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Standard Specification for Forged or Rolled Alloy and Stainless Steel Pipe Flanges, Forged Fittings, and Valves and Parts for High-Temperature Service[1]

This standard is issued under the fixed designation A 182/A 182M; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

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

1. Scope*

1.1 This specification[2] 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, refer to Specifications A 479/A 479M and A 739 for the similar grades available in those specifications. 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 A 336/A 336M and A 965/A 965M for the similar ferritic and austenitic grades, respectively, available in those specifications.

1.3 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.

1.4 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.

1.5 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.

1.6 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 are not exact equivalents; therefore, each system must be used independently of the other. Combining values from the two systems may result in nonconformance with the specification.

2. Referenced Documents

2.1 In addition to the referenced documents listed in Specification A 961/A 961M, the following list of standards apply to this specification.

2.2 *ASTM Standards:* [3]

A 234/A 234M Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service

A 262 Practices for Detecting Susceptibility to Intergranular Attack in Austenitic Stainless Steels

A 275/A 275M Practice for Magnetic Particle Examination of Steel Forgings

A 336/A 336M Specification for Alloy Steel Forgings for Pressure and High-Temperature Parts

A 370 Test Methods and Definitions for Mechanical Testing of Steel Products

A 403/A 403M Specification for Wrought Austenitic Stainless Steel Piping Fittings

A 479/A 479M Specification for Stainless Steel Bars and Shapes for Use in Boilers and Other Pressure Vessels

A 484/A 484M Specification for General Requirements for Stainless Steel Bars, Billets, and Forgings

A 739 Specification for Steel Bars, Alloy, Hot-Wrought, for Elevated Temperature or Pressure-Containing Parts, or Both

A 763 Practices for Detecting Susceptibility to Intergranular Attack in Ferritic Stainless Steels

A 788/A 788M Specification for Steel Forgings, General Requirements

A 961/A 961M Specification for Common Requirements for Steel Flanges, Forged Fittings, Valves, and Parts for Piping Applications

A 965/A 965M Specification for Steel Forgings, Austenitic, for Pressure and High Temperature Parts

E 112 Test Methods for Determining Average Grain Size

[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 on Steel Forgings and Wrought Fittings for Piping Applications and Bolting Materials for Piping and Special Purpose Applications.

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[2] For ASME Boiler and Pressure Vessel Code applications see related Specification SA-182 in Section II of that Code.

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

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

E 165 Test Method for Liquid Penetrant Examination
E 340 Test Method for Macroetching Metals and Alloys
2.3 *ASME Boiler and Pressure Vessel Codes:*[4]
Section IX Welding Qualifications
SFA-5.4 Specification for Corrosion-Resisting Chromium and Chromium-Nickel Steel Covered Welding Electrodes
SFA-5.5 Specification for Low-Alloy Steel Covered Arc-Welding Electrodes
SFA-5.9 Specification for Corrosion-Resisting Chromium and Chromium-Nickel Steel Welding Rods and Bare Electrodes
SFA-5.11 Specification for Nickel and Nickel-Alloy Covered Welding Electrodes

3. Ordering Information

3.1 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 A 961/A 961M, orders should include the following information:

3.1.1 Additional requirements (see 6.2.1, Table 2 footnotes, 8.3, and 17.2), and

3.1.2 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 8.3.1).

4. General Requirements

4.1 Product furnished to this specification shall conform to the requirements of Specification A 961/A 961M, including any supplementary requirements that are indicated in the purchase order. Failure to comply with the general requirements of Specification A 961/A 961M constitutes nonconformance with this specification. In case of conflict between the requirements of this specification and Specification A 961/A 961M, this specification shall prevail.

5. Manufacture

5.1 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.

5.2 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.

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

5.4 The material shall be forged as close as practicable to the specified shape and size. Except for flanges of any type, forged or rolled bar may be used without additional hot working for small cylindrically shaped parts within the limits defined by Specification A 234/A 234M for low alloy steels and martensitic stainless steels and Specification A 403/A 403M for austenitic and ferritic-austenitic stainless steels. Elbows, return bends, tees, and header tees shall not be machined directly from bar stock.

5.5 Except as provided for in 5.4, the finished product shall be a forging as defined in the Terminology section of Specification A 788.

6. Heat Treatment[5]

6.1 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.

6.2 *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 6.1 and Table 1.

6.2.1 *Liquid Quenching*—When agreed to by the purchaser, liquid quenching followed by tempering shall be permitted provided the temperatures in Table 1 for each grade are utilized.

