



Designation: **A182/A182M—22a A182/A182M – 23**

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<sup>1</sup>

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 ( $\epsilon$ ) 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<sup>2</sup> 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. [ASTM A182/A182M-23](#)

<https://standards.iteh.ai/catalog/standards/sist/658310bd-201e-4ba5-88c4-546a72b7e8e3/astm-a182-a182m-23>  
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.

<sup>1</sup> 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.

Current edition approved Nov. 15, 2022; May 1, 2023. Published December 2022; May 2023. Originally approved in 1935. Last previous edition approved in 2022 as [A182/A182M—22](#); [A182/A182M – 22a](#). DOI: [10.1520/A0182\\_A0182M-22A](#); [10.1520/A0182\\_A0182M-23](#).

<sup>2</sup> 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:<sup>3</sup>

**A262** Practices for Detecting Susceptibility to Intergranular Attack in Austenitic Stainless Steels  
**A275/A275M** Practice for Magnetic Particle Examination of Steel Forgings  
**A336/A336M** Specification for Alloy Steel Forgings for Pressure and High-Temperature Parts  
**A388/A388M** Practice for Ultrasonic Examination of Steel Forgings  
**A479/A479M** Specification for Stainless Steel Bars and Shapes for Use in Boilers and Other Pressure Vessels  
**A484/A484M** Specification for General Requirements for Stainless Steel Bars, Billets, and Forgings  
**A511/A511M** Specification for Seamless Stainless Steel Mechanical Tubing and Hollow Bar  
**A739** Specification for Steel Bars, Alloy, Hot-Wrought, for Elevated Temperature or Pressure-Containing Parts, or Both  
**A763** Practices for Detecting Susceptibility to Intergranular Attack in Ferritic Stainless Steels  
**A788/A788M** Specification for Steel Forgings, General Requirements  
**A923** Test Methods for Detecting Detrimental Intermetallic Phase in Duplex Austenitic/Ferritic Stainless Steels  
**A961/A961M** Specification for Common Requirements for Steel Flanges, Forged Fittings, Valves, and Parts for Piping Applications  
**A965/A965M** Specification for Steel Forgings, Austenitic, for Pressure and High Temperature Parts  
**A1049/A1049M** Specification for Stainless Steel Forgings, Ferritic/Austenitic (Duplex), for Pressure Vessels and Related Components  
**A1084** Test Method for Detecting Detrimental Phases in Lean Duplex Austenitic/Ferritic Stainless Steels  
**E92** Test Methods for Vickers Hardness and Knoop Hardness of Metallic Materials  
**E112** Test Methods for Determining Average Grain Size  
**E165/E165M** Practice for Liquid Penetrant Testing for General Industry  
**E340** Practice for Macroetching Metals and Alloys

