SPECIFICATION FOR FORGED OR ROLLED ALLOY AND STAINLESS STEEL PIPE FLANGES, FORGED FITTINGS, AND VALVES AND PARTS FOR HIGH-TEMPERATURE SERVICE

SA-182/SA-182M (23)

(Identical with ASTM Specification A182/A182M-21 except for the inclusion of Grade F316Ti in para. 7.3.1, the removal of reduced strength levels for thicker sections of Grade F53 in Table 3, the removal of Grade F53 Classes in Table 3, the removal of Note (G) in Table 3, the increase of minimum yield strength for Grade F60 in Table 3 and clarification of requirements for parts machined from bar or hollow bar in 6.4, and para. 7.2.1 revised to include F12, Classes 1 and 2.)

Specification for Forged or Rolled Alloy and Stainless Steel Pipe Flanges, Forged Fittings, and Valves and Parts for High-Temperature Service

1. Scope

1.1 This specification covers forged low alloy and stainless steel piping components for use in pressure systems. Included are flanges, fittings, valves, and similar parts to specified dimensions or to dimensional standards, such as the ASME specifications that are referenced in Section 2.

1.2 For bars and products machined directly from bar or hollow bar (other than those directly addressed by this specification; see 6.4), refer to Specifications A479/A479M, A739, or A511/A511M for the similar grades available in those specifications.

1.3 Products made to this specification are limited to a maximum weight of 10 000 lb [4540 kg]. For larger products and products for other applications, refer to Specifications A336/A336M and A965/A965M for the similar ferritic and austenitic grades, respectively, available in those specifications.

1.4 Several grades of low alloy steels and ferritic, martensitic, austenitic, and ferritic-austenitic stainless steels are included in this specification. Selection will depend upon design and service requirements. Several of the ferritic/austenitic (duplex) grades are also found in Specification A1049/A1049M.

1.5 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.

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

1.7 The values stated in either SI units or inch-pound 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.

1.8 *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 In addition to the referenced documents listed in Specification A961/A961M, the following list of standards apply to this specification.

2.2 *ASTM Standards:*

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

A275/A275M Practice for Magnetic Particle Examination of Steel Forgings

A336/A336M Specification for Alloy Steel Forgings for Pressure and High-Temperature Parts

A388/A388M Practice for Ultrasonic Examination of Steel Forgings

A479/A479M Specification for Stainless Steel Bars and Shapes for Use in Boilers and Other Pressure Vessels

A484/A484M Specification for General Requirements for Stainless Steel Bars, Billets, and Forgings

A511/A511M Specification for Seamless Stainless Steel Mechanical Tubing and Hollow Bar
A739 Specification for Steel Bars, Alloy, Hot-Wrought, for Elevated Temperature or Pressure-Containing Parts, or Both
A763 Practices for Detecting Susceptibility to Intergranular Attack in Ferritic Stainless Steels
A788/A788M Specification for Steel Forgings, General Requirements
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
A965/A965M Specification for Steel Forgings, Austenitic, for Pressure and High Temperature Parts
A1049/A1049M Specification for Stainless Steel Forgings, Ferritic/Austenitic (Duplex), for Pressure Vessels and Related Components
A1084 Test Method for Detecting Detrimental Phases in Lean Duplex Austenitic/Ferritic Stainless Steels
E92 Test Methods for Vickers Hardness and Knoop Hardness of Metallic Materials
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

2.3 *ASME Standards:*
B16.11 Forged Steel Fittings, Socket Welding, and Threaded

2.4 *ASME Boiler and Pressure Vessel Code:*
Section IX

2.5 *AWS Specifications*
A5.4/A5.4M Specification for Stainless Steel Electrodes for Shielded Metal Arc Welding
A5.5/A5.5M Specification for Low-Alloy Steel Electrodes for Shielded Metal Arc Welding
A5.9/A5.9M Specification for Bare Stainless Steel Welding Electrodes and Rods
A5.11/A5.11M Specification for Nickel and Nickel-Alloy Welding Electrodes for Shielded Metal Arc Welding
A5.14/A5.14M Specification for Nickel and Nickel-Alloy Bare Welding Electrodes and Rods
A5.23/A5.23M Specification for Low-Alloy Steel Electrodes and Fluxes for Submerged Arc Welding
A5.28/A5.28M Specification for Low-Alloy Steel Electrodes for Gas Shielded Arc Welding
A5.29/A5.29M Low-Alloy Steel Electrodes for Flux Cored Arc Welding

3. Terminology

3.1 *Definitions*—For definitions of terms used in this specification, refer to Specification A961/A961M.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *hardened condition, n*—for F 23, the metallurgical condition achieved after normalizing and cooling to room temperature but prior to tempering.

4. Ordering Information

4.1 It is the purchaser's responsibility to specify in the purchase order information necessary to purchase the needed material. In addition to the ordering information guidelines in Specification A961/A961M, orders should include the following information:

4.1.1 Additional requirements (see 7.2.1, Table 2 footnotes, 9.3, and 19.2), and

4.1.2 Requirement, if any, that manufacturer shall submit drawings for approval showing the shape of the rough forging before machining and the exact location of test specimen material (see 9.3.1).

5. General Requirements

5.1 Product furnished to this specification shall conform to the requirements of Specification A961/A961M, including any supplementary requirements that are indicated in the purchase order. Failure to comply with the general requirements of Specification A961/A961M constitutes nonconformance with this specification. In case of conflict between the requirements of this specification and Specification A961/A961M, this specification shall prevail.

6. Manufacture

6.1 The low-alloy ferritic steels shall be made by the open-hearth, electric-furnace, or basic-oxygen process with the option of separate degassing and refining processes in each case.

6.2 The stainless steels shall be melted by one of the following processes: *(a)* electric-furnace (with the option of separate degassing and refining processes); *(b)* vacuum-furnace; or *(c)* one of the former followed by vacuum or electroslag-consumable remelting. Grade F XM-27Cb may be produced by electron-beam melting.

6.3 A sufficient discard shall be made to secure freedom from injurious piping and undue segregation.

6.4 Except as permitted in 6.4.2 and 6.4.3, the material shall be forged as close as practicable to the specified shape and size.

6.4.1 Parts whose longitudinal axis is not parallel to the longitudinal axis of the bar (such as elbows, return bends, tees, and header tees), and flanges of any type shall be machined directly from the bar.

6.4.2 Parts may be machined from hollow bar or forged or rolled solution-annealed austenitic stainless seel bar without additional hot working, provided the longitudinal axis of the part is parallel to the longitudinal axis of the bar.

6.4.3 Low alloy, martensitic stainless, ferritic stainless, and ferritic-austenitic stainless steel parts, NPS 4 [DN 100] and under, may be machined from hollow bar or forged or rolled bar, without additional hot working, provided the longitudinal axis of the part is parallel to the longitudinal axis of the bar.

6.5 Except as provided for in 6.4, the finished product shall be a forging as defined in the Terminology section of Specification A788/A788M.

7. Heat Treatment

7.1 After hot working, forgings shall be cooled to a temperature below 1000 °F [538 °C] prior to heat treating in accordance with the requirements of Table 1.

7.2 *Low Alloy Steels and Ferritic and Martensitic Stainless Steels*—The low alloy steels and ferritic and martensitic stainless steels shall be heat treated in accordance with the requirements of 7.1 and Table 1. When more than one heat treatment option is listed for a Grade in Table 1, any one of the heat treatments listed shall be performed. The selection of the heat treatment shall be at the manufacturer's option, unless otherwise stated in the purchase order.

7.2.1 *Liquid Quenching*—Except as permitted in 7.2.2, for F 1, F 2, and F 12, Classes 1 and 2, and when agreed to by the purchaser, liquid quenching followed by tempering shall be permitted provided the temperatures in Table 1 for each grade are used.

7.2.1.1 *Marking*—Parts that are liquid quenched and tempered shall be marked "QT."

7.2.2 Alternatively, Grade F 1, F 2, and F 12, Classes 1 and 2 may be given a heat treatment of 1200 °F [650 °C] minimum after final hot or cold forming.

7.3 *Austenitic and Ferritic-Austenitic Stainless Steels*—Except as permitted by 7.5, the austenitic and ferritic-austenitic stainless steels shall be heat treated and liquid-quenched in accordance with the requirements of 7.1 and Table 1.

7.3.1 Alternatively, immediately following hot working, while the temperature of the forging is not less than the minimum solution annealing temperature specified in Table 1, forgings made from austenitic grades (except grades F 304H, F 309H, F 310, F 310H, F 316H, F 316Ti, F 321, F 321H, F 347, F 347H, F 348, F 348H, F 45, and F 56) may be individually rapidly quenched in accordance with the requirements of Table 1. Ferritic-austenitic grades may be solution annealed without cooling below 1000 °F by being re-heated to the soulutionannealing temperature required in Table 1, held for a time sufficient to dissolve phases and precipitates which may cause a reduction in corrosion or mechanical properties, and quenched in accordance with Table 1.

7.3.2 See Supplementary Requirement S8 if a particular heat treatment method is to be employed.

7.4 *Time of Heat Treatment*—Heat treatment of forgings may be performed before machining.

7.5 *Forged or Rolled Bar*—Forged or rolled austenitic stainless bar from which cylindrically shaped parts are to be machined, as permitted by 6.4, and the parts machined from such bar, without heat treatment after machining, shall be furnished to the annealing and quenching or rapid-cooling requirements of Specification A484/A484M or this specification, with subsequent light cold drawing and straightening permitted (see Supplementary Requirement S3 if annealing must be the final operation).

7.6 *Hollow Bar*—Austenitic stainless hollow bar from which cylindrically shaped parts are to be machined, as permitted by 6.4, and the parts machined from such hollow bar, without heat treatment after machining, shall be furnished to the annealing and quenching or rapid-cooling requirements of Specification A511/A511M, or this specification, with subsequent light cold drawing and straightening permitted (see Supplementary Requirement S3 if annealing must be the final operation).

8. Chemical Composition

8.1 A chemical heat analysis in accordance with Specification A961/A961M shall be made and conform to the chemical composition prescribed in Table 2.

8.2 Grades to which lead, selenium, or other elements are added for the purpose of rendering the material free-machining shall not be used.