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

6.2.2 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.

6.3 *Austenitic and Ferritic-Austenitic Stainless Steels*—The austenitic and ferritic-austenitic stainless steels shall be heat treated in accordance with the requirements of 6.1 and Table 1.

6.3.1 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 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.

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

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

6.5 *Forged or Rolled Bar*—Forged or rolled austenitic stainless bar from which small cylindrically shaped parts are to be machined, as permitted by 5.4, and the parts machined from such bar, without heat treatment after machining, shall be furnished to the annealing requirements of Specification A 479/A 479M or this specification, with subsequent light cold drawing and straightening permitted (see Supplementary Requirement S3 if annealing must be the final operation).

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

[5] A solution annealing temperature above 1950 °F [1065 °C] may impair the resistance to intergranular corrosion after subsequent exposure to sensitizing conditions in F 321, F 321H, F 347, F 347H, F 348, and F 348H. When specified by the purchaser, a lower temperature stabilization or resolution annealing shall be used subsequent to the initial high temperature solution anneal (see Supplementary Requirement S10).

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	normalize and temper	1900-1975 [1040-1080]	air cool	[B]	1350–1470 [730–800]
F 92	normalize and temper	1900-1975 [1040-1080]	air cool	[B]	1350–1470 [730–800]
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	1650 [900]	air cool	[B]	1100 [595]
	quench and temper	1650 [900]	accelerated air cool or liquid		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]

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]
		Austenitic Stainless Steels			
F 304	solution treat and quench	1900 [1040]	liquid	500 [260]	[B]
F 304H	solution treat and quench	1900 [1040]	liquid	500 [260]	[B]
F 304L	solution treat and quench	1900 [1040]	liquid	500 [260]	[B]
F 304N	solution treat and quench	1900 [1040]	liquid	500 [260]	[B]
F 304LN	solution treat and quench	1900 [1040]	liquid	500 [260]	[B]
F 309H	solution treat and quench	1900 [1040]	liquid	500 [260]	[B]
F 310	solution treat and quench	1900 [1040]	liquid	500 [260]	[B]
F 310H	solution treat and quench	1900 [1040]	liquid	500 [260]	[B]
F 310MoLN	solution treat and quench	1900–2010 [1050–1100]	liquid	500 [260]	[B]
F 316	solution treat and quench	1900 [1040]	liquid	500 [260]	[B]
F 316H	solution treat and quench	1900 [1040]	liquid	500 [260]	[B]
F 316L	solution treat and quench	1900 [1040]	liquid	500 [260]	[B]
F 316N	solution treat and quench	1900 [1040]	liquid	500 [260]	[B]
F 316LN	solution treat and quench	1900 [1040]	liquid	500 [260]	[B]
F 316Ti	solution treat and quench	1900 [1040]	liquid	500 [260]	[B]
F 317	solution treat and quench	1900 [1040]	liquid	500 [260]	[B]
F 317L	solution treat and quench	1900 [1040]	liquid	500 [260]	[B]
F 347	solution treat and quench	1900 [1040]	liquid	500 [260]	[B]
F 347H	solution treat and quench	2000 [1095]	liquid	500 [260]	[B]
F 348	solution treat and quench	1900 [1040]	liquid	500 [260]	[B]
F 348H	solution treat and quench	2000 [1095]	liquid	500 [260]	[B]
F 321	solution treat and quench	1900 [1040]	liquid	500 [260]	[B]
F 321H	solution treat and quench	2000 [1095]	liquid	500 [260]	[B]
F XM-11	solution treat and quench	1900 [1040]	liquid	500 [260]	[B]
F XM-19	solution treat and quench	1900 [1040]	liquid	500 [260]	[B]
F 20	solution treat and quench	1700-1850 [925-1010]	liquid	500 [260]	[B]
F 44	solution treat and quench	2100 [1150]	liquid	500 [260]	[B]
F 45	solution treat and quench	1900 [1040]	liquid	500 [260]	[B]
F 46	solution treat and quench	2010-2140 [1100-1140]	liquid	500 [260]	[B]
F 47	solution treat and quench	1900 [1040]	liquid	500 [260]	[B]
F 48	solution treat and quench	1900 [1040]	liquid	500 [260]	[B]
F 49	solution treat and quench	2050 [1120]	liquid	500 [260]	[B]
F 56	solution treat and quench	2050-2160 [1120-1180]	liquid	500 [260]	[B]
F 58	solution treat and quench	2085 [1140]	liquid	500 [260]	[B]
F 62	solution treat and quench	2025 [1105]	liquid	500 [260]	[B]
F 63	solution treat and quench	1900 [1040]	liquid	500 [260]	[B]
F 64	solution treat and quench	2010-2140 [1100-1170]	liquid	500 [250]	[B]
F 904L	solution treat and quench	1920-2100 [1050-1150]	liquid	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	1905-2100 [1040-1150]	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.

