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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 Service¹

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 specification² 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.

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

2. Referenced Documents

2.1 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

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

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.

🕼 A182/A182M – 18a

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

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 Examination 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 Specifications⁵

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: 1 efc 70-940e-4c1f-8fb4-a11313d3afab/astm-a182-a182m-18a

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.

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.



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 Cylindrically-shaped low alloy, martensitic stainless, ferritic stainless, and ferritic-austenitic stainless steel parts, NPS-4 [DN 100] and under, may be machined from forged or rolled bar, without additional hot working.

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 Treatment⁶

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

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

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

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

7.3.1 Alternatively, immediately following hot working, while the temperature of the forging is not less than the minimum solution annealing temperature specified in Table 1, forgings made from austenitic grades (except grades F 304H, F 309H, F 310, F 310H, F 316H, F 321, F 321H, F 347, F 347H, F 348, F 348H, F 45, and F 56) may be individually rapidly quenched in accordance with the requirements of Table 1. Ferritic-austenitic grades may be solution annealed without cooling below 1000 °F by being re-heated to the 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).

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

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 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).

🕼 A182/A182M – 18a

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]
			oy Steels		
1	anneal	1650 [900]	furnace cool	В	В
	normalize and temper	1650 [900]	air cool	В	1150 [620]
2	anneal	1650 [900]	furnace cool	B B	В
с с .	normalize and temper	1650 [900]	air cool	B	1150 [620] B
5, F 5a	anneal normalize and temper	1750 [955] 1750 [955]	furnace cool air cool	B	1250 [675]
9	anneal	1750 [955]	furnace cool	В	B
•	normalize and temper	1750 [955]	air cool	В	1250 [675]
10	solution treat and quench	1900 [1040]	liquid	500 [260]	B
91 Types 1 and 2	normalize and temper or quench and temper	1900–1975 [1040–1080]	air cool, accelerated air cool, or liquid	В	1350–1470 [730–800]
92	normalize and temper	1900–1975 [1040–1080]	air cool	В	1350–1470 [730–800]
93	normalize and temper	1960–2140 [1070–1170]	air cool	385 [200]	1380–1455 [750–790]
<u>115</u>	normalize and temper	<u>1920–2010 [1050–1100]</u>	air cool, accelerated air cool, or liquid	В В	1380-1455 [750-790]
122	normalize and temper	1900–1975 [1040–1080]	air cool	В	1350–1470 [730–800]
911	normalize and temper	1900–1975 [1040–1080]	air cool or liquid	В	1365–1435 [740–780] в
11, Class 1, 2, 3	anneal normalize and temper	1650 [900] 1650 [900]	furnace cool air cool	В	
12, Class 1, 2	anneal	1650 [900]	furnace cool	В	1150 [620] ^B
12, 01055 1, 2	normalize and temper	1650 [900]	air cool	В	1150 [620]
21, F 3V, and F /Cb	anneal	1750 [955]	furnace cool	В	B
	normalize and temper	1750 [955]	air cool	B	1250 [675] ^B
22, Class 1, 3	anneal	1650 [900]	furnace cool	B	
001/	normalize and temper	1650 [900]	air cool	В	1250 [675]
