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Endorsed by Manufacturers Standardization Society of the Valve and Fittings Industry
Used in USDOE-NE Standards

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 U.S. 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 or hollow bar (other than those directly addressed by this specification; see 6.4), refer to Specifications A479/A479M, A739, or A511/A511M for the similar grades available in those specifications.

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

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

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

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

1.7 The values stated in either SI units or inch-pound units are to be regarded separately as the standard. Within the text, the SI units are shown in brackets. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in non-conformance with the standard.

[1] 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.

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

1.8 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

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

2.2 *ASTM Standards:*[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
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, Shapes, and Forgings
A511/A511M Specification for Seamless Stainless Steel Mechanical Tubing and Hollow Bar
A739 Specification for Steel Bars, Alloy, Hot-Wrought, for Elevated Temperature or Pressure-Containing Parts, or Both
A763 Practices for Detecting Susceptibility to Intergranular Attack in Ferritic Stainless Steels
A788/A788M Specification for Steel Forgings, General Requirements
A923 Test Methods for Detecting Detrimental Intermetallic Phase in Duplex Austenitic/Ferritic Stainless Steels
A961/A961M Specification for Common Requirements for Steel Flanges, Forged Fittings, Valves, and Parts for Piping Applications
A965/A965M Specification for Steel Forgings, Austenitic, for Pressure and High Temperature Parts
A1049/A1049M Specification for Stainless Steel Forgings, Ferritic/Austenitic (Duplex), for Pressure Vessels and Related Components
A1084 Test Method for Detecting Detrimental Phases in Lean Duplex Austenitic/Ferritic Stainless Steels
E92 Test Methods for Vickers Hardness and Knoop Hardness of Metallic Materials
E112 Test Methods for Determining Average Grain Size
E165/E165M Practice for Liquid Penetrant Testing for General Industry
E340 Practice for Macroetching Metals and Alloys

2.3 *ASME Standards:*[4]

B16.11 Forged Steel Fittings, Socket Welding, and Threaded

2.4 *ASME Boiler and Pressure Vessel Code:*[4]

Section IX

2.5 *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 F 23, the metallurgical condition achieved after normalizing and cooling to room temperature but prior to tempering.

[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.

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

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

4. Ordering Information

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

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

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

5. General Requirements

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

6. Manufacture

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

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

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

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

6.4.1 Flanges, elbows, return bends, tees, and header tees shall not be machined directly from bar stock. Other parts whose longitudinal axis is not parallel to the longitudinal axis of the hollow bar or forged or rolled bar shall not be machined directly from bar.