### 2.3 ASME Standards:<sup>4</sup>

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

2.4 **ASME Boiler and Pressure Vessel Code:**<sup>4</sup>

Section IX

### 2.5 AWS Specifications<sup>5</sup>

**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.

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

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

<sup>5</sup> 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<sup>6</sup>

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

---

<sup>6</sup> 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] <sup>a</sup> | Cooling Media                             | Quenching Cool Below °F [°C] | Tempering Temperature, Minimum or Range, °F [°C] |
|-------------------------------------|---|---|---|------------------------------|--|
| <b>Low Alloy Steels</b>             |   |   |   |                              |  |
| F 1                                 | anneal                                    | 1650 [900]  | furnace cool                              | <i>B</i>                     | <i>B</i>   |
|                                     | normalize and temper                      | 1650 [900]  | air cool                                  | <i>B</i>                     | 1150 [620]                                       |
| F 2                                 | anneal                                    | 1650 [900]  | furnace cool                              | <i>B</i>                     | <i>B</i>   |
|                                     | normalize and temper                      | 1650 [900]  | air cool                                  | <i>B</i>                     | 1150 [620]                                       |
| F 5, F 5a                           | anneal                                    | 1750 [955]  | furnace cool                              | <i>B</i>                     | <i>B</i>   |
|                                     | normalize and temper                      | 1750 [955]  | air cool                                  | <i>B</i>                     | 1250 [675]                                       |
| F 9                                 | anneal                                    | 1750 [955]  | furnace cool                              | <i>B</i>                     | <i>B</i>   |
|                                     | normalize and temper                      | 1750 [955]  | air cool                                  | <i>B</i>                     | 1250 [675]                                       |
| F 10                                | solution treat and quench                 | 1900 [1040]   | liquid                                    | 500 [260]                    | <i>B</i>   |
| F 91 Types 1 and 2                  | normalize and temper or quench and temper | 1900–1975 [1040–1080]   | air cool, accelerated air cool, or liquid | <i>B</i>                     | 1350–1470 [730–800]                              |
| F 92                                | normalize and temper                      | 1900–1975 [1040–1080]   | air cool                                  | <i>B</i>                     | 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 | <i>B</i>                     | 1380–1455 [750–790]                              |
| F 122                               | normalize and temper                      | 1900–1975 [1040–1080]   | air cool                                  | <i>B</i>                     | 1350–1470 [730–800]                              |
| F 911                               | normalize and temper                      | 1900–1975 [1040–1080]   | air cool or liquid                        | <i>B</i>                     | 1365–1435 [740–780]                              |
| F 11, Class 1, 2, 3                 | anneal                                    | 1650 [900]  | furnace cool                              | <i>B</i>                     | <i>B</i>   |
|                                     | normalize and temper                      | 1650 [900]  | air cool                                  | <i>B</i>                     | 1150 [620]                                       |
| F 12, Class 1, 2                    | anneal                                    | 1650 [900]  | furnace cool                              | <i>B</i>                     | <i>B</i>   |
|                                     | normalize and temper                      | 1650 [900]  | air cool                                  | <i>B</i>                     | 1150 [620]                                       |
| F 21, F 3V, and F 3VCb              | anneal                                    | 1750 [955]  | furnace cool                              | <i>B</i>                     | <i>B</i>   |
|                                     | normalize and temper                      | 1750 [955]  | air cool                                  | <i>B</i>                     | 1250 [675]                                       |
| F 22, Class 1, 3                    | anneal                                    | 1650 [900]  | furnace cool                              | <i>B</i>                     | <i>B</i>   |
|                                     | normalize and temper                      | 1650 [900]  | air cool                                  | <i>B</i>                     | 1250 [675]                                       |
| F 22V                               | normalize and temper or quench and temper | 1650 [900]  | air cool or liquid                        | <i>B</i>                     | 1250 [675]                                       |
| F 23                                | normalize and temper                      | 1900–1975 [1040–1080]   | air cool accelerated cool                 | <i>B</i>                     | 1350–1470 [730–800]                              |
| F 24                                | normalize and temper                      | 1800–1975 [980–1080]  | air cool or liquid                        | <i>B</i>                     | 1350–1470 [730–800]                              |
| FR                                  | anneal                                    | 1750 [955]  | furnace cool                              | <i>B</i>                     | <i>B</i>   |
|                                     | normalize                                 | 1750 [955]  | air cool                                  | <i>B</i>                     | <i>B</i>   |