22V	normalize and temper or quench and temper	1650 [900]	air cool or liquid	B	1250 [675]
23	normalize and temper	1900–1975 [1040–1080]	air cool accelerated cool	В	1350–1470 [730–800]
24	normalize and temper	1800–1975 [980–1080]	air cool or liquid	h.ai)	1350–1470 [730–800] в
R	anneal	1750 [955]	furnace cool	В	B
	normalize	1750 [955]	air cool	B	
36, Class 1	normalize and temper	1750 [955] 1650 [900]	air cool revie	в	1250 [675]
36, Class 1	normalize and temper normalize and temper or	1650 [900]	air cool,	В	1100 [595] 1100 [595]
50, 01833 Z	quench and temper	1650 [900]	accelerated air cool,		1100 [595]
		ASTM A181	or liquid		
6a Class 1				B	
	anneal 1	not specified / 1 C 70			^B 92 - 192 - 19
mq55/Standa	anneal normalize and temper	not specified not specified not required	furnace cool _ 8164-a air cool	400 [205]	^B 225 [725] 1325 [725]
	normalize and temper	not specified not required	air cool ^B	400 [205]	⁸ 1325 [725] 1325 [725] ⁸
6a Class 2	normalize and temper temper anneal	not specified not required not specified	air cool ^B furnace cool	400 [205] в	1325 [725] в
	normalize and temper	not specified not required	air cool ^B	400 [205] <i>B</i> 400 [205] <i>B</i> 400 [205] <i>B</i>	1325 [725] <i>B</i> 1250 [675] 1250 [675]
6a Class 2	normalize and temper temper anneal normalize and temper	not specified not required not specified not specified	air cool ^B furnace cool air cool	400 [205] <i>B</i> 400 [205]	1325 [725] ^B 1250 [675]
6a Class 2 6a Class 3	normalize and temper temper anneal normalize and temper temper anneal normalize and temper	not specified not required not specified not specified not required not specified not specified	air cool B furnace cool air cool B furnace cool air cool	400 [205] <i>B</i> 400 [205] <i>B</i> 400 [205] <i>B</i> 400 [205]	1325 [725] ^B 1250 [675] 1250 [675]
6a Class 2 6a Class 3	normalize and temper temper anneal normalize and temper temper anneal normalize and temper anneal	not specified not specified not specified not specified not specified not specified not specified not specified	air cool B furnace cool air cool furnace cool air cool furnace cool air cool furnace cool	400 [205] <i>B</i> 4000 [205] <i>B</i> 4000 [205] <i>B</i> 4000 [205] <i>B</i> 4000 [205] <i>B</i>	1325 [725] ^B 1250 [675] 1250 [675] ^B 1100 [595] ^B
6a Class 2 6a Class 3 6a Class 4	normalize and temper temper anneal normalize and temper temper anneal normalize and temper anneal normalize and temper	not specified not specified not specified not specified not specified not specified not specified not specified not specified	air cool B furnace cool air cool furnace cool air cool furnace cool air cool furnace cool air cool	400 [205] <i>B</i> 400 [205] <i>B</i> 400 [205] <i>B</i> 400 [205] <i>B</i> 400 [205]	1325 [725] ^B 1250 [675] 1250 [675] ^B
6a Class 2 6a Class 3 6a Class 4	normalize and temper temper anneal normalize and temper temper anneal normalize and temper anneal normalize and temper anneal	not specified not specified not specified not specified not specified not specified not specified not specified not specified 1750 [955]	air cool B furnace cool air cool furnace cool air cool furnace cool air cool furnace cool air cool furnace cool air cool furnace cool	400 [205] <i>B</i> 400 [205] <i>B</i> 400 [205] <i>B</i> 400 [205] <i>B</i> 400 [205] <i>B</i> 400 [205] <i>B</i>	1325 [725] ^B 1250 [675] 1250 [675] ^B 1100 [595] 1000 [540] ^B
6a Class 2 6a Class 3 6a Class 4 6b	normalize and temper temper anneal normalize and temper temper anneal normalize and temper anneal normalize and temper anneal normalize and temper	not specified not specified not specified not specified not specified not specified not specified not specified 1750 [955] 1750 [955]	air cool B furnace cool air cool B furnace cool air cool furnace cool air cool furnace cool air cool furnace cool air cool furnace cool air cool furnace cool air cool	400 [205] <i>B</i> 400 [205] <i>B</i> 400 [205] <i>B</i> 400 [205] <i>B</i> 400 [205] 400 [205]	1325 [725] ^B 1250 [675] 1250 [675] ^B 1100 [595] ^B 1000 [540] ^B 1150 [620]