8.3 Starting material produced to a specification that specifically requires the addition of any element beyond those listed in Table 2 for the applicable grade of material is not permitted.

8.4 Steel grades covered in this specification shall not contain an unspecified element, other than nitrogen in stainless steels, for the ordered grade to the extent that the steel conforms to the requirements of another grade for which that element is a specified element having a required minimum content. For this requirement, a grade is defined as an alloy described individually and identified by its own UNS designation or Grade designation and identification symbol in Table 2.

8.5 *Product Analysis*—The purchaser may make a product analysis on products supplied to this specification in accordance with Specification A961/A961M.

9. Mechanical Properties

9.1 The material shall conform to the requirements as to mechanical properties for the grade ordered as listed in Table 3.

9.2 Mechanical test specimens shall be obtained from production forgings, or from separately forged test blanks prepared from the stock used to make the finished product. In either case, mechanical test specimens shall not be removed until after all heat treatment is complete. If repair welding is required, test specimens shall not be removed until after post-weld heat treatment is complete, except for ferritic grades when the post-weld heat treatment is conducted at least 50 °F [30 °C] below the actual tempering temperature. When test blanks are used, they shall receive approximately the same working as the finished product. The test blanks shall be heat treated with the finished product and shall approximate the maximum cross section of the forgings they represent.

9.3 For normalized and tempered, or quenched and tempered forgings, the central axis of the test specimen shall be taken at least ¼ T from the nearest surface as-heat-treated, where T is the maximum heat-treated thickness of the represented forging. In addition, for quenched and tempered forgings, the mid-length of the test specimen shall be at least T from all other surfaces as-heat-treated, exclusive of the T

TABLE 1 Heat Treating Requirements

Grade	Heat Treat Type	Austenitizing/Solutioning Temperature, Minimum or Range, °F [°C][A]	Cooling Media	Quenching Cool Below °F [°C]	Tempering Temperature, Minimum or Range, °F [°C]
		Low Alloy Steels			
F 1	anneal	1650 [900]	furnace cool	[B]	[B]
	normalize and temper	1650 [900]	air cool	[B]	1150 [620]
F 2	anneal	1650 [900]	furnace cool	[B]	[B]
	normalize and temper	1650 [900]	air cool	[B]	1150 [620]
F 5, F 5a	anneal	1750 [955]	furnace cool	[B]	[B]
	normalize and temper	1750 [955]	air cool	[B]	1250 [675]
F 9	anneal	1750 [955]	furnace cool	[B]	[B]
	normalize and temper	1750 [955]	air cool	[B]	1250 [675]
F 10	solution treat and quench	1900 [1040]	liquid	500 [260]	[B]
F 91 Types 1 and 2	normalize and temper or quench and temper	1900–1975 [1040–1080]	air cool, accelerated air cool, or liquid	[B]	1350–1470 [730–800]
F 92	normalize and temper	1900–1975 [1040–1080]	air cool	[B]	1350–1470 [730–800]
F 93	normalize and temper	1960–2140 [1070–1170]	air cool	385 [200]	1380–1455 [750–790]
F 115	normalize and temper	1920–2010 [1050–1100]	air cool, accelerated air cool, or liquid	[B]	1380–1455 [750–790]
F 122	normalize and temper	1900–1975 [1040–1080]	air cool	[B]	1350–1470 [730–800]
F 911	normalize and temper	1900–1975 [1040–1080]	air cool or liquid	[B]	1365–1435 [740–780]
F 11, Class 1, 2, 3	anneal	1650 [900]	furnace cool	[B]	[B]
	normalize and temper	1650 [900]	air cool	[B]	1150 [620]
F 12, Class 1, 2	anneal	1650 [900]	furnace cool	[B]	[B]
	normalize and temper	1650 [900]	air cool	[B]	1150 [620]
F 21, F 3V, and F 3VCb	anneal	1750 [955]	furnace cool	[B]	[B]
	normalize and temper	1750 [955]	air cool	[B]	1250 [675]
F 22, Class 1, 3	anneal	1650 [900]	furnace cool	[B]	[B]
	normalize and temper	1650 [900]	air cool	[B]	1250 [675]
F 22V	normalize and temper or quench and temper	1650 [900]	air cool or liquid	[B]	1250 [675]
F 23	normalize and temper	1900–1975 [1040–1080]	air cool accelerated cool	[B]	1350–1470 [730–800]
F 24	normalize and temper	1800–1975 [980–1080]	air cool or liquid	[B]	1350–1470 [730–800]
FR	anneal	1750 [955]	furnace cool	[B]	[B]
	normalize	1750 [955]	air cool	[B]	[B]
	normalize and temper	1750 [955]	air cool	[B]	1250 [675]
F 36, Class 1	normalize and temper	1650 [900]	air cool	[B]	1100 [595]
F 36, Class 2	normalize and temper or quench and temper	1650 [900] 1650 [900]	air cool, accelerated air cool, or liquid	[B]	1100 [595] 1100 [595]
		Martensitic Stainless Steels			
F 6a 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]
F 6a 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]
F 6a Class 3	anneal	not specified	furnace cool	[B]	[B]
	normalize and temper	not specified	air cool	400 [205]	1100 [595]
F 6a Class 4	anneal	not specified	furnace cool	[B]	[B]
	normalize and temper	not specified	air cool	400 [205]	1000 [540]
F 6b	anneal	1750 [955]	furnace cool	[B]	[B]
	normalize and temper	1750 [955]	air cool	400 [205]	1150 [620]
F 6NM	normalize and temper	1850 [1010]	air cool	200 [95]	1040–1120 [560–600]
		Ferritic Stainless Steels			
F XM-27 Cb	anneal	1850 [1010]	furnace cool	[B]	[B]
F 429	anneal	1850 [1010]	furnace cool	[B]	[B]
F 430	anneal	not specified	furnace cool	[B]	[B]
		Austenitic Stainless Steels			
F 304	solution treat and quench	1900 [1040]	liquid[E]	500 [260]	[B]
F 304H	solution treat and quench	1900 [1040]	liquid[E]	500 [260]	[B]
F 304L	solution treat and quench	1900 [1040]	liquid[E]	500 [260]	[B]
F 304N	solution treat and quench	1900 [1040]	liquid[E]	500 [260]	[B]
F 304LN	solution treat and quench	1900 [1040]	liquid[E]	500 [260]	[B]
F 309H	solution treat and quench	1900 [1040]	liquid[E]	500 [260]	[B]
F 310	solution treat and quench	1900 [1040]	liquid[E]	500 [260]	[B]
F 310H	solution treat and quench	1900 [1040]	liquid[E]	500 [260]	[B]
F 310MoLN	solution treat and quench	1900–2010 [1050–1100]	liquid[E]	500 [260]	[B]
F 316	solution treat and quench	1900 [1040]	liquid[E]	500 [260]	[B]
F 316H	solution treat and quench	1900 [1040]	liquid[E]	500 [260]	[B]
F 316L	solution treat and quench	1900 [1040]	liquid[E]	500 [260]	[B]
F 316N	solution treat and quench	1900 [1040]	liquid[E]	500 [260]	[B]
F 316LN	solution treat and quench	1900 [1040]	liquid[E]	500 [260]	[B]

TABLE 1 *Continued*

Grade	Heat Treat Type	Austenitizing/Solutioning Temperature, Minimum or Range, °F [°C][A]	Cooling Media	Quenching Cool Below °F [°C]	Tempering Temperature, Minimum or Range, °F [°C]
F 316Ti	solution treat and quench	1900 [1040]	liquid[E]	500 [260]	[B]
F 317	solution treat and quench	1900 [1040]	liquid[E]	500 [260]	[B]
F 317L	solution treat and quench	1900 [1040]	liquid[E]	500 [260]	[B]
F317LNCb	solution treat and quench	1900 [1040]	liquid[E]	500 [260]	[B]
F 72	solution treat and quench	1975–2155 [1080–1180]	liquid[E]	500 [260]	[B]
F 73	solution treat and quench	1975–2155 [1080–1180]	liquid[E]	500 [260]	[B]
F 347	solution treat and quench	1900 [1040]	liquid[E]	500 [260]	[B]
F 347H	solution treat and quench	2000 [1095]	liquid[E]	500 [260]	[B]
F 347LN	solution treat and quench	1900 [1040]	liquid[E]	500 [260]	[B]
F 347LNCuB	solution treat and quench	1940–2140 [1060–1170]	liquid[E]	500 [260]	[B]
F 348	solution treat and quench	1900 [1040]	liquid[E]	500 [260]	[B]
F 348H	solution treat and quench	2000 [1095]	liquid[E]	500 [260]	[B]
F 321	solution treat and quench	1900 [1040]	liquid[E]	500 [260]	[B]
F 321H	solution treat and quench	2000 [1095]	liquid[E]	500 [260]	[B]
F XM-11	solution treat and quench	1900 [1040]	liquid[E]	500 [260]	[B]
F XM-19	solution treat and quench	1900 [1040]	liquid[E]	500 [260]	[B]
F 20	solution treat and quench	1700-1850 [925-1010]	liquid[E]	500 [260]	[B]
F 44	solution treat and quench	2100 [1150]	liquid[E]	500 [260]	[B]
F 45	solution treat and quench	1900 [1040]	liquid[E]	500 [260]	[B]
F 46	solution treat and quench	2010-2140 [1100-1140]	liquid[E]	500 [260]	[B]
F 47	solution treat and quench	1900 [1040]	liquid[E]	500 [260]	[B]
F 48	solution treat and quench	1900 [1040]	liquid[E]	500 [260]	[B]
F 49	solution treat and quench	2050 [1120]	liquid[E]	500 [260]	[B]
F 56	solution treat and quench	2050-2160 [1120-1180]	liquid[E]	500 [260]	[B]
F 58	solution treat and quench	2085 [1140]	liquid[E]	500 [260]	[B]
F 62	solution treat and quench	2025 [1105]	liquid[E]	500 [260]	[B]
F 63	solution treat and quench	1900 [1040]	liquid[E]	500 [260]	[B]
F 64	solution treat and quench	2010-2140 [1100-1170]	liquid[E]	500 [260]	[B]
F 904L	solution treat and quench	1920-2100 [1050-1150]	liquid[E]	500 [260]	[B]
F 70	solution treat and quench	1900 [1040]	liquid[D]	500 [260]	[B]
F700	solution treat and quench	2025-2100 [1107 -1149]	liquid/rapid cool	500 [260]	[B]
FNIC	solution treat and quench	1800-1900 [983-1038]	liquid/rapid cool	500 [260]	[B]
FNIC10	solution treat and quench	2100-2150 [1149-1177]	liquid/rapid cool	500 [260]	[B]
FNIC11	solution treat and quench	2100-2150 [1149-1177]	liquid/rapid cool	500 [260]	[B]
F1925	solution treat and quench	1800-1900 [983-1038]	liquid/rapid cool	500 [260]	[B]
F1925N	solution treat and quench	2150 [1177]	liquid/rapid cool	500 [260]	[B]
		Ferritic-Austenitic Stainless Steels			
F 50	solution treat and quench	1925 [1050]	liquid	500 [260]	[B]
F 51	solution treat and quench	1870 [1020]	liquid	500 [260]	[B]
F 52[C]			liquid	500 [260]	[B]
F 53	solution treat and quench	1880 [1025]	liquid	500 [260]	[B]
F 54	solution treat and quench	1920-2060 [1050-1125]	liquid	500 [260]	[B]
F 55	solution treat and quench	2010-2085 [1100-1140]	liquid	500 [260]	[B]
F 57	solution treat and quench	1940 [1060]	liquid	175 [80]	[B]
F 59	solution treat and quench	1975-2050 [1080-1120]	liquid	500 [260]	[B]
F 60	solution treat and quench	1870 [1020]	liquid	500 [260]	[B]
F 61	solution treat and quench	1920-2060 [1050-1125]	liquid	500 [260]	[B]
F 65	solution treat and quench	1830-2100 [1000-1150]	liquid[D]	500 [260]	[B]
F 66	solution treat and quench	1870–1975 [1020–1080]	liquid	500 [260]	[B]
F 67	solution treat and quench	1870–2050 [1020–1120]	liquid	500 [260]	[B]
F 68	solution treat and quench	1700–1920 [925–1050]	liquid	500 [260]	[B]
F 69	solution treat and quench	1870 [1020]	liquid	500 [260]	[B]
F 71	solution treat and quench	1925–2100 [1050–1150]	liquid	500 [260]	[B]