7. Chemical Composition

7.1 A chemical heat analysis in accordance with Specification A 961/A 961M shall be made and conform to the chemical composition prescribed in Table 2.

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

7.3 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.

7.4 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.

7.5 *Product Analysis*—The purchaser may make a product analysis on products supplied to this specification in accordance with Specification A 961/A 961M.

8. Mechanical Properties

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

8.2 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.

8.3 For normalized and tempered, or quenched and tempered forgings, 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 forging. In addition, for quenched and tempered forgings, the mid-length 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.

8.3.1 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* 3 *T* testing (see 8.3) is not practical. Sketches showing the exact test locations shall be approved by the purchaser when this method is used.

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

8.4 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.

8.5 *Tension Tests*:

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

8.5.1.1 When the heat-treating cycles are the same and the furnaces (either batch or continuous type) are controlled within 625 °F [614 °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.

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

8.5.2.1 When heat treated in accordance with 6.1, the test blank or forging used to provide the test specimen shall be heat treated with a finished forged product.

8.5.2.2 When the alternative method in 6.3.1 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.

8.5.3 Testing shall be performed in accordance with Test Methods and Definitions A 370 using the largest feasible of the round specimens. The gage length for measuring elongation shall be four times the diameter of the test section.

8.6 *Hardness Tests*:

8.6.1 Except when only one forging is produced, a minimum of two pieces per batch or continuous run as defined in 8.6.2 shall be hardness tested in accordance with Test Methods and Definitions A 370 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.

8.6.2 When the reduced number of tension tests permitted by 8.5.1.1 is applied, additional hardness tests shall be made on forgings or samples, as defined in 8.2, scattered throughout the load (see Note 2). At least eight samples shall be checked from 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 8.5.1 shall apply.

NOTE 2—The tension test required in 8.5.1 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 8.6.2 are required when 8.5.1.1 is applied to ensure the prescribed heat-treating cycle and uniformity throughout the load.

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

8.7.1 Impact test specimens shall be Charpy V-notch Type, as shown in Fig. 11a of Test Methods and Definitions A 370. The usage of subsize specimens due to material limitations must have prior purchaser approval.

TABLE 2 Chemical Requirements[A]

Identification Symbol	UNS Designation	Grade	Composition, %										
			Carbon	Manganese	Phosphorus	Sulfur	Silicon	Nickel	Chromium	Molybdenum	Columbium	Titanium	Other Elements
						Low Alloy Steels							
F 1	K12822	carbon-molybdenum	0.28	0.60–0.90	0.045	0.045	0.15–0.35			0.44–0.65			
F 2[B]	K12122	0.5 % chromium, 0.5 % molybdenum	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[C]	K41545	4 to 6 % chromium	0.15	0.30–0.60	0.030	0.030	0.50	0.50	4.0–6.0	0.44–0.65			
F 5a[C]	K42544	4 to 6 % chromium	0.25	0.60	0.040	0.030	0.50	0.50	4.0–6.0	0.44–0.65			
F 9	K90941	9 % chromium	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	20 nickel, 8 chromium	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	K90901	9 % chromium, 1 % molybdenum, 0.2 % vanadium plus columbium and nitrogen	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[D] V 0.18–0.25 Ti 0.01[D] Zr 0.01[D] V
F 92	K92460	9 % chromium, 1.8 % tungsten, 0.2 % vanadium plus columbium	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		0.15–0.25 N 0.030–0.070 Al 0.02[D] W 1.50–2.00 B 0.001–0.006 Ti 0.01[D] Zr 0.01[D]
F 122	K91271	11 % chromium, 2 % tungsten, 0.2 % vanadium, plus molybdenum, columbium, copper, nickel, nitrogen, and boron	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[D] Cu 0.30–1.70 W 1.50–2.50 Ti 0.01[D] Zr 0.01[D]
F 911	K91061	9 % chromium, 1 % molybdenum, 0.2 % vanadium plus columbium and nitrogen	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[D] N 0.04–0.09 V 0.18–0.25 B 0.0003–0.006 Ti 0.01[D] Zr 0.01[D]
F 11 Class 1	K11597	1.25 % chromium, 0.5 % molybdenum	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	1.25 % chromium, 0.5 % molybdenum	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 11 Class 3	K11572	1.25 % chromium, 0.5 % molybdenum	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	1 % chromium, 0.5 % molybdenum	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	1 % chromium, 0.5 % molybdenum	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	chromium-molybdenum	0.05–0.15	0.30–0.60	0.040	0.040	0.50 max		2.7–3.3	0.80–1.06			

