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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 A182/A182M; 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 (other than those directly addressed by this specification; see 6.4), refer to Specifications A479/A479M and A739 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 A336/A336M and A965/A965M 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. Several of the ferritic/austenitic (duplex) grades are also found in Specification A1049/A1049M.

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 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.

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:*[3]

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 ~~A370Test Methods and Definitions for Mechanical Testing of Steel Products~~
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
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

[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.**

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
E92 Test Method for Vickers Hardness of Metallic Materials
E112 Test Methods for Determining Average Grain Size
E165 Practice for Liquid Penetrant Examination for General Industry
E340 Test Method for Macroetching Metals and Alloys
2.3 *ASME Boiler and Pressure Vessel Codes:*[4]
Section IX Welding and Brazing Qualifications
2.4 *AWS Specifications*[5]
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 F23, 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 The material shall be forged as close as practicable to the specified shape and size.
6.4.1 Flanges of any type, elbows, return bends, tees, and header tees shall not be machined directly from bar stock.
6.4.2 Cylindrically-shaped parts may be machined from forged or rolled solution-annealed austenitic stainless steel bar without additional hot working.
6.4.3 Small cylindrically-shaped low alloy and martensitic stainless steel parts, NPS-4 [DN 100] and under, may be machined from forged or rolled bar, without additional hot working.

[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] Available from American Welding Society (AWS), 550 NW LeJeune Rd., Miami, FL 33126, http://www.aws.org.

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[6]

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 3, and in 7.2.3, for F 91, 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.

7.2.3 Alternatively, Grade F 91 forged fittings having any section thickness greater than 3 in. [75 mm], at the time of heat treatment, shall be normalized and tempered or quenched and tempered at the manufacturer's option, provided that the temperatures in Table 1 for F 91 are used.

7.3 *Austenitic and Ferritic-Austenitic Stainless Steels*—The austenitic and ferritic-austenitic stainless steels shall be heat treated 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 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.

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 requirements of Specification A479/A479M or this specification, with subsequent light cold drawing and straightening permitted (see Supplementary Requirement S3 if annealing must be the final operation).

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]

[6] 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 *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 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]
			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]
S31727	solution treat and quench	1975–2155 [1080–1180]	liquid	500 [260]	[B]
S32053	solution treat and quench	1975–2155 [1080–1180]	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 347LN	solution treat and quench	1900 [1040]	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]

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 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	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]

[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 Grade F 65 shall be quenching in water or rapidly cooling by other means.

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 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.

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 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.

~~9.5.3Testing shall be performed in accordance with Test Methods and Definitions A370 using the largest feasible of the round specimens. The gage length for measuring elongation shall be four times the diameter of the test section.~~

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 in accordance with Test Methods and Definitions A370~~ 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 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 F23 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 F23 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 with Test Methods and Definitions A370~~or as specified in Specification A961/A961M.

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

~~9.7.1Impact test specimens shall be Charpy V-notch Type, as shown in Fig. 11a of Test Methods and Definitions A370. The usage of subsize specimens due to material limitations must have prior purchaser approval.~~

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.

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]
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	...	V 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	0.40	1.90-2.60	0.05-0.30	0.02–0.08	0.005–0.060[F]	V 0.20–0.30 B 0.0010–0.006 N 0.015[F] 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[G]	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[H]	S44627	27 chromium, 1 molybdenum XM-27[G]	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[G]	0.12	1.00	0.040	0.030	0.75	0.50	14.0–16.0	...	...	...	...
F 430	S43000	17 chromium 430[G]	0.12	1.00	0.040	0.030	0.75	0.50	16.0–18.0	...	...	...	...
Austenitic Stainless Steels													
F 304[I]	S30400	18 chromium, 8 nickel 304[G]	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[G]	0.04–0.10	2.00	0.045	0.030	1.00	8.0–11.0	18.0–20.0	...	...	...	...
F 304L[I]	S30403	18 chromium, 8 nickel, low carbon 304L[G]	0.030	2.00	0.045	0.030	1.00	8.0–13.0	18.0–20.0	...	...	...	...
F 304N[J]	S30451	18 chromium, 8 nickel, modified with nitrogen 304N[G]	0.08	2.00	0.045	0.030	1.00	8.0–10.5	18.0–20.0	...	...	...	...
F 304LN[J]	S30453	18 chromium, 8 nickel, modified with nitrogen 304LN[G]	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[G]	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[G]	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[G]	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[G]	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[I]	S31600	18 chromium, 8 nickel, modified with molybdenum 316[G]	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[G]	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[I]	S31603	18 chromium, 8 nickel, modified with molybdenum, low carbon 316L[G]	0.030	2.00	0.045	0.030	1.00	10.0–15.0	16.0–18.0	2.00–3.00	...	...	...
F 316N[J]	S31651	18 chromium, 8 nickel, modified with molybdenum and nitrogen 316N[G]	0.08	2.00	0.045	0.030	1.00	11.0–14.0	16.0–18.0	2.00–3.00	...	...	...
F 316LN[J]	S31653	18 chromium, 8 nickel, modified with molybdenum and nitrogen 316LN[G]	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	...	[K]	N 0.10 max
F 317	S31700	19 chromium, 13 nickel, 3.5 molybdenum 317[G]	0.08	2.00	0.045	0.030	1.00	11.0–15.0	18.0–20.0	3.0–4.0	...	...	...