[A] Minimum unless temperature range is listed.
[B] Not applicable.
[C] Grade F 52 shall be solution treated at 1825 to 1875 °F [995 to 1025 °C] 30 min/in. of thickness and water quenched.
[D] The cooling media for Grades F 65 and F 70 shall be quenching in water or rapidly cooling by other means.
[E] Forged or rolled bar meeting the requirements of 7.5 shall be liquid quenched or rapid-cooled by other means in accordance with Specification A484/A484M.

dimension surfaces. 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.

9.3.1 With prior purchase approval, the test specimen for ferritic steel forgings may be taken at a depth (t) corresponding to the distance from the area of significant stress to the nearest heat-treated surface and at least twice this distance (2 t) from any second surface. However, the test depth shall not be nearer to one treated surface than ¾ in. [19 mm] and to the second treated surface than 1½ in. [38 mm]. This method of test specimen location would normally apply to contour-forged parts, or parts with thick cross-sectional areas where ¼ $T \times T$ testing (see 9.3) is not practical. Sketches showing the exact test locations shall be approved by the purchaser when this method is used.

9.3.2 *Metal Buffers*—The required distances from heat-treated surfaces may be obtained with metal buffers instead of

TABLE 2 Chemical Requirements[A]

Grade/Identification Symbol	UNS Designation	Composition, %										
		Carbon	Manganese	Phosphorus	Sulfur	Silicon	Nickel	Chromium	Molybdenum	Niobium[B]	Titanium	Other Elements
						Low Alloy Steels						
F 1	K12822	0.28	0.60–0.90	0.045	0.045	0.15–0.35	...	...	0.44–0.65	...	...	...
F 2[C]	K12122	0.05–0.21	0.30–0.80	0.040	0.040	0.10–0.60	...	0.50–0.81	0.44–0.65	...	...	...
F 5[D]	K41545	0.15	0.30–0.60	0.030	0.030	0.50	0.50	4.0–6.0	0.44–0.65	...	...	...
F 5a[D]	K42544	0.25	0.60	0.040	0.030	0.50	0.50	4.0–6.0	0.44–0.65	...	...	...
F 9	K90941	0.15	0.30–0.60	0.030	0.030	0.50–1.00	...	8.0–10.0	0.90–1.10	...	...	...
F 10	S33100	0.10–0.20	0.50–0.80	0.040	0.030	1.00–1.40	19.0–22.0	7.0–9.0	...	...	...	...
F 91 Type 1	K90901	0.08–0.12	0.30–0.60	0.020	0.010	0.20–0.50	0.40	8.0–9.5	0.85–1.05	0.06–0.10	...	N 0.03–0.07 Al 0.02[E] V 0.18–0.25 Ti 0.01[E] Zr 0.01[E]
F 91 Type 2	K90901	0.08–0.12	0.30–0.50[E]	0.020[E]	0.005[E]	0.20–0.40[E]	0.20[E]	8.0–9.5[E]	0.85–1.05	0.06–0.10	0.01[E]	N 0.035–0.070[E] Al 0.020[E] N/Al ratio, min 4.0 V 0.18–0.25 Zr 0.01[E] B 0.001[E] Cu 0.10[E] W 0.05[E] Sn 0.010[E] As 0.010[E] Sb 0.003[E]
F 92	K92460	0.07–0.13	0.30–0.60	0.020	0.010	0.50	0.40	8.50–9.50	0.30–0.60	0.04–0.09	...	V 0.15–0.25 N 0.030–0.070 Al 0.02[E] W 1.50–2.00 B 0.001–0.006 Ti 0.01[E] Zr 0.01[E]
F 93	K91350	0.05–0.10	0.20–0.70	0.020	0.008	0.05–0.50	0.20	8.50–9.50	...	...	...	V 0.15–0.30 B 0.007–0.015 Al 0.030 W 2.5–3.5 Co 2.5–3.5 N 0.005–0.015 Nb 0.05–0.12 Nd 0.010–0.06 O 0.0050
F 115	K91060	0.08–0.13	0.20–0.50	0.020	0.005	0.15–0.45	0.25	10.0–11.0	0.40–0.60	0.02–0.06	0.01	V 0.18–0.25 B 0.001 Cu 0.10 Al 0.02 W 0.05 N 0.030–0.070 Zr 0.01 As 0.010 Sn 0.010 Sb 0.003 N/Al ratio 4.0 min CNB[P] 10.5
F 122	K91271	0.07–0.14	0.70	0.020	0.010	0.50	0.50	10.00–11.50	0.25–0.60	0.04–0.10	...	V 0.15–0.30 B 0.005 N 0.040–0.100 Al 0.02[E] Cu 0.30–1.70 W 1.50–2.50 Ti 0.01[E] Zr 0.01[E]
F 911	K91061	0.09–0.13	0.30–0.60	0.020	0.010	0.10–0.50	0.40	8.5–9.5	0.90–1.10	0.060–0.10	...	W 0.90–1.10 Al 0.02[E] N 0.04–0.09 V 0.18–0.25 B 0.0003–0.006 Ti 0.01[E] Zr 0.01[E]
F 11 Class 1	K11597	0.05–0.15	0.30–0.60	0.030	0.030	0.50–1.00	...	1.00–1.50	0.44–0.65	...	...	...
F 11 Class 2	K11572	0.10–0.20	0.30–0.80	0.040	0.040	0.50–1.00	...	1.00–1.50	0.44–0.65	...	...	...