TABLE 2 *Continued*

Identification Symbol	UNS Designation	Grade	Composition, %										
			Carbon	Manganese	Phosphorus	Sulfur	Silicon	Nickel	Chromium	Molybdenum	Columbium	Titanium	Other Elements
F 3V	K31830	3 % chromium, 1 % molybdenum, 0.25 % vanadium plus boron and titanium	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	3 % chromium, 1 % molybdenum, 0.25 % vanadium plus boron, columbium, and titanium	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	chromium-molybdenum	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	chromium-molybdenum	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	2.25 % chromium, 1 % molybdenum, 0.25 % vanadium	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[E]
F 23	K41650	2.25 % chromium, 1.6 % tungsten, 0.25 % vanadium, plus molybdenum, columbium, and boron	0.04–0.10	0.10–0.60	0.030	0.010	0.50		1.90-2.60	0.05-0.30	0.02–0.08		V 0.20–0.30 B 0.0005–0.006 N 0.030 Al 0.030 W 1.45–1.75
F 24	K30736	2.25 % chromium, 1 % molybdenum, 0.25 % vanadium plus titanium and boron	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	2 % nickel, 1 % copper	0.20	0.40–1.06	0.045	0.050		1.60–2.24					Cu 0.75–1.25
F 36	K21001	1.15 % nickel, 0.65 % copper, molybdenum, and columbium	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	13 % chromium 410[F]	0.15	1.00	0.040	0.030	1.00	0.50	11.5–13.5				
F 6b	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			Cu 0.50
F 6NM	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			
Ferritic Stainless Steels													
F XM-27Cb[G]	S44627	27 chromium, 1 molybdenum XM-27[F]	0.010	0.40	0.020	0.020	0.40	0.50	25.0–27.5	0.75–1.50	0.05–0.20		N 0.015 Cu 0.20
F 429	S42900	15 chromium 429[F]	0.12	1.00	0.040	0.030	0.75	0.50	14.0–16.0				
F 430	S43000	17 chromium 430[F]	0.12	1.00	0.040	0.030	0.75	0.50	16.0–18.0				
Austenitic Stainless Steels													
F 304[H]	S30400	18 chromium, 8 nickel 304[F]	0.08	2.00	0.045	0.030	1.00	8.0–11.0	18.0–20.0				

TABLE 2 *Continued*

Identification Symbol	UNS Designation	Grade	Composition, %										
			Carbon	Manganese	Phosphorus	Sulfur	Silicon	Nickel	Chromium	Molybdenum	Columbium	Titanium	Other Elements
F 304H	S30409	18 chromium, 8 nickel 304H[F]	0.04–0.10	2.00	0.045	0.030	1.00	8.0–11.0	18.0–20.0				
F 304L[H]	S30403	18 chromium, 8 nickel, low carbon 304L[F]	0.030	2.00	0.045	0.030	1.00	8.0–13.0	18.0–20.0				
F 304N[I]	S30451	18 chromium, 8 nickel, modified with nitrogen 304N[F]	0.08	2.00	0.045	0.030	1.00	8.0–10.5	18.0–20.0				
F 304LN[I]	S30453	18 chromium, 8 nickel, modified with nitrogen 304LN[F]	0.030	2.00	0.045	0.030	1.00	8.0–10.5	18.0–20.0				
F 309H	S30909	23 chromium, 13.5 nickel 309H[F]	0.04–0.10	2.00	0.045	0.030	1.00	12.0–15.0	22.0–24.0				
F 310	S31000	25 chromium, 20 nickel 310[F]	0.25	2.00	0.045	0.030	1.00	19.0–22.0	24.0–26.0				
F 310H	S31009	25 chromium, 20 nickel 310H[F]	0.04–0.10	2.00	0.045	0.030	1.00	19.0–22.0	24.0–26.0				
F 310MoLN	S31050	25 chromium, 22 nickel, modified with molybdenum and nitrogen, low carbon 310MoLN[F]	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[H]	S31600	18 chromium, 8 nickel, modified with molybdenum 316[F]	0.08	2.00	0.045	0.030	1.00	10.0–14.0	16.0–18.0	2.00–3.00			
F 316H	S31609	18 chromium, 8 nickel, modified with molybdenum 316H[F]	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[H]	S31603	18 chromium, 8 nickel, modified with molybdenum, low carbon 316L[F]	0.030	2.00	0.045	0.030	1.00	10.0–15.0	16.0–18.0	2.00–3.00			
F 316N[I]	S31651	18 chromium, 8 nickel, modified with molybdenum and nitrogen 316N[F]	0.08	2.00	0.045	0.030	1.00	11.0–14.0	16.0–18.0	2.00–3.00			
F 316LN[I]	S31653	18 chromium, 8 nickel, modified with molybdenum and nitrogen 316LN[F]	0.030	2.00	0.045	0.030	1.00	11.0–14.0	16.0–18.0	2.00–3.00			
F 316Ti	S31635	18 chromium, 8 nickel, modified with molybdenum and nitrogen 316Ti	0.08	2.00	0.045	0.030	1.00	10.0–14.0	16.0–18.0	2.00–3.00		[J]	N 0.10 max
F 317	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			