|                                     | normalize and temper                      | 1750 [955]  | air cool                                  | <i>B</i>                     | 1250 [675]                                       |
| F 36, Class 1                       | normalize and temper                      | 1650 [900]  | air cool                                  | <i>B</i>                     | 1100 [595]                                       |
| F 36, Class 2                       | normalize and temper or quench and temper | 1650 [900]  | air cool, accelerated air cool, or liquid | <i>B</i>                     | 1100 [595]                                       |
| <b>Martensitic Stainless Steels</b> |   |   |   |                              |  |
| F 6a Class 1                        | anneal                                    | not specified   | furnace cool                              | <i>B</i>                     | <i>B</i>   |
|                                     | normalize and temper                      | not specified   | air cool                                  | 400 [205]                    | 1325 [725]                                       |
|                                     | temper                                    | not required  |   | <i>B</i>                     | 1325 [725]                                       |
| F 6a Class 2                        | anneal                                    | not specified   | furnace cool                              | <i>B</i>                     | <i>B</i>   |
|                                     | normalize and temper                      | not specified   | air cool                                  | 400 [205]                    | 1250 [675]                                       |
|                                     | temper                                    | not required  |   | <i>B</i>                     | 1250 [675]                                       |
| F 6a Class 3                        | anneal                                    | not specified   | furnace cool                              | <i>B</i>                     | <i>B</i>   |
|                                     | normalize and temper                      | not specified   | air cool                                  | 400 [205]                    | 1100 [595]                                       |
| F 6a Class 4                        | anneal                                    | not specified   | furnace cool                              | <i>B</i>                     | <i>B</i>   |
|                                     | normalize and temper                      | not specified   | air cool                                  | 400 [205]                    | 1000 [540]                                       |
| F 6b                                | anneal                                    | 1750 [955]  | furnace cool                              | <i>B</i>                     | <i>B</i>   |
|                                     | 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]                              |
| <b>Ferritic Stainless Steels</b>    |   |   |   |                              |  |
| F XM-27 Cb                          | anneal                                    | 1850 [1010]   | furnace cool                              | <i>B</i>                     | <i>B</i>   |
| F 429                               | anneal                                    | 1850 [1010]   | furnace cool                              | <i>B</i>                     | <i>B</i>   |
| F 430                               | anneal                                    | not specified   | furnace cool                              | <i>B</i>                     | <i>B</i>   |
| <b>Austenitic Stainless Steels</b>  |   |   |   |                              |  |
| F 304                               | solution treat and quench                 | 1900 [1040]   | liquid <sup>E</sup>                       | 500 [260]                    | <i>B</i>   |
| F 304H                              | solution treat and quench                 | 1900 [1040]   | liquid <sup>E</sup>                       | 500 [260]                    | <i>B</i>   |
| F 304L                              | solution treat and quench                 | 1900 [1040]   | liquid <sup>E</sup>                       | 500 [260]                    | <i>B</i>   |
| F 304N                              | solution treat and quench                 | 1900 [1040]   | liquid <sup>E</sup>                       | 500 [260]                    | <i>B</i>   |
| F 304LN                             | solution treat and quench                 | 1900 [1040]   | liquid <sup>E</sup>                       | 500 [260]                    | <i>B</i>   |
| F 309H                              | solution treat and quench                 | 1900 [1040]   | liquid <sup>E</sup>                       | 500 [260]                    | <i>B</i>   |
| F 310                               | solution treat and quench                 | 1900 [1040]   | liquid <sup>E</sup>                       | 500 [260]                    | <i>B</i>   |
| F 310H                              | solution treat and quench                 | 1900 [1040]   | liquid <sup>E</sup>                       | 500 [260]                    | <i>B</i>   |
| F 310MoLN                           | solution treat and quench                 | 1900–2010 [1050–1100]   | liquid <sup>E</sup>                       | 500 [260]                    | <i>B</i>   |
| F 316                               | solution treat and quench                 | 1900 [1040]   | liquid <sup>E</sup>                       | 500 [260]                    | <i>B</i>   |
| F 316H                              | solution treat and quench                 | 1900 [1040]   | liquid <sup>E</sup>                       | 500 [260]                    | <i>B</i>   |
| F 316L                              | solution treat and quench                 | 1900 [1040]   | liquid <sup>E</sup>                       | 500 [260]                    | <i>B</i>   |
| F 316N                              | solution treat and quench                 | 1900 [1040]   | liquid <sup>E</sup>                       | 500 [260]                    | <i>B</i>   |
| F 316LN                             | solution treat and quench                 | 1900 [1040]   | liquid <sup>E</sup>                       | 500 [260]                    | <i>B</i>   |