TABLE 2 *Continued*

Grade/Identification Symbol	UNS Designation	Composition, %										
		Carbon	Manganese	Phosphorus	Sulfur	Silicon	Nickel	Chromium	Molybdenum	Niobium[B]	Titanium	Other Elements
F 11 Class 3	K11572	0.10–0.20	0.30–0.80	0.040	0.040	0.50–1.00	...	1.00–1.50	0.44–0.65	...	...	...
F 12 Class 1	K11562	0.05–0.15	0.30–0.60	0.045	0.045	0.50 max	...	0.80–1.25	0.44–0.65	...	...	...
F 12 Class 2	K11564	0.10–0.20	0.30–0.80	0.040	0.040	0.10–0.60	...	0.80–1.25	0.44–0.65	...	...	...
F 21	K31545	0.05–0.15	0.30–0.60	0.040	0.040	0.50 max	...	2.7–3.3	0.80–1.06	...	...	...
F 3V	K31830	0.05–0.18	0.30–0.60	0.020	0.020	0.10	...	2.8–3.2	0.90–1.10	...	0.015–0.035	V 0.20–0.30 B 0.001–0.003
F 3VCb	K31390	0.10–0.15	0.30–0.60	0.020	0.010	0.10	0.25	2.7–3.3	0.90–1.10	0.015–0.070	0.015	V 0.20–0.30 Cu 0.25 Ca 0.0005–0.0150
F 22 Class 1	K21590	0.05–0.15	0.30–0.60	0.040	0.040	0.50	...	2.00–2.50	0.87–1.13	...	...	...
F 22 Class 3	K21590	0.05–0.15	0.30–0.60	0.040	0.040	0.50	...	2.00–2.50	0.87–1.13	...	...	...
F 22V	K31835	0.11–0.15	0.30–0.60	0.015	0.010	0.10	0.25	2.00–2.50	0.90–1.10	0.07	0.030	Cu 0.20 V 0.25–0.35 B 0.002 Ca 0.015[F]
F 23	K40712	0.04–0.10	0.10–0.60	0.030	0.010	0.50	0.40	1.90–2.60	0.05–0.30	0.02–0.08	0.005–0.060[G]	V 0.20–0.30 B 0.0010–0.006 N 0.015[G] Al 0.030 W 1.45–1.75
F 24	K30736	0.05–0.10	0.30–0.70	0.020	0.010	0.15–0.45	...	2.20–2.60	0.90–1.10	...	0.06-0.10	V 0.20–0.30 N 0.12 Al 0.020 B 0.0015–0.0070
FR	K22035	0.20	0.40–1.06	0.045	0.050	...	1.60–2.24	...	...	...	...	Cu 0.75–1.25
F 36	K21001	0.10–0.17	0.80–1.20	0.030	0.025	0.25–0.50	1.00–1.30	0.30	0.25–0.50	0.015–0.045		N 0.020 Al 0.050 Cu 0.50–0.80 V 0.02
						Martensitic Stainless Steels						
F 6a	S41000	0.15	1.00	0.040	0.030	1.00	0.50	11.5–13.5	...	...	...	...
F 6b	S41026	0.15	1.00	0.020	0.020	1.00	1.00–2.00	11.5–13.5	0.40–0.60	...	...	Cu 0.50
F 6NM	S41500	0.05	0.50–1.00	0.030	0.030	0.60	3.5–5.5	11.5–14.0	0.50–1.00	...	...	...
						Ferritic Stainless Steels						
F XM-27Cb	S44627	0.010[H]	0.40	0.020	0.020	0.40	0.50[H]	25.0–27.5	0.75–1.50	0.05–0.20	...	N 0.015[H] Cu 0.20[H]
F 429	S42900	0.12	1.00	0.040	0.030	0.75	0.50	14.0–16.0	...	...	...	...
F 430	S43000	0.12	1.00	0.040	0.030	0.75	0.50	16.0–18.0	...	...	...	...
						Austenitic Stainless Steels						
F 304	S30400	0.08	2.00	0.045	0.030	1.00	8.0–11.0	18.0–20.0	...	...	...	N 0.10
F 304H	S30409	0.04–0.10	2.00	0.045	0.030	1.00	8.0–11.0	18.0–20.0	...	...	...	...
F 304L	S30403	0.030	2.00	0.045	0.030	1.00	8.0–13.0	18.0–20.0	...	...	...	N 0.10
F 304N	S30451	0.08	2.00	0.045	0.030	1.00	8.0–10.5	18.0–20.0	...	...	...	N 0.10–0.16
F 304LN	S30453	0.030	2.00	0.045	0.030	1.00	8.0–10.5	18.0–20.0	...	...	...	N 0.10–0.16
F 309H	S30909	0.04–0.10	2.00	0.045	0.030	1.00	12.0–15.0	22.0–24.0	...	...	...	...
F 310	S31000	0.25	2.00	0.045	0.030	1.00	19.0–22.0	24.0–26.0	...	...	...	...
F 310H	S31009	0.04–0.10	2.00	0.045	0.030	1.00	19.0–22.0	24.0–26.0	...	...	...	...
F 310MoLN	S31050	0.030	2.00	0.030	0.015	0.40	21.0–23.0	24.0–26.0	2.00–3.00	...	...	N 0.10–0.16
F 316	S31600	0.08	2.00	0.045	0.030	1.00	10.0–14.0	16.0–18.0	2.00–3.00	...	...	N 0.10
F 316H	S31609	0.04–0.10	2.00	0.045	0.030	1.00	10.0–14.0	16.0–18.0	2.00–3.00	...	...	...
F 316L	S31603	0.030	2.00	0.045	0.030	1.00	10.0–15.0	16.0–18.0	2.00–3.00	...	...	N 0.10
F 316N	S31651	0.08	2.00	0.045	0.030	1.00	11.0–14.0	16.0–18.0	2.00–3.00	...	...	N 0.10–0.16
F 316LN	S31653	0.030	2.00	0.045	0.030	1.00	11.0–14.0	16.0–18.0	2.00–3.00	...	...	N 0.10–0.16
F 316Ti	S31635	0.08	2.00	0.045	0.030	1.00	10.0–14.0	16.0–18.0	2.00–3.00	...	[I]	N 0.10 max
F 317	S31700	0.08	2.00	0.045	0.030	1.00	11.0–15.0	18.0–20.0	3.0–4.0	...	...	...
F 317L	S31703	0.030	2.00	0.045	0.030	1.00	11.0–15.0	18.0–20.0	3.0–4.0	...	...	...
F 317LNCb	S31740	0.005–0.020	2.00	0.045	0.030	1.00	11.0–15.0	17.0–19.0	3.0–4.5	0.20–0.50[N]	...	...
F 72	S31727	0.030	1.00	0.030	0.030	1.00	14.5–16.5	17.5–19.0	3.8–4.5	...	...	Cu 2.8–4.0 N 0.15–0.21
F 70	S31730	0.030	2.00	0.040	0.010	1.00	15–16.5	17.0–19.0	3.0–4.0	...	...	Cu 4.0–5.0 N 0.045
F 73	S32053	0.030	1.00	0.030	0.010	1.00	24.0–28.0	22.0–24.0	5.0–6.0	...	...	N 0.17–0.22
F 321	S32100	0.08	2.00	0.045	0.030	1.00	9.0–12.0	17.0–19.0	...	...	[J]	...
F 321H	S32109	0.04–0.10	2.00	0.045	0.030	1.00	9.0–12.0	17.0–19.0	...	...	[K]	...

TABLE 2 *Continued*

Grade/Identification Symbol	UNS Designation	Composition, %										
		Carbon	Manganese	Phosphorus	Sulfur	Silicon	Nickel	Chromium	Molybdenum	Niobium[B]	Titanium	Other Elements
F 347	S34700	0.08	2.00	0.045	0.030	1.00	9.0–13.0	17.0–20.0	...	[L]	...	...
F 347H	S34709	0.04–0.10	2.00	0.045	0.030	1.00	9.0–13.0	17.0–20.0	...	[M]	...	...
F347LN	S34751	0.005–0.020	2.00	0.045	0.030	1.00	9.0–13.0	17.0–19.0	...	0.20–0.50[N]	...	N 0.06–0.10
F347LNCuB	S34752	0.005-0.020	2.00	0.035	0.010	0.60	10.0-13.0	17.0-19.0	0.20-1.20	0.20–0.50[N]	...	Cu 2.50-3.50 B 0.001-0.005 N 0.06-0.12
F 348	S34800	0.08	2.00	0.045	0.030	1.00	9.0–13.0	17.0–20.0	...	[L]	...	Co 0.20 Ta 0.10
F 348H	S34809	0.04–0.10	2.00	0.045	0.030	1.00	9.0–13.0	17.0–20.0	...	[M]	...	Co 0.20 Ta 0.10
F XM-11	S21904	0.040	8.0–10.0	0.060	0.030	1.00	5.5–7.5	19.0–21.5	...	...	...	N 0.15–0.40
F XM-19	S20910	0.06	4.0–6.0	0.040	0.030	1.00	11.5–13.5	20.5–23.5	1.50–3.00	0.10–0.30	...	N 0.20–0.40 V 0.10–0.30
F 20	N08020	.07	2.00	0.045	0.035	1.00	32.0–38.0	19.0–21.0	2.00–3.00	8xCmin –1.00	...	Cu 3.0–4.0
F 44	S31254	0.020	1.00	0.030	0.010	0.80	17.5–18.5	19.5–20.5	6.0–6.5	...	...	Cu 0.50–1.00 N 0.18–0.25
F 45	S30815	0.05–0.10	0.80	0.040	0.030	1.40–2.00	10.0–12.0	20.0–22.0	...	...	...	N 0.14–0.20 Ce 0.03–0.08
F 46	S30600	0.018	2.00	0.020	0.020	3.7–4.3	14.0–15.5	17.0–18.5	0.20	...	...	Cu 0.50
F 47	S31725	0.030	2.00	0.045	0.030	0.75	13.0–17.5	18.0–20.0	4.0–5.0	...	...	N 0.10
F 48	S31726	0.030	2.00	0.045	0.030	0.75	13.5–17.5	17.0–20.0	4.0–5.0	...	...	N 0.10–0.20
F 49	S34565	0.030	5.0–7.0	0.030	0.010	1.00	16.0–18.0	23.0–25.0	4.0–5.0	0.10	...	N 0.40–0.60
F 56	S33228	0.04–0.08	1.00	0.020	0.015	0.30	31.0–33.0	26.0–28.0	...	0.6–1.0	...	Ce 0.05–0.10 Al 0.025
F 58	S31266	0.030	2.0–4.0	0.035	0.020	1.00	21.0–24.0	23.0–25.0	5.2–6.2	...	...	N 0.35–0.60 Cu 1.00–2.50 W 1.50–2.50
F 62	N08367	0.030	2.00	0.040	0.030	1.00	23.5–25.5	20.0–22.0	6.0–7.0	...	...	N 0.18–0.25 Cu 0.75
F 63	S32615	0.07	2.00	0.045	0.030	4.8–6.0	19.0-22.0	16.5–19.5	0.30–1.50	...	...	Cu 1.50–2.50
F 64	S30601	0.015	0.50–0.80	0.030	0.013	5.0–5.6	17.0–18.0	17.0–18.0	0.20	...	...	Cu 0.35, N 0.05
F 904L	N08904	0.020	2.0	0.040	0.030	1.00	23.0–28.0	19.0–23.0	4.0–5.0	...	...	Cu 1.00–2.00 N 0.10
F700	N08700	0.04	2.00	0.040	0.030	1.00	24.0-26.0	19.0-23.0	4.3-5.0	8XC Min 0.40 Max	...	Cu 0.50
FNIC	N08800	0.10	1.50	0.045	0.015	1.00	30.0-35.0	19.0-23.0	...	...	0.15-0.60	Al 0.15-0.60 Cu 0.75 Fe 39.5 min
FNIC10	N08810	0.05-0.10	1.50	0.045	0.015	1.00	30.0-35.0	19.0-23.0	...	...	0.15-0.60	Al 0.15-0.60 Cu 0.75 Fe 39.5 min
FNIC11	N08811	0.06-0.10	1.50	0.040	0.015	1.00	30.0-35.0	19.0-23.0	...	...	0.25-0.60[Q]	Cu 0.75 Al 0.25-0.60[Q] Fe 39.5 min
F1925	N08925	0.020	1.00	0.045	0.030	0.50	24.0-26.0	19.0-21.0	6.0-7.0	...	...	N_2 0.10-0.20[R] Cu 0.80-1.50
F1925N	N08926	0.020	2.00	0.030	0.010	0.50	24.0-26.0	19.0-21.0	6.0-7.0	...	...	N_2 0.15-0.25[R] Cu 0.50-1.50
Ferritic-Austenitic Stainless Steels												
F 50	S31200	0.030	2.00	0.045	0.030	1.00	5.5–6.5	24.0–26.0	1.20–2.00	...	...	N 0.14–0.20
F 51	S31803	0.030	2.00	0.030	0.020	1.00	4.5–6.5	21.0–23.0	2.5–3.5	...	...	N 0.08–0.20
F 69	S32101	0.040	4.00–6.00	0.040	0.030	1.00	1.35–1.70	21.0–22.0	0.10–0.80	...	...	N 0.20–0.25 Cu 0.10–0.80
F 52	S32950	0.030	2.00	0.035	0.010	0.60	3.5–5.2	26.0–29.0	1.00–2.50	...	...	N 0.15–0.35
F 53	S32750	0.030	1.20	0.035	0.020	0.80	6.0–8.0	24.0–26.0	3.0–5.0	...	...	N 0.24–0.32 Cu 0.50
F 54	S39274	0.030	1.00	0.030	0.020	0.80	6.0–8.0	24.0–26.0	2.5–3.5	...	...	N 0.24–0.32 Cu 0.20–0.80 W 1.50–2.50
F 55	S32760	0.030	1.00	0.030	0.010	1.00	6.0–8.0	24.0–26.0	3.0–4.0	...	...	N 0.20–0.30 Cu 0.50–1.00 W 0.50–1.00[O]
F 57	S39277	0.025	0.80	0.025	0.002	0.80	6.5–8.0	24.0–26.0	3.0–4.0	...	...	Cu 1.20–2.00 W 0.80–1.20 N 0.23–0.33
F 59	S32520	0.030	1.50	0.035	0.020	0.80	5.5–8.0	24.0–26.0	3.0–5.0	...	...	N 0.20–0.35 Cu 0.50–3.00
F 60	S32205	0.030	2.00	0.030	0.020	1.00	4.5–6.5	22.0–23.0	3.0–3.5	...	...	N 0.14–0.20