TABLE 2 *Continued*

Identification Symbol	UNS Designation	Grade	Composition, %										
			Carbon	Manganese	Phosphorus	Sulfur	Silicon	Nickel	Chromium	Molybdenum	Columbium	Titanium	Other Elements
F 317L	S31703	19 chromium, 13 nickel, 3.5 molybdenum 317L[F]	0.030	2.00	0.045	0.030	1.00	11.0–15.0	18.0–20.0	3.0–4.0			
F 321	S32100	18 chromium, 8 nickel modified with titanium 321[F]	0.08	2.00	0.045	0.030	1.00	9.0–12.0	17.0–19.0			[K]	
F 321H	S32109	18 chromium, 8 nickel, modified with titanium 321H[F]	0.04–0.10	2.00	0.045	0.030	1.00	9.0–12.0	17.0–19.0			[L]	
F 347	S34700	18 chromium, 8 nickel modified with columbium 347[F]	0.08	2.00	0.045	0.030	1.00	9.0–13.0	17.0–20.0		[M]		
F 347H	S34709	18 chromium, 8 nickel, modified with columbium 347H[F]	0.04–0.10	2.00	0.045	0.030	1.00	9.0–13.0	17.0–20.0		[N]		
F 348	S34800	18 chromium, 8 nickel modified with columbium 348[F]	0.08	2.00	0.045	0.030	1.00	9.0–13.0	17.0–20.0		[M]		Co 0.20 Ta 0.10
F 348H	S34809	18 chromium, 8 nickel, modified with columbium 348H[F]	0.04–0.10	2.00	0.045	0.030	1.00	9.0–13.0	17.0–20.0		[N]		Co 0.20 Ta 0.10
F XM-11	S21904	20 chromium, 6 nickel, 9 manganese XM-11[F]	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	22 chromium, 13 nickel, 5 manganese XM-19[F]	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	35 nickel, 20 chromium, 3.5 copper, 2.5 molybdenum	.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	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			Cu 0.50–1.00 N 0.18–0.22
F 45	S30815	21 chromium, 11 nickel modified with nitrogen and cerium	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	18 chromium, 15 nickel, 4 silicon	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	19 chromium, 15 nickel, 4 molybdenum 317LM[F]	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	19 chromium, 15 nickel, 4 molybdenum 317LMN[F]	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	24 chromium, 17 nickel, 6 manganese, 5 molybdenum	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	32 nickel, 27 chromium	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