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

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

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

7. Heat Treatment[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

[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 stabilizing treatment or a second solution 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 Types 1 and 2	normalize and temper or quench and temper	1900–1975 [1040–1080]	air cool, accelerated air cool, or liquid	[B]	1350–1470 [730–800]
F 92	normalize and temper	1900–1975 [1040–1080]	air cool	[B]	1350–1470 [730–800]
F 93	normalize and temper	1960–2140 [1070–1170]	air cool	385 [200]	1380–1455 [750–790]
F 115	normalize and temper	1920–2010 [1050–1100]	air cool, accelerated air cool, or liquid	[B]	1380–1455 [750–790]
F 122	normalize and temper	1900–1975 [1040–1080]	air cool	[B]	1350–1470 [730–800]
F 911	normalize and temper	1900–1975 [1040–1080]	air cool or liquid	[B]	1365–1435 [740–780]
F 11, Class 1, 2, 3	anneal	1650 [900]	furnace cool	[B]	[B]
	normalize and temper	1650 [900]	air cool	[B]	1150 [620]
F 12, Class 1, 2	anneal	1650 [900]	furnace cool	[B]	[B]
	normalize and temper	1650 [900]	air cool	[B]	1150 [620]
F 21, F 3V, and F 3VCb	anneal	1750 [955]	furnace cool	[B]	[B]
	normalize and temper	1750 [955]	air cool	[B]	1250 [675]
F 22, Class 1, 3	anneal	1650 [900]	furnace cool	[B]	[B]
	normalize and temper	1650 [900]	air cool	[B]	1250 [675]
F 22V	normalize and temper or quench and temper	1650 [900]	air cool or liquid	[B]	1250 [675]
F 23	normalize and temper	1900–1975 [1040–1080]	air cool accelerated cool	[B]	1350–1470 [730–800]
F 24	normalize and temper	1800–1975 [980–1080]	air cool or liquid	[B]	1350–1470 [730–800]
FR	anneal	1750 [955]	furnace cool	[B]	[B]
	normalize	1750 [955]	air cool	[B]	[B]
	normalize and temper	1750 [955]	air cool	[B]	1250 [675]
F 36, Class 1	normalize and temper	1650 [900]	air cool	[B]	1100 [595]
F 36, Class 2	normalize and temper or	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[E]	500 [260]	[B]
F 304H	solution treat and quench	1900 [1040]	liquid[E]	500 [260]	[B]
F 304L	solution treat and quench	1900 [1040]	liquid[E]	500 [260]	[B]
F 304N	solution treat and quench	1900 [1040]	liquid[E]	500 [260]	[B]
F 304LN	solution treat and quench	1900 [1040]	liquid[E]	500 [260]	[B]
F 309H	solution treat and quench	1900 [1040]	liquid[E]	500 [260]	[B]
F 310	solution treat and quench	1900 [1040]	liquid[E]	500 [260]	[B]
F 310S	solution treat and quench	1900 [1040]	liquid[E]	500 [260]	[B]
F 310H	solution treat and quench	1900 [1040]	liquid[E]	500 [260]	[B]
F 310MoLN	solution treat and quench	1900–2010 [1050–1100]	liquid[E]	500 [260]	[B]
F 316	solution treat and quench	1900 [1040]	liquid[E]	500 [260]	[B]
F 316H	solution treat and quench	1900 [1040]	liquid[E]	500 [260]	[B]
F 316L	solution treat and quench	1900 [1040]	liquid[E]	500 [260]	[B]
F 316N	solution treat and quench	1900 [1040]	liquid[E]	500 [260]	[B]