TABLE 2 *Continued*

Grade/Identification Symbol	UNS Designation	Composition, %										
		Carbon	Manganese	Phosphorus	Sulfur	Silicon	Nickel	Chromium	Molybdenum	Niobium[B]	Titanium	Other Elements
F 61	S32550	0.040	1.50	0.040	0.030	1.00	4.5–6.5	24.0–27.0	2.9–3.9	...	...	Cu 1.50–2.50 N 0.10–0.25
F 65	S32906	0.030	0.80–1.50	0.030	0.030	0.80	5.8–7.5	28.0–30.0	1.5–2.6	...	...	Cu 0.80 N 0.30–0.40
F 66	S32202	0.030	2.00	0.040	0.010	1.00	1.00–2.80	21.5–24.0	0.45	...	...	N 0.18–0.26
F 67	S32506	0.030	1.00	0.040	0.015	0.90	5.5–7.2	24.0–26.0	3.0–3.5	...	...	N 0.08–0.20 W 0.05–0.30
F 68	S32304	0.030	2.50	0.040	0.030	1.00	3.0–5.5	21.5–24.5	0.05–0.60	...	...	N 0.05–0.20 Cu 0.05–0.60
F 71	S32808	0.030	1.10	0.030	0.010	0.50	7.0–8.2	27.0–27.9	0.80–1.2	...	...	N 0.30–0.40 W 2.10–2.50

[A] All values are maximum unless otherwise stated. Where ellipses (...) appear in this table, there is no requirement and analysis for the element need not be determined or reported.
[B] Niobium and columbium are interchangeable names for the same element and both names are acceptable for use in A01.22 specifications.
[C] Grade F 2 was formerly assigned to the 1 % chromium, 0.5 % molybdenum grade which is now Grade F 12.
[D] The present grade F 5a (0.25 max carbon) previous to 1955 was assigned the identification symbol F 5. Identification symbol F 5 in 1955 was assigned to the 0.15 max carbon grade to be consistent with ASTM specifications for other products such as pipe, tubing, bolting, welding fittings, and the like.
[E] Applies to both heat and product analyses.
[F] For Grade F 22V, rare earth metals (REM) may be added in place of calcium, subject to agreement between the producer and the purchaser. In that case the total amount of REM shall be determined and reported.
[G] The ratio of Titanium to Nitrogen shall be ≥ 3.5. Alternatively, in lieu of this ratio limit, Grade F 23 shall have a minimum hardness of 275 HV (26 HRC, 258 HBW) in the hardened condition (see 3.2.1). Hardness testing shall be performed in accordance with 9.6.3, and the hardness testing results shall be reported on the material test report (see 18.2.5).
[H] Grade F XM-27Cb shall have a nickel plus copper content of 0.50 max %. Product analysis tolerance over the maximum specified limit for carbon and nitrogen shall be 0.002 %.
[I] Grade F 316Ti shall have a titanium content not less than five times the carbon plus nitrogen content and not more than 0.70 %.
[J] Grade F 321 shall have a titanium content of not less than five times the carbon plus nitrogen content and not more than 0.70 %.
[K] Grade F 321H shall have a titanium content of not less than four times the carbon plus nitrogen content and not more than 0.70 %.
[L] Grades F 347 and F 348 shall have a niobium (columbium) content of not less than ten times the carbon content and not more than 1.10 %.
[M] Grades F 347H and F 348H shall have a niobium (columbium) content of not less than eight times the carbon content and not more than 1.10 %.
[N] Grade F 347LN, Grade F 347LNCuB, and Grade F 317LNCb shall have a niobium (columbium) content of not less than 15 times the carbon content.
[O] % Cr + 3.3 × % (Mo + ½ W) + 16 × % N = 41 min.
[P] Chromium Nickel Balance is defined as CNB = (Cr+6Si+4Mo+1.5W+11V+5Nb+9Ti+12Al) – (40C+30N+4Ni+2Mn+1Cu).
[Q] Al + Ti shall be 0.85 % min: 1.20 % max.
[R] The method of analysis for nitrogen shall be a matter of agreement between purchaser and manufacturer.

integral extensions. Buffer material may be carbon or low-alloy steel, and shall be joined to the forging with a partial penetration weld that seals the buffered surface. Specimens shall be located at ½-in. [13-mm] minimum from the buffered surface of the forging. Buffers shall be removed and the welded areas subjected to magnetic particle test to ensure freedom from cracks unless the welded areas are completely removed by subsequent machining.

9.4 For annealed low alloy steels, ferritic stainless steels, and martensitic stainless steels, and also for austenitic and ferritic-austenitic stainless steels, the test specimen may be taken from any convenient location.

9.5 *Tension Tests:*

9.5.1 *Low Alloy Steels and Ferritic and Martensitic Stainless Steels*—One tension test shall be made for each heat in each heat treatment charge.

9.5.1.1 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 heat of each forging type (see Note 1) and section size is required, instead of one test from each heat in each heat-treatment charge.

NOTE 1—"Type" in this case is used to describe the forging shape such as a flange, ell, tee, and the like.

9.5.2 *Austenitic and Ferritic-Austenitic Stainless Steel Grades*—One tension test shall be made for each heat.

9.5.2.1 When heat treated in accordance with 7.1, the test blank or forging used to provide the test specimen shall be heat treated with a finished forged product.

9.5.2.2 When the alternative method in 7.3.1 is used, the test blank or forging used to provide the test specimen shall be forged and quenched under the same processing conditions as the forgings they represent.

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 Except when only one forging is 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 forgings are within the hardness limits given for each grade in Table 3. The purchaser may verify that the requirement has been met by testing at any location on the forging provided such testing does not render the forging useless.

9.6.2 When the reduced number of tension tests permitted by 9.5.1.1 is applied, additional hardness tests shall be made on forgings or samples, as defined in 9.2, scattered throughout the load (see Note 2). At least eight samples shall be checked from

TABLE 3 Tensile and Hardness Requirements[A]