TABLE 2 *Continued*

Identification Symbol	UNS Designation	Grade	Composition, %										
			Carbon	Manganese	Phosphorus	Sulfur	Silicon	Nickel	Chromium	Molybdenum	Columbium	Titanium	Other Elements
F 58	S31266	24 chromium, 20 nickel, 6 molybdenum, 2 tungsten with nitrogen	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	21 chromium, 25 nickel, 6.5 molybdenum	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	18 chromium, 20 nickel, 5.5 silicon	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	17.5 chromium, 17.5 nickel, 5.3 silicon	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	21 chromium, 26 nickel, 4.5 molybdenum 904L[F]	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
		Ferritic-Austenitic Stainless Steels											
F 50	S31200	25 chromium, 6 nickel, modified with nitrogen	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	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			N 0.08–0.20
F 52	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			N 0.15–0.35
F 53	S32750	25 chromium, 7 nickel, 4 molybdenum, modified with nitrogen 2507[F]	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	25 chromium, 7 nickel, modified with nitrogen and tungsten	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	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			N 0.20–0.30 Cu 0.50–1.00 W 0.50–1.00[O]
F 57	S39277	26 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			Cu 1.20–2.00 W 0.80–1.20 N 0.23–0.33
F 59	S32520	25 chromium, 6.5 nickel, 4 molybdenum with nitrogen	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	22 chromium, 5.5 nickel, 3 molybdenum, modified with nitrogen 2205[F]	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*

Identification Symbol	UNS Designation	Grade	Composition, %										
			Carbon	Manganese	Phosphorus	Sulfur	Silicon	Nickel	Chromium	Molybdenum	Columbium	Titanium	Other Elements
F 61	S32550	26 chromium, 6 nickel, 3.5 molybdenum with nitrogen and copper 255[F]	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	29 chromium, 6.5 nickel, 2 molybdenum with nitrogen	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

[A] All values are maximum unless otherwise stated.
[B] Grade F 2 was formerly assigned to the 1 % chromium, 0.5 % molybdenum grade which is now Grade F 12.
[C] 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.
[D] Applies to both heat and product analyses.
[E] For Grade F22V, 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.
[F] Naming system developed and applied by ASTM.
[G] 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 %.
[H] Grades F 304, F 304L, F 316, and F 316L shall have a maximum nitrogen content of 0.10 %.
[I] Grades F 304N, F 316N, F 304LN, and F 316LN shall have a nitrogen content of 0.10 to 0.16 %.
[J] Grade F 316Ti shall have a titanium content not less than five times the carbon plus nitrogen content and not more than 0.70 %.
[K] Grade F 321 shall have a titanium content of not less than five times the carbon content and not more than 0.70 %.
[L] Grade F 321H shall have a titanium content of not less than four times the carbon content and not more than 0.70 %.
[M] Grades F 347 and F 348 shall have a columbium content of not less than ten times the carbon content and not more than 1.10 %.
[N] Grades F 347H and F 348H shall have a columbium content of not less than eight times the carbon content and not more than 1.10 %.
[O] % Cr + 3.3 × % Mo + 16 × % N = 40 min.

TABLE 3 Tensile and Hardness Requirements

Grade Symbol	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
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	85 [585]	60 [415]	20	40	248 max
F 92	90 [620]	64 [440]	20	45	269 max
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][B]	30 [205]	30	50	. . .
F 304H	75 [515][B]	30 [205]	30	50	. . .
F 304L	70 [485][C]	25 [170]	30	50	. . .
F 304N	80 [550]	35 [240]	30[D]	50[E]	. . .
F 304LN	75 [515][B]	30 [205]	30	50	. . .
F 309H	75 [515][B]	30 [205]	30	50	. . .
F 310	75 [515][B]	30 [205]	30	50	. . .
F 310 MoLN	78 [540]	37 [255]	25	40	. . .
F 310H	75 [515][B]	30 [205]	30	50	. . .
F 316	75 [515][B]	30 [205]	30	50	. . .
F 316H	75 [515][B]	30 [205]	30	50	. . .
F 316L	70 [485][C]	25 [170]	30	50	. . .
F 316N	80 [550]	35 [240]	30[D]	50[E]	. . .
F 316LN	75 [515][B]	30 [205]	30	50	. . .
F 316Ti	75 [515]	30 [205]	30	40	. . .
F 317	75 [515][B]	30 [205]	30	50	. . .
F 317L	70 [485][C]	25 [170]	30	50	. . .
F 347	75 [515][B]	30 [205]	30	50	. . .
F 347H	75 [515][B]	30 [205]	30	50	. . .
F 348	75 [515][B]	30 [205]	30	50	. . .
F 348H	75 [515][B]	30 [205]	30	50	. . .
F 321	75 [515][B]	30 [205]	30	50	. . .
F 321H	75 [515][B]	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	. . .
F 44	94 [650]	44 [300]	35	50	. . .

TABLE 3 *Continued*

Grade Symbol	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
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
F 904L	71 [490]	31 [215]	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][F]	80 [550][F]	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]	65 [450]	25	45	. . .
F 61	109 [750]	80 [550]	25	50	. . .
F 65	109 [750]	80 [550]	25	. . .	. . .