6a Class 2 6a Class 3 6a Class 4 6b 6NM	normalize and temper temper anneal normalize and temper temper anneal normalize and temper anneal normalize and temper anneal normalize and temper normalize and temper	not specified not required not specified not specified not specified not specified not specified not specified 1750 [955] 1750 [955] 1850 [1010]	air cool B furnace cool air cool furnace sool air cool air cool air cool air cool air cool air cool air cool	400 [205] <i>B</i> 400 [205] <i>B</i> 400 [205] <i>B</i> 400 [205] <i>B</i> 400 [205] <i>B</i> 400 [205] <i>B</i> 400 [205] <i>B</i> 400 [205]	1325 [725] ^B 1250 [675] 1250 [675] ^B 1100 [595] ^B 1000 [540] ^B 1150 [620] 1040–1120 [560–600]
6a Class 2 6a Class 3 6a Class 4 6b 6NM XM-27 Cb	normalize and temper temper anneal normalize and temper temper anneal normalize and temper anneal normalize and temper anneal normalize and temper normalize and temper anneal	not specified not specified not specified not specified not specified not specified not specified not specified 1750 [955] 1850 [1010] Ferritic Sta	air cool B furnace cool air cool furnace cool	400 [205] B 400 [205] B 40	1325 [725] ^В 1250 [675] 1250 [675] ^В 1100 [595] ^В 1000 [540] ^В 1150 [620] 1040–1120 [560–600] В
6a Class 2 6a Class 3 6a Class 4 6b 6NM XM-27 Cb 429	normalize and temper temper anneal normalize and temper temper anneal normalize and temper anneal normalize and temper anneal normalize and temper normalize and temper anneal anneal	not specified not specified not specified not specified not specified not specified not specified not specified not specified 1750 [955] 1850 [1010] Ferritic Sta 1850 [1010]	air cool B furnace cool air cool furnace cool furnace cool furnace cool furnace cool	400 [205] <i>B</i> 400 [205] <i>B</i> 400 [205] <i>B</i> 400 [205] <i>B</i> 400 [205] <i>B</i> 400 [205] <i>B</i> 400 [205] <i>B</i> 400 [205]	1325 [725] ^B 1250 [675] 1250 [675] ^B 1100 [595] ^B 1000 [540] ^B 1150 [620] 1040–1120 [560–600]
6a Class 2 6a Class 3 6a Class 4 6b 6NM XM-27 Cb 429	normalize and temper temper anneal normalize and temper temper anneal normalize and temper anneal normalize and temper anneal normalize and temper normalize and temper anneal	not specified not specified not specified not specified not specified not specified not specified not specified 1750 [955] 1750 [955] 1850 [1010] 1850 [1010] not specified	air cool B furnace cool air cool furnace cool air cool furnace cool air cool furnace cool air cool inless Steels furnace cool furnace cool	A00 [205] B 400 [200] B 400 [200] B 40	1325 [725] ^В 1250 [675] 1250 [675] ^В 1100 [595] ^В 1000 [540] ^В 1150 [620] 1040–1120 [560–600] ^В ^В
6a Class 2 6a Class 3 6a Class 4 6b 6NM	normalize and temper temper anneal normalize and temper temper anneal normalize and temper anneal normalize and temper anneal normalize and temper normalize and temper anneal anneal	not specified not specified not specified not specified not specified not specified not specified not specified 1750 [955] 1750 [955] 1850 [1010] 1850 [1010] not specified	air cool B furnace cool air cool furnace cool furnace cool furnace cool furnace cool	A00 [205] B 400 [200] B 400 [200] B 40	1325 [725] B 1250 [675] 1250 [675] B 1100 [595] B 1000 [540] B 1150 [620] 1040–1120 [560–600] B B B B