Grade Symbol	Tensile Strength, min, ksi [MPa]	Yield Strength, min, ksi [MPa][B]	Elongation in 2 in. [50 mm] or 4*D*, min, %	Reduction of Area, min, %	Brinell Hardness Number, HBW, unless otherwise indicated
Low Alloy Steels					
F 1	70 [485]	40 [275]	20	30	143–192
F 2	70 [485]	40 [275]	20	30	143–192
F 5	70 [485]	40 [275]	20	35	143–217
F 5a	90 [620]	65 [450]	22	50	187–248
F 9	85 [585]	55 [380]	20	40	179–217
F 10	80 [550]	30 [205]	30	50	. . .
F 91 Types 1 and 2	90 [620]	60 [415]	20	40	190–248
F 92	90 [620]	64 [440]	20	45	269 max
F 93	90 [620]	64 [440]	19	40	250 max
F 115	90 [620]	65 [450]	20	40	190–248
F 122	90 [620]	58 [400]	20	40	250 max
F 911	90 [620]	64 [440]	18	40	187–248
F 11 Class 1	60 [415]	30 [205]	20	45	121–174
F 11 Class 2	70 [485]	40 [275]	20	30	143–207
F 11 Class 3	75 [515]	45 [310]	20	30	156–207
F 12 Class 1	60 [415]	32 [220]	20	45	121–174
F 12 Class 2	70 [485]	40 [275]	20	30	143–207
F 21	75 [515]	45 [310]	20	30	156–207
F 3V, and F 3VCb	85–110 [585–760]	60 [415]	18	45	174–237
F 22 Class 1	60 [415]	30 [205]	20	35	170 max
F 22 Class 3	75 [515]	45 [310]	20	30	156–207
F 22V	85–110 [585–780]	60 [415]	18	45	174–237
F 23	74 [510]	58 [400]	20	40	220 max
F 24	85 [585]	60 [415]	20	40	248 max
FR	63 [435]	46 [315]	25	38	197 max
F 36, Class 1	90 [620]	64 [440]	15	. . .	252 max
F 36, Class 2	95.5 [660]	66.5 [460]	15	. . .	252 max
Martensitic Stainless Steels					
F 6a Class 1	70 [485]	40 [275]	18	35	143–207
F 6a Class 2	85 [585]	55 [380]	18	35	167–229
F 6a Class 3	110 [760]	85 [585]	15	35	235–302
F 6a Class 4	130 [895]	110 [760]	12	35	263–321
F 6b	110–135 [760–930]	90 [620]	16	45	235–285
F 6NM	115 [790]	90 [620]	15	45	295 max
Ferritic Stainless Steels					
F XM-27Cb	60 [415]	35 [240]	20	45	190 max
F 429	60 [415]	35 [240]	20	45	190 max
F 430	60 [415]	35 [240]	20	45	190 max
Austenitic Stainless Steels					
F 304	75 [515][C]	30 [205]	30	50	. . .
F 304H	75 [515][C]	30 [205]	30	50	. . .
F 304L	70 [485][D]	25 [170]	30	50	. . .
F 304N	80 [550]	35 [240]	30[E]	50[F]	. . .
F 304LN	75 [515][C]	30 [205]	30	50	. . .
F 309H	75 [515][C]	30 [205]	30	50	. . .
F 310	75 [515][C]	30 [205]	30	50	. . .
F 310MoLN	78 [540]	37 [255]	25	40	. . .
F 310H	75 [515][C]	30 [205]	30	50	. . .
F 316	75 [515][C]	30 [205]	30	50	. . .
F 316H	75 [515][C]	30 [205]	30	50	. . .
F 316L	70 [485][D]	25 [170]	30	50	. . .
F 316N	80 [550]	35 [240]	30[E]	50[F]	. . .
F 316LN	75 [515][C]	30 [205]	30	50	. . .
F 316Ti	75 [515]	30 [205]	30	40	. . .
F 317	75 [515][C]	30 [205]	30	50	. . .
F 317L	70 [485][D]	25 [170]	30	50	. . .
F 317LNCb	75 [515]	30 [205]	35	50	. . .
F 72	80 [550]	36 [245]	35	50	217
F 73	93 [640]	43 [295]	40	50	217
F 347	75 [515][C]	30 [205]	30	50	. . .
F 347H	75 [515][C]	30 [205]	30	50	. . .
F 347LN	75 [515]	30 [205]	30	50	. . .
F 347LNCuB	75 [515]	30 [205]	30	50	. . .
F 348	75 [515][C]	30 [205]	30	50	. . .
F 348H	75 [515][C]	30 [205]	30	50	. . .
F 321	75 [515][C]	30 [205]	30	50	. . .
F 321H	75 [515][C]	30 [205]	30	50	. . .
F XM-11	90 [620]	50 [345]	45	60	. . .
F XM-19	100 [690]	55 [380]	35	55	. . .
F 20	80 [550]	35 [240]	30	50	. . .

TABLE 3 *Continued*

Grade Symbol	Tensile Strength, min, ksi [MPa]	Yield Strength, min, ksi [MPa][B]	Elongation in 2 in. [50 mm] or 4*D*, min, %	Reduction of Area, min, %	Brinell Hardness Number, HBW, unless otherwise indicated
F 44	94 [650]	44 [300]	35	50	. . .
F 45	87 [600]	45 [310]	40	50	. . .
F 46	78 [540]	35 [240]	40	50	. . .
F 47	75 [525]	30 [205]	40	50	. . .
F 48	80 [550]	35 [240]	40	50	. . .
F 49	115 [795]	60 [415]	35	40	. . .
F 56	73 [500]	27 [185]	30	35	. . .
F 58	109 [750]	61 [420]	35	50	. . .
F 62	95 [655]	45 [310]	30	50	. . .
F 63	80 [550]	32 [220]	25	. . .	192 max
F 64	90 [620]	40 [275]	35	50	217 max
F70	70 [480]	25 [175]	35	. . .	HRB 90 max
F 904L	71 [490]	31 [215]	35	. . .	. . .
F700	80 [550]	35 [240]	30	. . .	192
FNIC	65 [450]	25 [170]	30	. . .	. . .
FNIC10	65 [450]	25 [170]	30	. . .	. . .
FNIC11	65 [450]	25 [170]	30	. . .	. . .
F1925	87 [600]	43 [295]	30	. . .	. . .
F1925N	94 [650]	43 [295]	35	. . .	. . .
		Ferritic-Austenitic Stainless Steels			
F 50	100–130 [690–900]	65 [450]	25	50	. . .
F 51	90 [620]	65 [450]	25	45	. . .
F 52	100 [690]	70 [485]	15	. . .	. . .
F 53	116 [800]	80 [550]	15	. . .	310 max
F 54	116 [800]	80 [550]	15	30	310 max
F 55	109–130 [750–895]	80 [550]	25	45	. . .
F 57	118 [820]	85 [585]	25	50	. . .
F 59	112 [770]	80 [550]	25	40	. . .
F 60	95 [655]	70 [485]	25	45	. . .
F 61	109 [750]	80 [550]	25	50	. . .
F 65	109 [750]	80 [550]	25	. . .	. . .
F 66	94 [650]	65 [450]	30	. . .	290 max
F 67	90 [620]	65 [450]	18	. . .	302
F 68	87 [600]	58 [400]	25	. . .	290 max
F 69	94 [650]	65 [450]	30	. . .	. . .
F 71	101 [700]	72 [500]	15	. . .	321

[A] Where ellipses appear in this table, there is no requirement and the test for the value need neither be performed nor a value reported.
[B] Determined by the 0.2 % offset method. For ferritic steels only, the 0.5 % extension-under-load method may also be used.
[C] For sections over 5 in. [130 mm] in thickness, the minimum tensile strength shall be 70 ksi [485 MPa].
[D] For sections over 5 in. [130 mm] in thickness, the minimum tensile strength shall be 65 ksi [450 MPa].
[E] Longitudinal. The transverse elongation shall be 25 % in 2 in. or 50 mm, min.
[F] Longitudinal. The transverse reduction of area shall be 45 % min.

each batch load, and at least one check per hour shall be made from a continuous run. When the furnace batch is less than eight forgings, each forging shall be checked. If any check falls outside the prescribed limits, the entire lot of forgings shall be reheat treated and the requirements of 9.5.1 shall apply.

NOTE 2—The tension test required in 9.5.1 is used to determine material capability and conformance in addition to verifying the adequacy of the heat-treatment cycle. Additional hardness tests in accordance with 9.6.2 are required when 9.5.1.1 is applied to ensure the prescribed heat-treating cycle and uniformity throughout the load.

9.6.3 When the alternative to the Ti/N ratio limit for F 23 is applied, (see Note *P* in Table 2), a minimum of two pieces per batch or continuous run as defined in 9.6.2 shall be hardness tested, in the hardened condition (see 3.2.1), to ensure that the forgings are within the hardness limit given for F 23 in Note *P* of Table 2. The test samples shall be taken at the mid thickness of the thickest section of the product. Testing shall be performed in accordance with the Test Method E92 or as specified in Specification A961/A961M.

9.7 *Notch Toughness Requirements*—Grades F 3V, F 3VCb, and F 22V.

9.7.1 Impact test specimens shall be Charpy V-notch Type. The usage of subsize specimens due to material limitations must have prior purchaser approval.

9.7.2 The Charpy V-notch test specimens shall be obtained as required for tension tests in 9.2, 9.3, and 9.5. One set of three Charpy V-notch specimens shall be taken from each tensile specimen location.

9.7.3 The longitudinal axis and mid-length of impact specimen shall be located similarly to the longitudinal axis of the tension test specimens. The axis of the notch shall be normal to the nearest heat-treated surface of the forging.

9.7.4 The Charpy V-notch tests shall meet a minimum energy absorption value of 40 ft-lbf [54 J] average of three specimens. One specimen only in one set may be below 40 ft-lbf [54 J], and it shall meet a minimum value of 35 ft-lbf [48 J].

9.7.5 The impact test temperature shall be 0 °F [−18 °C].

10. Grain Size for Austenitic Grades

10.1 All H grades and grade F 63 shall be tested for average grain size by Test Methods E112.

10.1.1 Grades F 304H, F 309H, F 310H, and F 316H shall have a grain size of ASTM No. 6 or coarser.

10.1.2 Grades F 321H, F 347H, and F 348H shall have a grain size of ASTM No. 7 or coarser.

10.1.3 Grade F 63 shall have a grain size of ASTM No. 3 or finer.

10.1.4 Annealed Alloys UNS N08810 and UNS N08811 shall conform to an average grain size of ASTM No. 5 or coarser.

11. Corrosion Testing for Austenitic Grades and Detrimental Phase Detection in Austenitic/Ferritic Stainless Grades

11.1 Corrosion testing is not required by this specification nor is detrimental phase detection.

11.2 Austenitic grades shall be capable of meeting the intergranular corrosion test requirements described in Supplementary Requirement S4.

11.3 Austenitic/Ferritic Stainless grades shall be capable of meeting the requirements described in Supplementary Requirement S12 if the subject grade is included in the specifications listed in Supplementary Requirement S12.

12. Retreatment

12.1 If the results of the mechanical tests do not conform to the requirements specified, the manufacturer may reheat treat the forgings and repeat the tests specified in Section 9.

13. Nondestructive Test Requirements

13.1 Hollow forgings of Grades F 91 Types 1 and 2, F 92, F 115, F 122, and F 911, NPS 4 [DIN 100] and larger, whose finished internal surfaces are not accessible to magnetic particle or liquid penetrant examination, shall be examined by an ultrasonic test in accordance with Practice A388/A388M, after all forging, mechanical processing, and heat treatment operations have been completed.

13.2 Hollow forgings of Grades F 91 Types 1 and 2, F 92, F 115, F 122, and F 911, NPS 4 [DIN 100] and larger, whose finished internal surfaces are accessible to magnetic particle or liquid penetrant examination, shall be examined on their internal surfaces by either a magnetic particle test in accordance with Practice A275/A275M, or by a liquid penetrant examination in accordance with Test Method E165/E165M, as applicable, after all heat treatment, machining, and other mechanical processing operations are completed.

13.3 *Time of Examination*—Examination by one of the methods in 13.1 or 13.2, for specification acceptance, shall be performed as specified in 13.1 or 13.2. This requirement does not preclude additional testing at earlier stages in the processing.

13.4 *Evaluation of Imperfections Found by Ultrasonic Examination:*

13.4.1 Forgings producing a signal equal to or greater than the lowest signal produced by the reference discontinuities shall be identified and separated from the acceptable forgings. The area producing the signal may be reexamined.