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 316LN	solution treat and quench	1900 [1040]	liquid[E]	500 [260]	[B]
F 316Ti	solution treat and quench	1900 [1040]	liquid[E]	500 [260]	[B]
F 317	solution treat and quench	1900 [1040]	liquid[E]	500 [260]	[B]
F 317L	solution treat and quench	1900 [1040]	liquid[E]	500 [260]	[B]
F317LNCb	solution treat and quench	1900 [1040]	liquid[E]	500 [260]	[B]
F 72	solution treat and quench	1975–2155 [1080–1180]	liquid[E]	500 [260]	[B]
F 73	solution treat and quench	1975–2155 [1080–1180]	liquid[E]	500 [260]	[B]
F 347	solution treat and quench	1900 [1040]	liquid[E]	500 [260]	[B]
F 347H	solution treat and quench	2000 [1095]	liquid[E]	500 [260]	[B]
F 347LN	solution treat and quench	1900 [1040]	liquid[E]	500 [260]	[B]
F 347LNCuB	solution treat and quench	1940–2140 [1060–1170]	liquid[E]	500 [260]	[B]
F 348	solution treat and quench	1900 [1040]	liquid[E]	500 [260]	[B]
F 348H	solution treat and quench	2000 [1095]	liquid[E]	500 [260]	[B]
F 321	solution treat and quench	1900 [1040]	liquid[E]	500 [260]	[B]
F 321H	solution treat and quench	2000 [1095]	liquid[E]	500 [260]	[B]
F XM-11	solution treat and quench	1900 [1040]	liquid[E]	500 [260]	[B]
F XM-19	solution treat and quench	1900 [1040]	liquid[E]	500 [260]	[B]
F 20	solution treat and quench	1700-1850 [925-1010]	liquid[E]	500 [260]	[B]
F 44	solution treat and quench	2100 [1150]	liquid[E]	500 [260]	[B]
F 45	solution treat and quench	1900 [1040]	liquid[E]	500 [260]	[B]
F 46	solution treat and quench	2010-2140 [1100-1140]	liquid[E]	500 [260]	[B]
F 47	solution treat and quench	1900 [1040]	liquid[E]	500 [260]	[B]
F 48	solution treat and quench	1900 [1040]	liquid[E]	500 [260]	[B]
F 49	solution treat and quench	2050 [1120]	liquid[E]	500 [260]	[B]
F 56	solution treat and quench	2050-2160 [1120-1180]	liquid[E]	500 [260]	[B]
F 58	solution treat and quench	2085 [1140]	liquid[E]	500 [260]	[B]
F 62	solution treat and quench	2025 [1105]	liquid[E]	500 [260]	[B]
F 63	solution treat and quench	1900 [1040]	liquid[E]	500 [260]	[B]
F 64	solution treat and quench	2010-2140 [1100-1170]	liquid[E]	500 [260]	[B]
F 904L	solution treat and quench	1920-2100 [1050-1150]	liquid[E]	500 [260]	[B]
F 70	solution treat and quench	1900 [1040]	liquid[D]	500 [260]	[B]
F700	solution treat and quench	2025-2100 [1107 -1149]	liquid/rapid cool	500 [260]	[B]
FNIC	solution treat and quench	1800-1900 [983-1038]	liquid/rapid cool	500 [260]	[B]
FNIC10	solution treat and quench	2100-2150 [1149-1177]	liquid/rapid cool	500 [260]	[B]
FNIC11	solution treat and quench	2100-2150 [1149-1177]	liquid/rapid cool	500 [260]	[B]
F1925	solution treat and quench	1800-1900 [983-1038]	liquid/rapid cool	500 [260]	[B]
F1925N	solution treat and quench	2150 [1177]	liquid/rapid cool	500 [260]	[B]
F35030	solution treat and quench	1900 [1040]	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]
F 68	solution treat and quench	1700–1920 [925–1050]	liquid	500 [260]	[B]
F 69	solution treat and quench	1870 [1020]	liquid	500 [260]	[B]
F 71	solution treat and quench	1925–2100 [1050–1150]	liquid	500 [260]	[B]