6a Class 2 6a Class 3 6a Class 4 6b 6NM XM-27 Cb 429 430 304 304	normalize and temper temper anneal normalize and temper temper anneal normalize and temper anneal normalize and temper anneal normalize and temper normalize and temper anneal anneal anneal anneal	not specified not specified not specified not specified not specified not specified not specified not specified 1750 [955] 1750 [955] 1850 [1010] 1850 [1010] 1850 [1010] not specified Austenitic S	air cool B furnace cool air cool furnace cool air cool furnace cool air cool furnace cool air cool inless Steels furnace cool furnace cool	400 [205] B 400 [200] B 400 [200] B 40	1325 [725] B 1250 [675] 1250 [675] B 1100 [595] B 1000 [540] B 1150 [620] 1040–1120 [560–600] B B B B B B
6a Class 2 6a Class 3 6a Class 4 6b 6NM XM-27 Cb 429 430 304 304 304 304	normalize and temper temper anneal normalize and temper temper anneal normalize and temper anneal normalize and temper anneal normalize and temper normalize and temper normalize and temper anneal anneal anneal anneal anneal	not specified not required not specified not specified not specified not specified not specified not specified 1750 [955] 1750 [955] 1850 [1010] Ferritic Sta 1850 [1010] not specified Austenitic S 1900 [1040]	air cool $_{B}$ furnace cool air cool furnace cool air cool furnace cool air cool furnace cool air cool inless Steels furnace cool furnace cool	400 [205] B 400 [205] B 400 [205] B 400 [205] B 400 [205] B 400 [205] B 400 [205] B 500 [260]	1325 [725] B 1250 [675] 1250 [675] B 1000 [595] B 1000 [540] B 1150 [620] 1040–1120 [560–600] B B B B B B B B
6a Class 2 6a Class 3 6a Class 4 6b 6NM XM-27 Cb 429 430 304 304 304 304 304 N	normalize and temper temper anneal normalize and temper temper anneal normalize and temper anneal normalize and temper anneal normalize and temper normalize and temper anneal	not specified not specified not specified not specified not specified not specified not specified not specified not specified 1750 [955] 1850 [1010] Ferritic Sta 1850 [1010] not specified Austenitic S 1900 [1040] 1900 [1040] 1900 [1040]	air cool B furnace cool air cool furnace cool air cool furnace cool air cool furnace cool air cool inless Steels furnace cool furnace furnace furnace cool furnace furnace furnace for the furnace fur	A00 [205] B 400 [205] B 400 [205] B 400 [205] B 400 [205] B 400 [205] B 400 [205] B 400 [205] B 500 [205] 500 [260] 500 [260] 500 [260] 500 [260]	1325 [725] B 1250 [675] 1250 [675] B 1100 [595] B 1000 [540] B 1150 [620] 1040–1120 [560–600] B B B B B B B B B
6a Class 2 6a Class 3 6a Class 4 6b 6NM XM-27 Cb 429 430 304 304H 304L 304N 304LN	normalize and temper temper anneal normalize and temper temper anneal normalize and temper anneal normalize and temper anneal normalize and temper normalize and temper anneal anneal anneal anneal solution treat and quench solution treat and quench solution treat and quench solution treat and quench	not specified not specified not specified not specified not specified not specified not specified not specified not specified 1750 [955] 1850 [1010] Ferritic Sta 1850 [1010] not specified Austenitic S 1900 [1040] 1900 [1040] 1900 [1040]	air cool B furnace cool air cool furnace cool air cool furnace cool air cool furnace cool air cool air cool inless Steels furnace cool furnace	A00 [205] B 400 [205] B 400 [205] B 400 [205] B 400 [205] B 400 [205] B 400 [205] B 500 [205] 500 [260] 500 [260] 500 [260] 500 [260] 500 [260] 500 [260]	1325 [725] ^B 1250 [675] 1250 [675] ^B 1100 [595] ^B 1000 [540] ^B 1150 [620] 1040–1120 [560–600] ^B ^B ^B ^B ^B ^B ^B ^B