13.4.2 Such forgings shall be rejected if the test signals were produced by imperfections that cannot be identified or were produced by cracks or crack-like imperfections. Such forgings may be repaired. To be accepted, a repaired forging shall pass the same nondestructive test by which it was rejected, and it shall meet the minimum wall thickness requirements of this specification and the purchase order.

13.4.3 If the test signals were produced by visual imperfections such as scratches, surface roughness, dings, tooling marks, cutting chips, steel die stamps, or stop marks, the forging is permitted to be accepted based upon visual examination provided that the depth of the imperfection is less than 0.004 in. [0.1 mm] or 12.5 % of the specified wall thickness, whichever is the greater.

13.5 *Treatment of Imperfections Found by Magnetic Particle or Liquid Penetrant Examination:*

13.5.1 Defects shall be completely removed prior to weld repair by chipping or grinding to sound metal. Removal of these defects shall be verified by magnetic particle inspection in accordance with Test Method A275/A275M or by liquid penetrant inspection in accordance with Test Method E165/E165M.

13.5.2 Rejected forgings may be reconditioned and retested, provided that the wall thickness is not decreased to less than that required by this specification and the purchase order. The outside diameter at the point of grinding may be reduced by the amount so removed. To be accepted, retested forgings shall meet the test requirement.

13.5.3 If the imperfection is explored to the extent that it can be identified as non-rejectable, the forging may be accepted without further test provided that the imperfection does not encroach on the minimum required wall thickness.

14. Surface Finish, Appearance, and Corrosion Protection

14.1 Forgings and finished parts shall conform to the requirements of Specification A961/A961M.

14.2 The forgings and finished parts shall be free of scale, machining burrs which might hinder fit-up, and other injurious imperfections as defined herein. The forgings and finished parts shall have a workmanlike finish, and machined surfaces (other than surfaces having special requirements) shall have a surface finish not to exceed 250 AA (arithmetic average) roughness height.

15. Repair by Welding

15.1 Weld repairs shall be permitted (see Supplementary Requirement S58 of Specification A961/A961M) at the discretion of the manufacturer with the following limitations and requirements:

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

15.1.2 The weld metal shall be deposited using the electrodes specified in Table 4 except as otherwise provided in Supplementary Requirement S5. The electrodes shall be purchased in accordance with AWS Specifications A5.4/A5.4M, A5.5/A5.5M, A5.9/A5.9M, A5.11/A5.11M, A5.14/A5.14M, A5.23/A5.23M, A5.28/A5.28M, or A5.29/A5.29M. The submerged arc process with neutral flux, the gas metal-arc process, the gas tungsten-arc process, and gas shielded processes using flux-core consumables, may be used. For weld deposits made on S20910, the deposited weld metal shall correspond to either the alloy content of the base metal or AWS A5.4 E209 or A5.9 ER209. For weld deposits made on N08367, N08700, N08925 or N08926, the deposited weld metal shall correspond to either the alloy content of the base metal or one of the following filler metals in AWS A5.11 ENiCrMo-3 or A5.14 ERNiCrMo-3, A5.11 ENiCrMo-4 or A5.14 ERNiCrMo-4, or A5.11 ENiCrMo-10 or A5.14 ERNiCrMo-10. For weld deposits made on N08020, the deposited weld metal shall correspond to either the alloy content of the base metal or AWS A5.4 E320/E320LR or A5.9 ER320/320LR. For weld deposits made on N08800, N08810 and N08811, the deposited weld metal shall correspond to either the alloy content of the base metal or AWS A5.11 ENiCr-3 or A5.14 ERNiCr-3. However, the fillers used on these alloys (as well as other listed above) may be dependent on the end service use and service temperature and shall be agreed upon between purchaser and manufacturer.

15.1.2.1 Weld deposits made on S20910, N08020, N08367, N08700, N08800, N08810, N08811, N08925, N08926 shall be made using filler metal with a composition conforming to the base material or the equivalent classification in the AWS Filler Metal Specification A5.11 and A5.14. It is possible that weld deposit chemistry will not meet the limits of either the base metal or the filler metal for some elements. The weld deposit chemistry shall meet the lowest minimum and highest maximum values for each specification element in either of the base metal or filler metal specification. Dilution of the base metal and filler metal must be considered when determining weld deposit criteria for over-alloyed filler metals. In either case, the weld deposit chemistry shall be tested and recorded on the Procedure Qualification Record.

15.1.3 Defects shall be completely removed 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 low alloy steels and ferritic, martensitic, or ferritic-austenitic stainless steels, or by liquid-penetrant inspection in accordance with Test Method E165/E165M for all grades.

15.1.4 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.

15.1.5 The preheat, interpass temperature, and post-weld heat treatment requirements given in Table 4 shall be met. Austenitic stainless steel forgings may be repair-welded without the post-weld heat treatment of Table 4, provided purchaser approval is obtained prior to repair.

15.1.6 Repair by welding shall not exceed 10 % of the surface area of the forging nor 33⅓ % of the wall thickness of the finished forging or ⅜ in. [9.5 mm], whichever is less, without prior approval of the purchaser.

15.1.7 When approval of the purchaser is obtained, the limitations set forth in 15.1.6 may be exceeded, but all other requirements of Section 15 shall apply.

15.1.8 No weld repairs are permitted for F 6a Classes 3 and 4.

15.1.9 Post-weld heat treatment times for F 36 are: for Class 1, up to 2 in. [50 mm] in thickness, 1 h per in. [25 mm], 15 minutes minimum, and over 2 in. [50 mm], 15 minutes for each additional in. of thickness or fraction thereof; for Class 2, 1 h per in. [25 mm], ½ h minimum.

16. Inspection

16.1 Inspection provisions of Specification A961/A961M apply.

17. Rejection and Rehearing

17.1 The purchaser shall comply with the provisions of Specification A961/A961M.

18. Certification

18.1 In addition to the certification requirements of Specification A961/A961M, test reports shall be furnished to the purchaser or his representative.

18.2 Test reports shall provide the following where applicable:

18.2.1 Type heat treatment, Section 7,

18.2.2 Product analysis results, Section 8 of Specification A961/A961M,

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

18.2.4 Chemical analysis results, Section 8 (Table 2), reported results shall be to the same number of significant figures as the limits specified in Table 2 for that element,

18.2.5 Hardness results, Section 9 (Table 3, and for F 23, Tables 2 and 3),

18.2.6 Grain size results, Section 10, and

18.2.7 Any supplementary testing required by the purchase order.

TABLE 4 Repair Welding Requirements

Grade Symbol	Electrodes[A]	Recommended Preheat and Interpass Temperature Range, °F [°C]	Post Weld Heat-Treatment Temperature, Minimum or Range, °F [°C]
	Low Alloy Steels		
F 1	E 7018-A 1	200–400 [95–205]	1150 [620]
F 2	E 8018-B 1	300–600 [150–315]	1150 [620]
F 5	E80XX-B6, where XX can be 15, 16, or 18	400–700 [205–370]	1250 [675]
F 5a	E80XX-B6, where XX can be 15, 16, or 18	400–700 [205–370]	1250 [675]
F 9	E80XX-B8, where XX can be 15, 16, or 18	400–700 [205–370]	1250 [675]
F 10[B]	. . .	. . .	. . .
F 91 Types 1 and 2	. . .[C]	400–700 [205–370]	1350–1470 [730–800]
F 92	. . .[D]	400–700 [205–370]	1350–1470 [730–800]
F 93	. . .[D]	400–700 [205–370]	1350–1455 [730–790]
F 115	. . .[D]	400–700 [205–370]	1345–1435 [730–780]
F 122	. . .[D]	400–700 [205–370]	1350–1470 [730–800]
F 911	. . .[D]	400–700 [205–370]	1365–1435 [740–780]
F 11, Class 1, 2, and 3	E 8018-B 2	300–600 [150–315]	1150 [620]
F 12, Class 1 and 2	E 8018-B 2	300–600 [150–315]	1150 [620]
F 21	E 9018-B 3	300–600 [150–315]	1250 [675]
F 3V, and F 3VCb	3 % Cr, 1 % Mo, ¼ % V-Ti	300–600 [150–315]	1250 [675]
F 22 Class 1	E 9018-B 3	300–600 [150–315]	1250 [675]
F 22 Class 3	E 9018-B 3	300–600 [150–315]	1250 [675]
F 22V	2.25 % Cr, 1 % Mo, 0.25 % V-Cb	300–600 [150–315]	1250 [675]
F 23	2.25 % Cr, 1.6 % W, 0.25 % V-Mo-Cb-B	300-600 [150–315]	1350–1470 [730–800]
F 24	2.25 % Cr, 1 % Mo, 0.25 % V	200–400 [95–205][E]	1350–1470 [730–800][E]
F 36, Class 1	1.15 Ni, 0.65 Cu, Mo, Cb	400–700 [205–370]	1100–1200 [595–650]
F 36, Class 2	1.15 Ni, 0.65 Cu, Mo, Cb	400–700 [205–370]	1000–1150 [540–620]
	Martensitic Stainless Steels		
F 6a, Class 1	E 410-15 or 16	400–700 [205–370]	1250 [675]
F 6a, Class 2	E 410-15 or 16	400–700 [205–370]	1250 [675]
F 6b	13 % Cr, 1½ % Ni, ½ % Mo	400–700 [205–370]	1150 [620]
F 6NM	13 % Cr, 4 % Ni	300–700 [150–370]	1050 [565]
	Ferritic Stainless Steels		
F XM-27Cb	26 % Cr, 1 % Mo	NR[F]	NR
F 429	E 430-16	400–700 [205–370]	1400 [760]
F 430	E 430-16	NR	1400 [760]
FR	E 8018-C2	NR	NR
	Austenitic Stainless Steels		
F 304	E 308-15 or 16	NR	1900 [1040] + WQ[G]
F 304L	E 308L-15 or 16	NR	1900 [1040] + WQ
F 304H	E 308-15 or 16[H] or E308H-XX	NR	1900 [1040] + WQ
F 304N	E 308-15 or 16	NR	1900 [1040] + WQ
F 304LN	E 308L-15 or 16	NR	1900 [1040] + WQ
F 309H	E 309-15 or 16[H] or E309H-XX	NR	1900 [1040] + WQ
F 310	E 310-15 or 16	NR	1900 [1040] + WQ
F 310H	E 310-15 or 16[H]	NR	1900 [1040] + WQ
F 310MoLN	E 310Mo-15 or 16	NR	1920–2010 [1050–1100] + WQ
F 316	E 316-15 or 16	NR	1900 [1040] + WQ
F 316L	E 316L-15 or 16	NR	1900 [1040] + WQ
F 316H	E 316-15 or 16[H] or E316H-XX	NR	1900 [1040] + WQ
F 316N	E 316-15 or 16	NR	1900 [1040] + WQ
F 316LN	E 316L-15 or 16	NR	1900 [1040] + WQ
F 316Ti	E 316-15 or 16	NR	1900 [1040] + WQ
F 317	E 317-15 or 16	NR	1900 [1040] + WQ
F 317L	E 317L-15 or 16	NR	1900 [1040] + WQ
F 317LNCb	E NiCrCoMo-1 or E NiCrMo-3	NR	1900 [1040] + WQ
F 72	. . .	NR	. . .
F 73	. . .	NR	. . .
F 321[B]	E 347-15 or 16	NR	1900 [1040] + WQ
F 321H[B]	E 347-15 or 16[H]	NR	1925 [1050] + WQ
F 347	E 347-15 or 16	NR	1900 [1040] + WQ
F 347H	E 347-15 or 16[H]	NR	1925 [1050] + WQ
F 347LN[I]	E 347-15 or 16	NR	. . .
F 347LNCuB[I]	E 347-15 or 16	NR	. . .
E 348	E 347-15 or 16	NR	1900 [1040] + WQ
F 348H	E 347-15 or 16[H]	NR	1925 [1050] + WQ
F XM-11	XM-10W	NR	NR
F XM-19	XM-19W	NR	NR
F 20	E/ER-320, 320LR	NR	1700–1850 [925–1010] + WQ
F 44	E NiCrMo-3	NR	2100 [1150] + WQ