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

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 when agreed to by the purchaser, liquid quenching followed by tempering shall be permitted provided the temperatures in Table 1 for each grade are used.

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

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

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

7.3.1 Alternatively, immediately following hot working, while the temperature of the forging is not less than the minimum solution annealing temperature specified in Table 1, forgings made from austenitic grades (except grades F 304H, F 309H, F 310, F 310S, F 310H, F 316H, F 316Ti, F 321, F 321H, F 347, F 347H, F 348, F 348H, F 45, F35030, and F 56) may be individually rapidly quenched in accordance with the requirements of Table 1. Ferritic-austenitic grades may be solution annealed without cooling below 1000 °F by being re-heated to the solution annealing temperature required in Table 1, held for a time sufficient to dissolve phases and precipitates which may cause a reduction in corrosion or mechanical properties, and quenched in accordance with Table 1.

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

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

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

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

8. Chemical Composition

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

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

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

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

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

9. Mechanical Properties

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

9.2 Mechanical test specimens shall be obtained from production forgings, or from separately forged test blanks prepared from

TABLE 2 Chemical Requirements[A]

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

TABLE 2 *Continued*

Grade/Identification Symbol	UNS Designation	Composition, %										
		Carbon	Manganese	Phosphorus	Sulfur	Silicon	Nickel	Chromium	Molybdenum	Niobium[B]	Titanium	Other Elements
F 11 Class 3	K11572	0.10–0.20	0.30–0.80	0.040	0.040	0.50–1.00	...	1.00–1.50	0.44–0.65	...	...	...
F 12 Class 1	K11562	0.05–0.15	0.30–0.60	0.045	0.045	0.50 max	...	0.80–1.25	0.44–0.65	...	...	...
F 12 Class 2	K11564	0.10–0.20	0.30–0.80	0.040	0.040	0.10–0.60	...	0.80–1.25	0.44–0.65	...	...	...
F 21	K31545	0.05–0.15	0.30–0.60	0.040	0.040	0.50 max	...	2.7–3.3	0.80–1.06	...	...	...
F 3V	K31830	0.05–0.18	0.30–0.60	0.020	0.020	0.10	...	2.8–3.2	0.90–1.10	...	0.015–0.035	V 0.20–0.30 B 0.001–0.003
F 3VCb	K31390	0.10–0.15	0.30–0.60	0.020	0.010	0.10	0.25	2.7–3.3	0.90–1.10	0.015–0.070	0.015	V 0.20–0.30 Cu 0.25 Ca 0.0005–0.0150
F 22 Class 1	K21590	0.05–0.15	0.30–0.60	0.040	0.040	0.50	...	2.00–2.50	0.87–1.13	...	...	... ...
F 22 Class 3	K21590	0.05–0.15	0.30–0.60	0.040	0.040	0.50	...	2.00–2.50	0.87–1.13	...	...	...
F 22V	K31835	0.11–0.15	0.30–0.60	0.015	0.010	0.10	0.25	2.00–2.50	0.90–1.10	0.07	0.030	Cu 0.20 V 0.25–0.35 B 0.002 Ca 0.015[F]