6a Class 2 6a Class 3 6a Class 4 6b 6NM XM-27 Cb 429 430 304 304 304L 304L 304L 304L 304L 30	normalize and temper temper anneal normalize and temper temper anneal normalize and temper anneal normalize and temper anneal normalize and temper normalize and temper normalize and temper solution treat and quench solution treat and quench	not specified not required not specified not specified not specified not specified not specified not specified 1750 [955] 1750 [955] 1850 [1010] Ferritic Sta 1850 [1010] not specified Austenitic S 1900 [1040] 1900 [1040] 1900 [1040] 1900 [1040]	air cool B furnace cool air cool furnace cool air cool furnace cool air cool furnace cool air cool furnace fund fund fund liquid fund liquid fund liquid fund liquid fun	A00 [205] B 400 [205] B 400 [205] B 400 [205] B 400 [205] B 400 [205] 200 [95] B 500 [260] 500 [260] 500 [260] 500 [260] 500 [260] 500 [260] 500 [260] 500 [260]	1325 [725] B 1250 [675] 1250 [675] B 1100 [595] B 1000 [540] B 1150 [620] 1040–1120 [560–600] B B B B B B B B B B B B B
6a Class 2 6a Class 3 6a Class 4 6b 6NM XM-27 Cb 429 430 304 304H 304H 304H 304L 304N 304LN 309H 310	normalize and temper temper anneal normalize and temper temper anneal normalize and temper anneal normalize and temper anneal normalize and temper normalize and temper anneal anna	not specified not required not specified not specified not specified not specified not specified not specified not specified 1750 [955] 1850 [1010] Ferritic Sta 1850 [1010] not specified Austenitic S 1900 [1040] 1900 [1040] 1900 [1040] 1900 [1040] 1900 [1040]	air cool air cool air cool air cool air cool furnace cool air cool furnace cool air cool furnace cool air cool inless Steels furnace cool furnace fiquid ^E liquid ^E liquid ^E liquid ^E liquid ^E liquid ^E liquid ^E liquid ^E liquid ^E liquid ^E	400 [205] B 500 [200] 500 [260] 500 [260] 500 [260] 500 [260] 500 [260] 500 [260] 500 [260] 500 [260]	1325 [725] B 1250 [675] 1250 [675] B 1100 [595] B 1000 [540] B 1150 [620] 1040–1120 [560–600] B B B B B B B B B B B B B
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6a Class 2 6a Class 3 6a Class 4 6b 6NM XM-27 Cb 429 430 304 304 304 304 304 304 304 304 304	normalize and temper temper anneal normalize and temper temper anneal normalize and temper anneal normalize and temper anneal normalize and temper anneal normalize and temper anneal anneal anneal anneal solution treat and quench solution treat and quench	not specified not specified not specified not specified not specified not specified not specified not specified not specified not specified 1750 [955] 1850 [1010] Ferritic Sta 1850 [1010] not specified Austenitic S 1900 [1040] 1900 [1040]	air cool B furnace cool air cool b furnace cool air cool furnace cool air cool furnace cool air cool air cool air cool air cool air cool air cool air cool turnace cool furnace function furnace function furnace function fu	A00 [205] B A00 [205] B 400 [205] B 400 [205] B 400 [205] B 400 [205] B 400 [205] B 400 [205] B 500 [260] 500 [260]	1325 [725] B 1250 [675] 1250 [675] B 1100 [595] B 1000 [540] B 1150 [620] 1040–1120 [560–600] B B B B B B B B B B B B B
6a Class 2 6a Class 3 6a Class 4 6b 6NM XM-27 Cb 429 430 304 304H 304H 304L 304H 304L 304H 304L 309H 310 310H 310M 310M 310M 310M	normalize and temper temper anneal normalize and temper temper anneal normalize and temper anneal normalize and temper anneal normalize and temper anneal normalize and temper anneal anneal anneal anneal anneal solution treat and quench solution treat and quench	not specified not specified <u>Ferritic Sta</u> 1850 [1010] 1850 [1010] not specified <u>Austenitic S</u> 1900 [1040] 1900 [1040] 1900 [1040] 1900 [1040] 1900 [1040] 1900 [1040] 1900 [1040] 1900 [1040] 1900 [1040] 1900 [1040]	air cool B furnace cool air cool furnace cool air cool furnace cool air cool furnace cool air cool furnace furnace liquid ^E liquid ^E liquid liquid ^E liquid liquid liq	400 [205] B 400 [205] B 400 [205] B 400 [205] B 400 [205] B 400 [205] B 400 [205] B 400 [205] B 500 [205] 500 [25] 500 [25] 500 [260] 500 [260]	1325 [725] B 1250 [675] 1250 [675] B 1100 [595] B 11000 [540] B 1150 [620] 1040-1120 [560-600] B B B B B B B B B B B B B