TABLE 4 *Continued*

Grade Symbol	Electrodes[A]	Recommended Preheat and Interpass Temperature Range, °F [°C]	Post Weld Heat-Treatment Temperature, Minimum or Range, °F [°C]
F 45[B]	. . .	. . .	. . .
F 46	. . .	. . .	. . .
F 47	. . .[J]	. . .	2100 [1150] + WQ
F 48	. . .[J]	. . .	2100 [1150] + WQ
F 49	. . .[J]	. . .	2100 [1150] + WQ
F 58	E NiCrMo-10	. . .	2100 [1150] + WQ
F 62	E NiCrMo-3	NR	2025 [1105] + WQ
F 70	ERNiCr-3, or ERNiCrMo-3, or ERNiCrMo-4	NR	1900 [1040] + WQ
F 904L	E NiCrMo-3	NR	1920–2100 [1050–1150] + WQ
	Ferritic-Austenitic Stainless Steels		
F 50	25 % Cr, 6 % Ni, 1.7 % Mo	NR	NR
F 51	22 % Cr, 5.5 % Ni, 3 % Mo	NR	NR
F 52	26 % Cr, 8 % Ni, 2 % Mo	NR	NR
F 53	25 % Cr, 7 % Ni, 4 % Mo	NR	NR
F 54	25 % Cr, 7 % Ni, 3 % Mo, W	NR	NR
F 55	25 % Cr, 7 % Ni, 3.5 % Mo	NR	NR
F 57	25 % Cr, 7 % Ni, 3 % Mo, 1.5 % Cu, 1 % W	NR	NR
F 59	E Ni CrMo-10	NR	NR
F 60	22 % Cr, 5.5 % Ni, 3 % Mo	NR	NR
F 61	26 % Cr, 9 % Ni, 3.5 % Mo	NR	NR
F 65	29 % Cr, 6.5 % Ni, 2 % Mo	NR	NR
F 66	22 % Cr, 2 % Ni, 0.25 % Mo	NR	NR
F 67	. . .	NR	NR
F 68	. . .	NR	NR
F 69	. . .	NR	NR
F 71	27.5 Cr, 7.6 Ni, 1 Mo, 2.3 W	NR	NR

[A] Except for Grades F 91 Types 1 and 2, F 92, F 93, F 115, F 911, F 122, F 47, F 48, and F 49, electrodes shall comply with AWS Specifications A5.4/A5.4M, A5.5/A5.5M, A5.9/A5.9M, A5.11/A5.11M, A5.14/A5.14M, A5.23/A5.23M, or A5.28/A5.28M.
[B] Purchaser approval required.
[C] All repairs in F 91 Types 1 and 2 shall be made with one of the following welding processes and consumables: SMAW, A5.5/A5.5M E90XX-B9; SAW, A5.23/A5.23M EB9 + flux; GTAW, A5.28/A5.28M ER90S-B9; and FCAW, A5.29/A5.29M E91T1-B9. In addition, the sum of the Ni+Mn content of all welding consumables shall not exceed 1.0 %.
[D] All repairs in F 92, F 93, F 115, F 911, and F 122, shall be made using welding consumables meeting the chemical requirements for the grade in Table 2.
[E] Preheat and PWHT are not required for this grade for forgings whose section thickness does not exceed 0.500 in. [12.7 mm].
[F] NR = not required.
[G] WQ = water quench.
[H] Filler metal shall additionally have 0.04 % minimum carbon.
[I] Matching filler metal is available.
[J] Match filler metal is available. Fabricators have also used AWS A5.14/A5.14M, Classification ERNiCrMo-3 and AWS A5.11/A5.11M, Class E, ENiCrMo-3 filler metals.

19. Product Marking

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

19.1.1 Quenched and tempered low alloy or martensitic stainless forgings shall be stamped with the letters QT following the specification designation.

19.1.2 Forgings repaired by welding shall be marked with the letter "W" following the Specification designation. When repair-welded austenitic stainless steel forgings have not been postweld heat treated in accordance with Table 4, the letters "WNS" shall be marked following the specification designation.

19.1.3 Parts meeting all requirements for more than one class or grade may be marked with more than one class or grade designation such as F 304/F 304H, F 304/F 304L, and the like.

19.1.4 Plugs and bushings furnished to ASME B16.11 requirements are not required to be marked.

19.1.5 When agreed upon between the purchaser and manufacturer, and specified in the order, the markings shall be painted or stenciled on the fitting or stamped on a metal or plastic tag which shall be securely attached to the fitting.

19.1.6 Grade F 91 shall be additionally marked with the appropriate Type.

19.2 *Bar Coding*—In addition to the requirements in 19.1, bar coding is acceptable as a supplemental identification method. The purchaser may specify in the order a specific bar coding system to 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.

20. Keywords

20.1 austenitic stainless steel; chromium alloy steel; chromium-molybdenum steel; ferritic/austenitic stainless steel; ferritic stainless steel; martensitic stainless steel; nickel alloy steel; notch toughness requirements; pipe fittings; piping applications; pressure containing parts; stainless steel fittings; stainless steel forgings; steel; steel flanges; steel forgings,

alloy; steel valves; temperature service applications, elevated; temperature service applications, high; wrought material

SUPPLEMENTARY REQUIREMENTS

In addition to any of the supplementary requirements of Specification A961/A961M, the following supplementary requirements shall apply only when specified by the purchaser in the order.

S1. Macroetch Test

S1.1 A sample forging shall be sectioned and etched to show flow lines and 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. Heat Treatment Details

S2.1 The manufacturer shall furnish a detailed test report containing the information required in 18.2 and shall include all pertinent details of the heat-treating cycle given the forgings.

S3. Material for Optimum Resistance to Stress-Corrosion Cracking

S3.1 Austenitic stainless steel shall be furnished in the solution-annealed condition as a final operation with no subsequent cold working permitted, except, unless specifically prohibited by the purchaser, straightening of bars from which parts are machined is permitted to meet the requirements of Specification A484/A484M.

S4. Corrosion Tests

S4.1 All austenitic stainless steels shall pass intergranular corrosion tests performed in accordance with Practice E of Practices A262.

S4.2 Intergranular corrosion tests shall be performed on specimens of ferritic stainless steels as described in Practices A763.

S4.3 For both the austenitic and ferritic 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.

S5. Special Filler Metal

S5.1 In repair-welded F 316, F 316L, F 316H, and F 316N forgings, the deposited weld metal shall conform to E 308 composition wire. Forgings repair welded with E 308 weld metal shall be marked F __ W 308.

S6. Hardness Test

S6.1 Each forging shall be hardness tested and shall meet the requirements of Table 3.

S8. Heat Treatment of Austenitic Forgings

S8.1 The purchaser shall specify the heat-treatment method (in 7.1 or in 7.3.1) that shall be employed.

S8.2 The manufacturer shall provide a test report containing the information required in 18.2 and shall include a statement of the heat-treatment method employed.

S9. Grain Size for Austenitic Grades

S9.1 Forgings made from austenitic grades other than H grades shall be tested for average grain size by Test Method E112. Details of the test shall be agreed upon between the manufacturer and the purchaser.

S10. Stabilizing Treatment

S10.1 Subsequent to the solution anneal for Grades F 321, F 321H, F 347, F 347H, F 348, and F 348H, these grades shall be given a stabilizing treatment at 1500 to 1600 °F [815 to 870 °C] for a minimum of 2 h/in. [4.7 min/mm] of thickness and then cooling in the furnace or in air. In addition to the marking required in Section 19, the grade designation symbol shall be followed by the symbol "S10."

S11. Grain Size Requirements for Non-H-Grade Austenitic Steels Used Above 1000 °F [540 °C]

S11.1 Non-H grades of austenitic stainless steels shall have a grain size of No. 7 or coarser as determined in accordance with Test Methods E112. The grain size so determined shall be on a certified test report.

S12. Detection of Detrimental Phases in Austenitic/Ferritic Stainless Steels

S12.1 All austenitic/ferritic stainless steels that are included in Test Methods A923 shall meet the requirements of those test methods.

S12.2 All austenitic/ferritic stainless steels that are included in Test Method A1084 shall meet the requirements of that test method.