F 23	K40712	0.04–0.10	0.10–0.60	0.030	0.010	0.50	0.40	1.90–2.60	0.05–0.30	0.02–0.08	0.005–0.060[G]	V 0.20–0.30 B 0.0010–0.006 N 0.015[G] Al 0.030 W 1.45–1.75
F 24	K30736	0.05–0.10	0.30–0.70	0.020	0.010	0.15–0.45	...	2.20–2.60	0.90–1.10	...	0.06-0.10	V 0.20–0.30 N 0.12 Al 0.020 B 0.0015–0.0070
FR	K22035	0.20	0.40–1.06	0.045	0.050	...	1.60–2.24	...	...	...	...	Cu 0.75–1.25
F 36	K21001	0.10–0.17	0.80–1.20	0.030	0.025	0.25–0.50	1.00–1.30	0.30	0.25–0.50	0.015–0.045		N 0.020 Al 0.050 Cu 0.50–0.80 V 0.02
Martensitic Stainless Steels												
F 6a	S41000	0.15	1.00	0.040	0.030	1.00	0.50	11.5–13.5	...	...	...	...
F 6b	S41026	0.15	1.00	0.020	0.020	1.00	1.00–2.00	11.5–13.5	0.40–0.60	...	...	Cu 0.50
F 6NM	S41500	0.05	0.50–1.00	0.030	0.030	0.60	3.5–5.5	11.5–14.0	0.50–1.00	...	...	...
Ferritic Stainless Steels												
F XM-27Cb	S44627	0.010[H]	0.40	0.020	0.020	0.40	0.50[H]	25.0–27.5	0.75–1.50	0.05–0.20	...	N 0.015[H] Cu 0.20[H]
F 429	S42900	0.12	1.00	0.040	0.030	0.75	0.50	14.0–16.0	...	...	...	...
F 430	S43000	0.12	1.00	0.040	0.030	0.75	0.50	16.0–18.0	...	...	...	...
Austenitic Stainless Steels												
F 304	S30400	0.08	2.00	0.045	0.030	1.00	8.0–11.0	18.0–20.0	...	...	...	N 0.10
F 304H	S30409	0.04–0.10	2.00	0.045	0.030	1.00	8.0–11.0	18.0–20.0	...	...	...	...
F 304L	S30403	0.030	2.00	0.045	0.030	1.00	8.0–13.0	18.0–20.0	...	...	...	N 0.10
F 304N	S30451	0.08	2.00	0.045	0.030	1.00	8.0–10.5	18.0–20.0	...	...	...	N 0.10–0.16
F 304LN	S30453	0.030	2.00	0.045	0.030	1.00	8.0–10.5	18.0–20.0	...	...	...	N 0.10–0.16
F 309H	S30909	0.04–0.10	2.00	0.045	0.030	1.00	12.0–15.0	22.0–24.0	...	...	...	...
F 310	S31000	0.25	2.00	0.045	0.030	1.00	19.0–22.0	24.0–26.0	...	...	...	...
F 310S	S31008	0.08	2.00	0.045	0.030	1.00	19.0–22.0	24.0–26.0	...	...	...	...
F 310H	S31009	0.04–0.10	2.00	0.045	0.030	1.00	19.0–22.0	24.0–26.0	...	...	...	...
F 310MoLN	S31050	0.030	2.00	0.030	0.015	0.40	21.0–23.0	24.0–26.0	2.00–3.00	...	...	N 0.10–0.16
F 316	S31600	0.08	2.00	0.045	0.030	1.00	10.0–14.0	16.0–18.0	2.00–3.00	...	...	N 0.10
F 316H	S31609	0.04–0.10	2.00	0.045	0.030	1.00	10.0–14.0	16.0–18.0	2.00–3.00	...	...	...
F 316L	S31603	0.030	2.00	0.045	0.030	1.00	10.0–15.0	16.0–18.0	2.00–3.00	...	...	N 0.10
F 316N	S31651	0.08	2.00	0.045	0.030	1.00	11.0–14.0	16.0–18.0	2.00–3.00	...	...	N 0.10–0.16
F 316LN	S31653	0.030	2.00	0.045	0.030	1.00	11.0–14.0	16.0–18.0	2.00–3.00	...	...	N 0.10–0.16
F 316Ti	S31635	0.08	2.00	0.045	0.030	1.00	10.0–14.0	16.0–18.0	2.00–3.00	...	[I]	N 0.10 max
F 317	S31700	0.08	2.00	0.045	0.030	1.00	11.0–15.0	18.0–20.0	3.0–4.0	...	...	...
F 317L	S31703	0.030	2.00	0.045	0.030	1.00	11.0–15.0	18.0–20.0	3.0–4.0	...	...	...
F 317LNCb	S31740	0.005–0.020	2.00	0.045	0.030	1.00	11.0–15.0	17.0–19.0	3.0–4.5	0.20–0.50[N]	...	...
F 72	S31727	0.030	1.00	0.030	0.030	1.00	14.5–16.5	17.5–19.0	3.8–4.5	...	...	Cu 2.8–4.0 N 0.15–0.21
F 70	S31730	0.030	2.00	0.040	0.010	1.00	15–16.5	17.0–19.0	3.0–4.0	...	...	Cu 4.0–5.0 N 0.045
F 73	S32053	0.030	1.00	0.030	0.010	1.00	24.0–28.0	22.0–24.0	5.0–6.0	...	...	N 0.17–0.22
F 321	S32100	0.08	2.00	0.045	0.030	1.00	9.0–12.0	17.0–19.0	...	...	[J]	...