∰ A182/A182M – 18a

Temperature, Minimum Media Below °F [°C] Minimu			
F 3101 Solution treat and quench 1300 [1040] liquid 300 [260] F 317L solution treat and quench 1390 [1040] liquid ^E 500 [260] # F 317 solution treat and quench 1397.5-2155 [1080-1180] liquid ^E 500 [260] # F 33 solution treat and quench 1397.5-2155 [1080-1180] liquid ^E 500 [260] # F 347 solution treat and quench 1900 [1040] liquid ^E 500 [260] # F 347 solution treat and quench 1900 [1040] liquid ^E 500 [260] # F 347LN solution treat and quench 1900 [1040] liquid ^E 500 [260] # F 348 solution treat and quench 1900 [1040] liquid ^E 500 [260] # F 321 solution treat and quench 1900 [1040] liquid ^E 500 [260] # F 347 solution treat and quench 1900 [1040] liquid ^E 500 [260] # F 347 solution treat and quench 1900 [1040] <thliquid<sup>E 500 [260]</thliquid<sup>	Tempering Temperature, Minimum or Range, °F [°C]		
511 solution treat and quench 1000 1000 inquide 500 260 # F 72 solution treat and quench 1975-2155 1080-1180 liquide 500 260 # F 73 solution treat and quench 1975-2155 1080-1180 liquide 500 260 # F 347 solution treat and quench 1900 10401 liquide 500 260 # F 347H solution treat and quench 1900 10401 liquide 500 260 # F 348H solution treat and quench 1900 10401 liquide 500 260 # F 341 solution treat and quench 1900 10401 liquide 500 260 # F 321H solution treat and quench 1900 10401 liquide 500 260 # F XM-10 solution treat and quench 1900 10401 liquide 500 260 # F 44 solution treat and quench 1900 10401 liquide 500 260 # <			
F 31/L Solution treat and quench 1800 [1040] inquide 300 [260] a F 72 solution treat and quench 1975–2155 [1080–1180] liquide 500 [260] a F 73 solution treat and quench 1907–2155 [1080–1180] liquide 500 [260] a F 347 solution treat and quench 1900 [1040] liquide 500 [260] a F 347 solution treat and quench 1900 [1040] liquide 500 [260] a F 347 solution treat and quench 1900 [1040] liquide 500 [260] a F 348 solution treat and quench 1900 [1040] liquide 500 [260] a F 321 solution treat and quench 1900 [1040] liquide 500 [260] a F 347 solution treat and quench 1900 [1040] liquide 500 [260] a F 44 solution treat and quench 1900 [1040] liquide 500 [260] a F 45 solution treat and quench 1900 [1040] liquide 500 [260] a			
F2 Solution treat and quench 1973–2155 [1080–1180] liquid # 500 [200] # F347 solution treat and quench 1900 [1040] liquid # 500 [260] # F347H solution treat and quench 1900 [1040] liquid # 500 [260] # F347LN solution treat and quench 1900 [1040] liquid # 500 [260] # F348H solution treat and quench 1900 [1040] liquid # 500 [260] # F321H solution treat and quench 1900 [1040] liquid # 500 [260] # FXM-11 solution treat and quench 1900 [1040] liquid # 500 [260] # F44 solution treat and quench 1900 [1040] liquid # 500 [260] # F44 solution treat and quench 1900 [1040] liquid # 500 [260] # F44 solution treat and quench 1900 [1040] liquid # 500 [260] # F44 solution treat and quench 1900 [1040] liquid # 500 [260] # F44 solution treat and quench 1900 [1040] liquid #			
7.3 solution treat and quench 1900 [1040] liquid # 5.00 [260] # F 347 solution treat and quench 2000 [1040] liquid # 5.00 [260] # F 347 solution treat and quench 1900 [1040] liquid # 5.00 [260] # F 348 solution treat and quench 1900 [1040] liquid # 5.00 [260] # F 347 solution treat and quench 1900 [1040] liquid # 5.00 [260] # F 321 solution treat and quench 1900 [1040] liquid # 5.00 [260] # F 321.H solution treat and quench 1900 [1040] liquid # 5.00 [260] # F XM-11 solution treat and quench 1900 [1040] liquid # 5.00 [260] # F 44 solution treat and quench 1900 [1040] liquid # 5.00 [260] # F 45 solution treat and quench 1900 [1040] liquid # 5.00 [260] # F 44 solution treat and quench 1900 [1040] liquid # 5.00 [260] # F 46 solution treat and quench 1900 [1040] liq			
F 347LM solution treat and quench 2000 [1095] liquid ^E 500 [260] # F 34RLN solution treat and quench 1900 [1040] liquid ^E 500 [260] # F 348 solution treat and quench 1900 [1040] liquid ^E 500 [260] # F 348 solution treat and quench 2000 [1095] liquid ^E 500 [260] # F 321 solution treat and quench 2000 [1040] liquid ^E 500 [260] # F XM-11 solution treat and quench 1900 [1040] liquid ^E 500 [260] # F XM-13 solution treat and quench 1900 [1040] liquid ^E 500 [260] # F 44 solution treat and quench 1900 [1040] liquid ^E 500 [260] # F 45 solution treat and quench 1900 [1040] liquid ^E 500 [260] # F 46 solution treat and quench 1900 [1040] liquid ^E 500 [260] # F 48 solution treat and quench 1900 [1040] liquid ^E 500 [260] # F 48 solution treat and quench 2050-2160 [1120-1180] <td></td>			
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F 68 solution treat and quench $1700-1920$ [925-1050] liquid 500 [260]			
F 69 solution treat and quench $1870 [1020]$ liquid $500 [200]$			
F 71 solution treat and quench $1925-2100 [1050-1150]$ liquid $500 [200]$			

^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.