TABLE 1 Continued

| Grade                                | Heat Treat Type           | Austenitizing/Solutioning Temperature, Minimum or Range, °F [°C] <sup>A</sup> | Cooling Media       | Quenching Cool Below °F [°C] | Tempering Temperature, Minimum or Range, °F [°C] |
|--------------------------------------|---------------------------|---|---------------------|------------------------------|--|
| F 316Ti                              | solution treat and quench | 1900 [1040]   | liquid <sup>E</sup> | 500 [260]                    | <i>B</i>   |
| F 317                                | solution treat and quench | 1900 [1040]   | liquid <sup>E</sup> | 500 [260]                    | <i>B</i>   |
| F 317L                               | solution treat and quench | 1900 [1040]   | liquid <sup>E</sup> | 500 [260]                    | <i>B</i>   |
| F317LNCb                             | solution treat and quench | 1900 [1040]   | liquid <sup>E</sup> | 500 [260]                    | <i>B</i>   |
| F 72                                 | solution treat and quench | 1975–2155 [1080–1180]   | liquid <sup>E</sup> | 500 [260]                    | <i>B</i>   |
| F 73                                 | solution treat and quench | 1975–2155 [1080–1180]   | liquid <sup>E</sup> | 500 [260]                    | <i>B</i>   |
| F 347                                | solution treat and quench | 1900 [1040]   | liquid <sup>E</sup> | 500 [260]                    | <i>B</i>   |
| F 347H                               | solution treat and quench | 2000 [1095]   | liquid <sup>E</sup> | 500 [260]                    | <i>B</i>   |
| F 347LN                              | solution treat and quench | 1900 [1040]   | liquid <sup>E</sup> | 500 [260]                    | <i>B</i>   |
| F 347LNCuB                           | solution treat and quench | 1940–2140 [1060–1170]   | liquid <sup>E</sup> | 500 [260]                    | <i>B</i>   |
| F 348                                | solution treat and quench | 1900 [1040]   | liquid <sup>E</sup> | 500 [260]                    | <i>B</i>   |
| F 348H                               | solution treat and quench | 2000 [1095]   | liquid <sup>E</sup> | 500 [260]                    | <i>B</i>   |
| F 321                                | solution treat and quench | 1900 [1040]   | liquid <sup>E</sup> | 500 [260]                    | <i>B</i>   |
| F 321H                               | solution treat and quench | 2000 [1095]   | liquid <sup>E</sup> | 500 [260]                    | <i>B</i>   |
| F XM-11                              | solution treat and quench | 1900 [1040]   | liquid <sup>E</sup> | 500 [260]                    | <i>B</i>   |
| F XM-19                              | solution treat and quench | 1900 [1040]   | liquid <sup>E</sup> | 500 [260]                    | <i>B</i>   |
| F 20                                 | solution treat and quench | 1700-1850 [925-1010]  | liquid <sup>E</sup> | 500 [260]                    | <i>B</i>   |
| F 44                                 | solution treat and quench | 2100 [1150]   | liquid <sup>E</sup> | 500 [260]                    | <i>B</i>   |
| F 45                                 | solution treat and quench | 1900 [1040]   | liquid <sup>E</sup> | 500 [260]                    | <i>B</i>   |
| F 46                                 | solution treat and quench | 2010-2140 [1100-1140]   | liquid <sup>E</sup> | 500 [260]                    | <i>B</i>   |
| F 47                                 | solution treat and quench | 1900 [1040]   | liquid <sup>E</sup> | 500 [260]                    | <i>B</i>   |
| F 48                                 | solution treat and quench | 1900 [1040]   | liquid <sup>E</sup> | 500 [260]                    | <i>B</i>   |
| F 49                                 | solution treat and quench | 2050 [1120]   | liquid <sup>E</sup> | 500 [260]                    | <i>B</i>   |
| F 56                                 | solution treat and quench | 2050-2160 [1120-1180]   | liquid <sup>E</sup> | 500 [260]                    | <i>B</i>   |
| F 58                                 | solution treat and quench | 2085 [1140]   | liquid <sup>E</sup> | 500 [260]                    | <i>B</i>   |
| F 62                                 | solution treat and quench | 2025 [1105]   | liquid <sup>E</sup> | 500 [260]                    | <i>B</i>   |
