed.

S18.2 The fatigue test shall be performed in air at 1100 °F [595 °C] at an axial strain range of 1.0 % with a one hour hold period at the maximum positive strain point in each cycle. Test specimen location and orientation shall be as specified in Specification A961/A961M and the applicable product specifications. Testing shall be conducted in accord with Practice E606/E606M. The test shall exceed 200 cycles without fracture or a 20 % drop in the load range.

S18.3 Failure to meet this requirement shall be cause for rejection of all parts from that blend.

S18.4 Test frequency shall be the same as for tension tests (See 9.5). Retesting is permitted. For a retest, two additional specimens produced from the same blend shall be tested and both specimens must pass the cyclic life requirement. Further retests are not permitted.

S19. Powder Size

S19.1 The maximum allowable powder size is 0.020 in. [0.5 mm], and the powder shall be produced by the gas atomization process.

S20. Powder Shielding

S20.1 Immediately following atomization, the powder shall remain shielded by an inert gas until the powder is below a temperature of 105 °F [40 °C] to ensure that the detrimental absorption of oxygen and other deleterious contaminants is no longer possible.

S21. Chemical Analysis

S21.1 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.

S22. Manufacturer's Certification

S22.1 A manufacturer's certification shall be furnished to the purchaser stating that material has been manufactured, tested, and inspected in accordance with this specification, and that the test results on representative samples meet specification requirements. A report of the test results shall be furnished.

SUMMARY OF CHANGES

Committee A01 has identified the location of selected changes to this specification since the last issue, A988/A988M – 16, that may impact the use of this specification. (Approved May 1, 2017)

(1) Updated 8.1.2.1, 8.1.2.2, 8.1.2.3, and 9.2.
(2) Added new Supplementary Requirements S19 – S22.
(3) Editorially corrected S322205 to S32205 in Table 5.
(4) Revised hardness requirement for UNS S32505 in Table 3.

Committee A01 has identified the location of selected changes to this specification since the last issue, A988/A988M–15a, that may impact the use of this specification. (Approved May 1, 2016)

(1) Added UNS N08028 and N08029 to Table 1, Table 2, Table 3, and Table 5.
(2) Added additional tolerances for chromium and nickel in Table 4.
(3) Added Other Elements column to Table 1.
(4) Changed Columbium to Niobium in Header and Cb to Nb in Table 1.
(5) Moved Footnote B and C references in Table 5 to column heading.
(6) Added AWS A5.11 and A5.14 and ASME SFA-5.14 to Referenced Documents.

Committee A01 has identified the location of selected changes to this specification since the last issue, A988/A988M–15, that may impact the use of this specification. (Approved December 1, 2015)

(1) Added UNS S32906 to Table 1, Table 2, Table 3, and Table 5.