^DThe cooling media for Grades F 65 and F 70 shall be quenching in water or rapidly cooling by other means.

^EForged 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.

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.



TABLE 2 Chemical Requirements^A

Grade/Identifi-	UNS	Composition, %										
cation Symbol	Desig- nation	Carbon	Manga- nese	Phos- phorus	Sulfur	Silicon	Nickel	Chromium	Molybde- num	Colum- Niobium ^P bium	Titan- ium	Other Elements
	1(10000			0.045		Alloy Steels			0.44.0.05			
F 1	K12822	0.28	0.60–0.90	0.045	0.045	0.15–0.35			0.44–0.65			
= 2 ^B	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			
= 5 ^C	K41545	0.15	0.30-0.60	0.030	0.030	0.50	0.50	4.0-6.0	0.44–0.65			
= 5a ^C	K42544	0.25	0.60	0.040	0.030	0.50	0.50	4.0-6.0	0.44-0.65			
= 9 = 10	K90941 S33100	0.15 0.10–0.20	0.30-0.60 0.50-0.80	0.030 0.040	0.030 0.030	0.50–1.00 1.00–1.40	 19.0–22.0	8.0–10.0 7.0–9.0	0.90–1.10 			
F 91 Type 1	K90901	0.08–0.12	0.30–0.60		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 91 Type 2 Heat Product	K90901	0.08–0.12 0.07–0.13	0.30–0.50 ^D	0.020 ^D	0.005 ^D	0.20–0.40 ^D	0.20 ^D	8.0–9.5 ^D	0.85–1.05 0.80–1.05	0.06–0.10 0.05–0.11	0.01 ^D	N $0.035-0.070^{D}$ Al 0.020^{D} N/Al ratio, min 4.0 V Heat 0.18-0.25 V Prod 0.16-0.27 Zr 0.01^{D} B 0.001^{D} Gu 0.05^{D} Sn 0.010^{D} As 0.010^{D}
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		Sb 0.003 ^D V 0.15–0.25 N 0.030–0.070
												AI 0.02 ^D W 1.50–2.00 B 0.001–0.006
F 93	K91350	0.05–0.10	0.20–0.70	0.020	0.008	0.05–0.50		8.50–9.50	V			Ti 0.01 ^D Zr 0.01 ^D V 0.15–0.30 B 0.007–0.015
												AI 0.030 W 2.5–3.5
												Co 2 5-3 5
пцрулята <u>F 115</u>	<u>K91060</u>	<u>0.08–0.13</u>	<u>0.20–0.50</u>		<u>0.005</u>	<u>0.15–0.45</u>	<u>0.25</u>	11f-8fb4-a1 <u>10.0-11.0</u>	<u>0.40–0.60</u>	<u>0.02–0.06</u>	<u>0.01</u>	$\begin{array}{c} Cb + Ta \\ 0.05 - 0.12 \\ Nd \; 0.010 - 0.06 \\ O \; 0.0050 \\ \hline V \; 0.18 - 0.25 \\ \hline B \; 0.001 \\ \hline Cu \; 0.10 \\ \hline Al \; 0.02 \end{array}$
												<u>W 0.05</u> <u>N 0.030-0.070</u> <u>Zr 0.01</u> <u>As 0.010</u> <u>Sn 0.010</u> <u>Sb 0.003</u> <u>N/AI ratio 4.0</u> <u>min</u>
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		<u>CNB^O10.5</u> V 0.15–0.30 B 0.005 N 0.040–0.100 AI 0.02 ^D Cu 0.30–1.70 W 1.50–2.50
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		Ti 0.01 ^{<i>p</i>} Zr 0.01 ^{<i>p</i>} W 0.90–1.10 AI 0.02 ^{<i>p</i>} N 0.04–0.09 V 0.18–0.25 B 0.0003– 0.006 Ti 0.01 ^{<i>p</i>} Zr 0.01 ^{<i>p</i>}