[A] Determined by the 0.2 % offset method. For ferritic steels only, the 0.5 % extension-under-load method may also be used.
[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].
[D] Longitudinal. The transverse elongation shall be 25 % in 2 in. or 50 mm, min.
[E] Longitudinal. The transverse reduction of area shall be 45 % min.
[F] For sections over 2 in. [50 mm] in thickness, the minimum tensile strength shall be 106 ksi [730 MPa]; the minimum yield strength shall be 75 ksi [515 MPa].

8.7.2 The Charpy V-notch test specimens shall be obtained as required for tension tests in 8.2, 8.3 and 8.5. One set of three Charpy V-notch specimens shall be taken from each tensile specimen location.

8.7.3 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.

8.7.4 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].

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

9. Grain Size for Austenitic Grades

9.1 All H grades and grade F 63 shall be tested for average grain size by Test Methods E 112.

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

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

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

10. Corrosion Testing for Austenitic Grades

10.1 Corrosion testing is not required by this specification.

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

11. Retreatment

11.1 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 8.

12. Workmanship, Finish, and Appearance

12.1 Forgings shall conform to the requirements of Specification A 961/A 961M.

12.2 The forgings shall be free of scale, machining burrs which might hinder fit-up, and other injurious imperfections as defined herein. The forgings 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.

13. Repair by Welding

13.1 Weld repairs shall be permitted (see Supplementary Requirement S9 of Specification A 961/A 961M) at the discretion of the manufacturer with the following limitations and requirements:

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

13.1.2 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 ASME Specifications SFA-5.4, SFA-5.5, SFA-5.9, or SFA-5.11. 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.

13.1.3 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 A 275/A 275M for the low alloy steels and ferritic, martensitic, or ferritic-austenitic stainless steels, or by liquid-penetrant inspection in accordance with Test Method E 165 for all grades.

13.1.4 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.

13.1.5 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.

13.1.6 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.

13.1.7 When approval of the purchaser is obtained, the limitations set forth in 13.1.6 may be exceeded, but all other requirements of Section 13 shall apply.

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

13.1.9 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.

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	E 502-15 or 16	400–700 [205–370]	1250 [675]
F 5a	E 502-15 or 16	400–700 [205–370]	1250 [675]
F 9	E 505-15 or 16	400–700 [205–370]	1250 [675]
F 10[B]	...	...	...
F 91	9 % Cr, 1 % Mo, VCbN	400–700 [205–370]	1350–1470 [730–800]
F 92	9 % Cr, 0.5 % Mo, 1.5 % W, VCbNiN	400–700 [205–370]	1350–1470 [730–800]
F 122	11 % Cr, 2 % W, MoVCbCuN	400–700 [205–370]	1350–1470 [730–800]
F 911	9 % Cr, 1 % Mo, 1 % W, VCbN	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][C]	1350–1470 [730–800][C]
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[D]	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[E]
F 304L	E 308L-15 or 16	NR	1900 [1040] + WQ
F 304H	E 308-15 or 16	NR	1900 [1040] + WQ
F 304N	E 308-15 or 16	NR	1900 [1040] + 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 304LN	E 308L-15 or 16	NR	1900 [1040] + WQ
F 309H	E 309-15 or 16[F]	NR	1900 [1040] + WQ
F 310	E 310-15 or 16	NR	1900 [1040] + WQ
F 310H	E 310-15 or 16	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	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 321[B]	E 347-15 or 16	NR	1900 [1040] + WQ
F 321H[B]	E 347-15 or 16	NR	1925 [1050] + WQ
F 347	E 347-15 or 16	NR	1900 [1040] + WQ
F 347H	E 347-15 or 16	NR	1925 [1050] + WQ
F 348	E 347-15 or 16	NR	1900 [1040] + WQ
F 348H	E 347-15 or 16	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
F 45[B]	. . .	. . .	. . .
F 46	. . .	. . .	. . .
F 47	. . .[G]	. . .	2100 [1150] + WQ
F 48	. . .[G]	. . .	2100 [1150] + WQ
F 49	. . .[G]	. . .	2100 [1150] + WQ
F 58	E NiCrMo-10	. . .	2100 [1150] + WQ
F 62	E NiCrMo-3	NR	2025 [1105] + 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

[A] Electrodes shall comply with ASME SFA 5.4, SFA 5.5, and corresponding ER grades of SFA-5.9 or SFA-5.11.