TABLE 2 *Continued*

Grade/Identification Symbol	UNS Designation	Composition, %										
		Carbon	Manganese	Phosphorus	Sulfur	Silicon	Nickel	Chromium	Molybdenum	Niobium[B]	Titanium	Other Elements
F 321H	S32109	0.04–0.10	2.00	0.045	0.030	1.00	9.0–12.0	17.0–19.0	...	...	[K]	...
F 347	S34700	0.08	2.00	0.045	0.030	1.00	9.0–13.0	17.0–20.0	...	[L]	...	...
F 347H	S34709	0.04–0.10	2.00	0.045	0.030	1.00	9.0–13.0	17.0–20.0	...	[M]	...	...
F347LN	S34751	0.005–0.020	2.00	0.045	0.030	1.00	9.0–13.0	17.0–19.0	...	0.20–0.50[N]	...	N 0.06–0.10
F347LNCuB	S34752	0.005-0.020	2.00	0.035	0.010	0.60	10.0-13.0	17.0-19.0	0.20-1.20	0.20–0.50[N]	...	Cu 2.50-3.50 B 0.001-0.005 N 0.06-0.12
F 348	S34800	0.08	2.00	0.045	0.030	1.00	9.0–13.0	17.0–20.0	...	[L]	...	Co 0.20 Ta 0.10
F 348H	S34809	0.04–0.10	2.00	0.045	0.030	1.00	9.0–13.0	17.0–20.0	...	[M]	...	Co 0.20 Ta 0.10
F XM-11	S21904	0.040	8.0–10.0	0.060	0.030	1.00	5.5–7.5	19.0–21.5	...	...	...	N 0.15–0.40
F XM-19	S20910	0.06	4.0–6.0	0.040	0.030	1.00	11.5–13.5	20.5–23.5	1.50–3.00	0.10–0.30	...	N 0.20–0.40 V 0.10–0.30
F 20	N08020	.07	2.00	0.045	0.035	1.00	32.0–38.0	19.0–21.0	2.00–3.00	8xCmin –1.00	...	Cu 3.0–4.0
F 44	S31254	0.020	1.00	0.030	0.010	0.80	17.5–18.5	19.5–20.5	6.0–6.5	...	...	Cu 0.50–1.00 N 0.18–0.25
F 45	S30815	0.05–0.10	0.80	0.040	0.030	1.40–2.00	10.0–12.0	20.0–22.0	...	...	...	N 0.14–0.20 Ce 0.03–0.08
F 46	S30600	0.018	2.00	0.020	0.020	3.7–4.3	14.0–15.5	17.0–18.5	0.20	...	...	Cu 0.50
F 47	S31725	0.030	2.00	0.045	0.030	0.75	13.0–17.5	18.0–20.0	4.0–5.0	...	...	N 0.10
F 48	S31726	0.030	2.00	0.045	0.030	0.75	13.5–17.5	17.0–20.0	4.0–5.0	...	...	N 0.10–0.20
F 49	S34565	0.030	5.0–7.0	0.030	0.010	1.00	16.0–18.0	23.0–25.0	4.0–5.0	0.10	...	N 0.40–0.60
F 56	S33228	0.04–0.08	1.00	0.020	0.015	0.30	31.0–33.0	26.0–28.0	...	0.6–1.0	...	Ce 0.05–0.10 Al 0.025
F 58	S31266	0.030	2.0–4.0	0.035	0.020	1.00	21.0–24.0	23.0–25.0	5.2–6.2	...	...	N 0.35–0.60 Cu 1.00–2.50 W 1.50–2.50
F 62	N08367	0.030	2.00	0.040	0.030	1.00	23.5–25.5	20.0–22.0	6.0–7.0	...	...	N 0.18–0.25 Cu 0.75
F 63	S32615	0.07	2.00	0.045	0.030	4.8–6.0	19.0-22.0	16.5–19.5	0.30–1.50	...	...	Cu 1.50–2.50
F 64	S30601	0.015	0.50–0.80	0.030	0.013	5.0–5.6	17.0–18.0	17.0–18.0	0.20	...	...	Cu 0.35, N 0.05
F 904L	N08904	0.020	2.0	0.040	0.030	1.00	23.0–28.0	19.0–23.0	4.0–5.0	...	...	Cu 1.00–2.00 N 0.10
F700	N08700	0.04	2.00	0.040	0.030	1.00	24.0-26.0	19.0-23.0	4.3-5.0	8XC Min 0.40 Max	...	Cu 0.50
FNIC	N08800	0.10	1.50	0.045	0.015	1.00	30.0-35.0	19.0-23.0	...	...	0.15-0.60	Al 0.15-0.60 Cu 0.75 Fe 39.5 min
FNIC10	N08810	0.05-0.10	1.50	0.045	0.015	1.00	30.0-35.0	19.0-23.0	...	...	0.15-0.60	Al 0.15-0.60 Cu 0.75 Fe 39.5 min
FNIC11	N08811	0.06-0.10	1.50	0.040	0.015	1.00	30.0-35.0	19.0-23.0	...	...	0.25-0.60[Q]	Cu 0.75 Al 0.25-0.60[Q] Fe 39.5 min
F1925	N08925	0.020	1.00	0.045	0.030	0.50	24.0-26.0	19.0-21.0	6.0-7.0	...	...	N_2 0.10-0.20[R] Cu 0.80-1.50
F1925N	N08926	0.020	2.00	0.030	0.010	0.50	24.0-26.0	19.0-21.0	6.0-7.0	...	...	N_2 0.15-0.25[R] Cu 0.50-1.50
F35030	S35030	0.05-0.10	1.50	0.030	0.015	0.50-2.0	22.5-27.5	18.5-22.5	...	0.25-0.75	...	N: 0.05-0.15 Cu: 2.50-3.50
Ferritic-Austenitic Stainless Steels												
F 50	S31200	0.030	2.00	0.045	0.030	1.00	5.5–6.5	24.0–26.0	1.20–2.00	...	...	N 0.14–0.20
F 51	S31803	0.030	2.00	0.030	0.020	1.00	4.5–6.5	21.0–23.0	2.5–3.5	...	...	N 0.08–0.20
F 69	S32101	0.040	4.00–6.00	0.040	0.030	1.00	1.35–1.70	21.0–22.0	0.10–0.80	...	...	N 0.20–0.25 Cu 0.10–0.80
F 52	S32950	0.030	2.00	0.035	0.010	0.60	3.5–5.2	26.0–29.0	1.00–2.50	...	...	N 0.15–0.35
F 53	S32750	0.030	1.20	0.035	0.020	0.80	6.0–8.0	24.0–26.0	3.0–5.0	...	...	N 0.24–0.32[S] Cu 0.50
F 54	S39274	0.030	1.00	0.030	0.020	0.80	6.0–8.0	24.0–26.0	2.5–3.5	...	...	N 0.24–0.32 Cu 0.20–0.80 W 1.50–2.50
F 55	S32760	0.030	1.00	0.030	0.010	1.00	6.0–8.0	24.0–26.0	3.0–4.0	...	...	N 0.20–0.30 Cu 0.50–1.00 W 0.50–1.00[O]
F 57	S39277	0.025	0.80	0.025	0.002	0.80	6.5–8.0	24.0–26.0	3.0–4.0	...	...	Cu 1.20–2.00 W 0.80–1.20 N 0.23–0.33