| F 63                                 | solution treat and quench | 1900 [1040]   | liquid <sup>E</sup> | 500 [260]                    | <i>B</i>   |
| F 64                                 | solution treat and quench | 2010-2140 [1100-1170]   | liquid <sup>E</sup> | 500 [260]                    | <i>B</i>   |
| F 904L                               | solution treat and quench | 1920-2100 [1050-1150]   | liquid <sup>E</sup> | 500 [260]                    | <i>B</i>   |
| F 70                                 | solution treat and quench | 1900 [1040]   | liquid <sup>D</sup> | 500 [260]                    | <i>B</i>   |
| F700                                 | solution treat and quench | 2025-2100 [1107 -1149]  | liquid/rapid cool   | 500 [260]                    | <i>B</i>   |
| FNiC                                 | solution treat and quench | 1800-1900 [983-1038]  | liquid/rapid cool   | 500 [260]                    | <i>B</i>   |
| FNiC10                               | solution treat and quench | 2100-2150 [1149-1177]   | liquid/rapid cool   | 500 [260]                    | <i>B</i>   |
| FNiC11                               | solution treat and quench | 2100-2150 [1149-1177]   | liquid/rapid cool   | 500 [260]                    | <i>B</i>   |
| F1925                                | solution treat and quench | 1800-1900 [983-1038]  | liquid/rapid cool   | 500 [260]                    | <i>B</i>   |
| F1925N                               | solution treat and quench | 2150 [1177]   | liquid/rapid cool   | 500 [260]                    | <i>B</i>   |
| F35030                               | solution treat and quench | 1900 [1040]   | liquid              | 500 [260]                    | <i>B</i>   |
| Ferritic-Austenitic Stainless Steels |                           |   |                     |                              |  |
| F 50                                 | solution treat and quench | 1925 [1050]   | liquid              | 500 [260]                    | <i>B</i>   |
| F 51                                 | solution treat and quench | 1870 [1020]   | liquid              | 500 [260]                    | <i>B</i>   |
| F 52 <sup>C</sup>                    | solution treat and quench | 1880 [1025]   | liquid              | 500 [260]                    | <i>B</i>   |
| F 53                                 | solution treat and quench | 1880 [1025]   | liquid              | 500 [260]                    | <i>B</i>   |
| F 54                                 | solution treat and quench | 1920-2060 [1050-1125]   | liquid              | 500 [260]                    | <i>B</i>   |
| F 55                                 | solution treat and quench | 2010-2085 [1100-1140]   | liquid              | 500 [260]                    | <i>B</i>   |
| F 57                                 | solution treat and quench | 1940 [1060]   | liquid              | 175 [80]                     | <i>B</i>   |
| F 59                                 | solution treat and quench | 1975-2050 [1080-1120]   | liquid              | 500 [260]                    | <i>B</i>   |
| F 60                                 | solution treat and quench | 1870 [1020]   | liquid              | 500 [260]                    | <i>B</i>   |
| F 61                                 | solution treat and quench | 1920-2060 [1050-1125]   | liquid              | 500 [260]                    | <i>B</i>   |
| F 65                                 | solution treat and quench | 1830-2100 [1000-1150]   | liquid <sup>D</sup> | 500 [260]                    | <i>B</i>   |
| F 66                                 | solution treat and quench | 1870–1975 [1020–1080]   | liquid              | 500 [260]                    | <i>B</i>   |
| F 67                                 | solution treat and quench | 1870–2050 [1020–1120]   | liquid              | 500 [260]                    | <i>B</i>   |
| F 68                                 | solution treat and quench | 1700–1920 [925–1050]  | liquid              | 500 [260]                    | <i>B</i>   |
| F 69                                 | solution treat and quench | 1870 [1020]   | liquid              | 500 [260]                    | <i>B</i>   |
| F 71                                 | solution treat and quench | 1925–2100 [1050–1150]   | liquid              | 500 [260]                    | <i>B</i>   |