[B] Purchaser approval required.

[C] Not required for not below 0.500 in. [12.7 mm].

[D] NR = not required.

[E] WQ = water quench.

[F] Filler metal shall additionally have 0.04 % minimum carbon.

[G] Match filler metal is available. Fabricators have also used AWS A 5.14, Class ER, NiCrMo-3 and AWS A 5.11, Class E, NiCrMo-3 filler metals.

14. Inspection

14.1 Inspection provisions of Specification A 961/A 961M apply.

15. Rejection and Rehearing

15.1 The purchaser shall comply with the provisions of Specification A 961/A 961M.

16. Certification

16.1 In addition to the certification requirements of Specification A 961/A 961M, test reports shall be furnished to the purchaser or his representative.

16.2 Test reports shall include certification that all requirements of this specification have been met. The specification designation included on test reports shall include year of issue and revision letter, if any. The manufacturer shall provide the following where applicable:

16.2.1 Type heat treatment, Section 6,

16.2.2 Product analysis results, Section 8 of Specification A 961/A 961M,

16.2.3 Tensile property results, Section 8 (Table 3), report the yield strength and ultimate strength, in ksi [MPa], elongation and reduction in area, in percent,

16.2.4 Chemical analysis results, Section 7 (Table 2),

16.2.5 Hardness results, Section 8 (Table 3),
16.2.6 Grain size results, Section 9, and
16.2.7 Any supplementary testing required by the purchase order.

17. Product Marking

17.1 In addition to the marking requirements of Specification A 961/A 961M, the manufacturer's name (see Note 3) or symbol shall be permanently marked on each forging.

NOTE 3—For purposes of identification marking, the manufacturer is considered the organization that certifies the piping component was manufactured, sampled, and tested in accordance with this specification, and the results have been determined to meet the requirements of this specification.

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

17.1.2 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.

17.1.3 When test reports are required, the markings shall consist of the manufacturer's symbol or name, the grade symbol, and such other markings as necessary to identify the part with the test report (17.1.1 and 17.1.2 shall apply).

17.1.4 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.

17.2 *Bar Coding*—In addition to the requirements in 17.1, 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.

18. Keywords

18.1 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 A 961/A 961M, 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 E 340. 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 16.2 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 A 484/A 484M.

S4. Corrosion Tests

S4.1 All austenitic stainless steels shall pass intergranular corrosion tests performed in accordance with Practice E of Practices A 262.

S4.2 Intergranular corrosion tests shall be performed on specimens of ferritic stainless steels as described in Practices A 763.

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.

S7. Alternate Heat Treatment (Grade F 91 and F 92)

S7.1 Grade F 91 shall be normalized in accordance with Section 6 and tempered at a temperature, to be specified by the purchaser, less than 1350 °F [730 °C]. It shall be the purchaser's responsibility to subsequently temper at 1350 °F [730 °C] minimum to conform to the requirements of the specification. All mechanical tests shall be made on material heat treated in accordance with Section 6. The certification shall reference this

supplementary requirement indicating the tempering temperature applied. The notation "S7"shall be included with the required marking of the forging.

S8. Heat Treatment of Austenitic Forgings

S8.1 The purchaser shall specify the heat-treatment method (in 6.1 or in 6.3.1) that shall be employed.

S8.2 The manufacturer shall provide a test report containing the information required in 16.2 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 E 112. Details of the test shall be agreed upon between the manufacturer and the purchaser.

S10. Stabilization 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 stabilization heat 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 17, 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 E 112. The grain size so determined shall be on a certified test report.

SUMMARY OF CHANGES

Committee A01 has identified the location of selected changes to this specification since the last issue, A 182/A 182M – 07, that may impact the use of this specification. (Approved September 1, 2007)

(*1*) Revised the Yield Strength for Grade F 60 in Table 3.

Committee A01 has identified the location of selected changes to this specification since the last issue, A 182/A 182M – 06, that may impact the use of this specification. (Approved May 1, 2007)

(1) Added Grade F 316Ti, S31635, to Tables 1-4
(2) Revised chemistry of Grades F 91, F 92, F 911, and F 122 in Table 2.
(3) Added grades to direct quench exclusion in 6.3.1.

Committee A01 has identified the location of selected changes to this specification since the last issue, A 182/A 182M – 05a, that may impact the use of this specification. (Approved September 1, 2006)

(*1*) Added Grade F 65, UNS 32906, to Tables 1-4.