TABLE 2 *Continued*

Grade/Identification Symbol	UNS Designation	Composition, %										
		Carbon	Manganese	Phosphorus	Sulfur	Silicon	Nickel	Chromium	Molybdenum	Niobium[B]	Titanium	Other Elements
F 59	S32520	0.030	1.50	0.035	0.020	0.80	5.5–8.0	24.0–26.0	3.0–5.0	...	...	N 0.20–0.35 Cu 0.50–3.00
F 60	S32205	0.030	2.00	0.030	0.020	1.00	4.5–6.5	22.0–23.0	3.0–3.5	...	...	N 0.14–0.20
F 61	S32550	0.040	1.50	0.040	0.030	1.00	4.5–6.5	24.0–27.0	2.9–3.9	...	...	Cu 1.50–2.50 N 0.10–0.25
F 65	S32906	0.030	0.80–1.50	0.030	0.030	0.80	5.8–7.5	28.0–30.0	1.5–2.6	...	...	Cu 0.80 N 0.30–0.40
F 66	S32202	0.030	2.00	0.040	0.010	1.00	1.00–2.80	21.5–24.0	0.45	...	...	N 0.18–0.26
F 67	S32506	0.030	1.00	0.040	0.015	0.90	5.5–7.2	24.0–26.0	3.0–3.5	...	...	N 0.08–0.20 W 0.05–0.30
F 68	S32304	0.030	2.50	0.040	0.030	1.00	3.0–5.5	21.5–24.5	0.05–0.60	...	...	N 0.05–0.20 Cu 0.05–0.60
F 71	S32808	0.030	1.10	0.030	0.010	0.50	7.0–8.2	27.0–27.9	0.80–1.2	...	...	N 0.30–0.40 W 2.10–2.50

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

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

9.3 For normalized and tempered, or quenched and tempered forgings, the central axis of the test specimen shall be taken at least ¼ *T* from the nearest surface as-heat-treated, where *T* is the maximum heat-treated thickness of the represented forging. In addition, for quenched and tempered forgings, the mid-length of the test specimen shall be at least *T* from all other surfaces as-heat-treated, exclusive of the *T* dimension surfaces. When the section thickness does not permit this positioning, the test specimen shall be positioned as near as possible to the prescribed location, as agreed to by the purchaser and the supplier.

9.3.1 With prior purchase approval, the test specimen for ferritic steel forgings may be taken at a depth (*t*) corresponding to the distance from the area of significant stress to the nearest heat-treated surface and at least twice this distance (2 *t*) from any second surface. However, the test depth shall not be nearer to one treated surface than ¾ in. [19 mm] and to the second treated surface than 1½ in. [38 mm]. This method of test specimen location would normally apply to contour-forged parts, or parts with thick cross-sectional areas where ¼ *T* × *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