<sup>A</sup> Minimum unless temperature range is listed.

<sup>B</sup> Not applicable.

<sup>C</sup> Grade F 52 shall be solution treated at 1825 to 1875 °F [995 to 1025 °C] 30 min/in. of thickness and water quenched.

<sup>D</sup> The cooling media for Grades F 65 and F 70 shall be quenching in water or rapidly cooling by other means.

<sup>E</sup> 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 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 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

TABLE 2 Chemical Requirements<sup>A</sup>

| Grade/Identification Symbol | UNS Designation | Composition, % |                        |                    |                    |                        |                   |                      |            |                      |                   |   |
|-----------------------------|-----------------|----------------|------------------------|--------------------|--------------------|------------------------|-------------------|----------------------|------------|----------------------|-------------------|---|
|                             |                 | Carbon         | Manganese              | Phosphorus         | Sulfur             | Silicon                | Nickel            | Chromium             | Molybdenum | Niobium <sup>B</sup> | 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 <sup>C</sup>            | 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 <sup>D</sup>            | 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 <sup>D</sup>           | 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<br>Al 0.02 <sup>E</sup><br>V 0.18–0.25<br>Ti 0.01 <sup>E</sup><br>Zr 0.01 <sup>E</sup>  |
| F 91 Type 2                 | K90901          | 0.08–0.12      | 0.30–0.50 <sup>E</sup> | 0.020 <sup>E</sup> | 0.005 <sup>E</sup> | 0.20–0.40 <sup>E</sup> | 0.20 <sup>E</sup> | 8.0–9.5 <sup>E</sup> | 0.85–1.05  | 0.06–0.10            | 0.01 <sup>E</sup> | N 0.035–0.070 <sup>E</sup><br>Al 0.020 <sup>E</sup><br>N/Al ratio, min 4.0<br>V 0.18–0.25<br>Zr 0.01 <sup>E</sup><br>B 0.001 <sup>E</sup><br>Cu 0.10 <sup>E</sup><br>W 0.05 <sup>E</sup><br>Sn 0.010 <sup>E</sup><br>As 0.010 <sup>E</sup><br>Sb 0.003 <sup>E</sup> |
| 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<br>N<br>0.030–0.070<br>Al 0.02 <sup>E</sup><br>W 1.50–2.00<br>B<br>0.001–0.006<br>Ti 0.01 <sup>E</sup><br>Zr 0.01 <sup>E</sup>  |
| 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<br>B 0.007–0.015<br>Al 0.030<br>W 2.5–3.5<br>Co 2.5–3.5<br>N 0.005–0.015<br>Nb 0.05–0.12<br>Nd 0.010–0.06<br>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<br>B 0.001<br>Cu 0.10<br>Al 0.02<br>W 0.05<br>N 0.030–0.070<br>Zr 0.01<br>As 0.010<br>Sn 0.010<br>Sb 0.003<br>N/Al ratio 4.0 min<br>CNB <sup>F</sup> 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<br>B 0.005<br>N 0.040–0.100<br>Al 0.02 <sup>E</sup><br>Cu 0.30–1.70<br>W 1.50–2.50<br>Ti 0.01 <sup>E</sup><br>Zr 0.01 <sup>E</sup>  |
| 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<br>Al 0.02 <sup>E</sup><br>N 0.04–0.09<br>V 0.18–0.25<br>B 0.0003–0.006<br>Ti 0.01 <sup>E</sup><br>Zr 0.01 <sup>E</sup>   |
| 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 <sup>B</sup>   | Titanium                 | Other Elements   |
| F 11<br>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<br>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<br>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<br>B   |
| 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<br>Cu 0.25<br>Ca 0.0005–0.0150                                       |
| F 22<br>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<br>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<br>V 0.25–0.35<br>B 0.002<br>Ca 0.015 <sup>F</sup>                       |
| 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 <sup>G</sup> | V 0.20–0.30<br>B 0.0010–0.006<br>N 0.015 <sup>G</sup><br>Al 0.030<br>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<br>N 0.12<br>Al 0.020<br>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<br>Al 0.050<br>Cu 0.50–0.80<br>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 <sup>H</sup> | 0.40      | 0.020      | 0.020  | 0.40      | 0.50 <sup>H</sup> | 25.0–27.5 | 0.75–1.50  | 0.05–0.20              | ...                      | N 0.015 <sup>H</sup><br>Cu 0.20 <sup>H</sup>                                     |
| F 429                        | S42900          | 0.12               | 1.00      | 0.040      | 0.030  | 0.75      | 0.50              | 14.0–16.0 | ...        | ...                    | ...                      | ...  |
| F 430                        | S43000          | 0.12               | 1.00      | 0.040      | 0.030  | 0.75      | 0.50              | 16.0–18.0 | ...        | ...                    | ...                      | ...  |
| Austenitic Stainless Steels  |                 |                    |           |            |        |           |                   |           |            |                        |                          |  |
| F 304                        | S30400          | 0.08               | 2.00      | 0.045      | 0.030  | 1.00      | 8.0–11.0          | 18.0–20.0 | ...        | ...                    | ...                      | N 0.10   |
| F 304H                       | S30409          | 0.04–0.10          | 2.00      | 0.045      | 0.030  | 1.00      | 8.0–11.0          | 18.0–20.0 | ...        | ...                    | ...                      | ...  |
| F 304L                       | S30403          | 0.030              | 2.00      | 0.045      | 0.030  | 1.00      | 8.0–13.0          | 18.0–20.0 | ...        | ...                    | ...                      | N 0.10   |
| F 304N                       | S30451          | 0.08               | 2.00      | 0.045      | 0.030  | 1.00      | 8.0–10.5          | 18.0–20.0 | ...        | ...                    | ...                      | N 0.10–0.16  |
| F 304LN                      | S30453          | 0.030              | 2.00      | 0.045      | 0.030  | 1.00      | 8.0–10.5          | 18.0–20.0 | ...        | ...                    | ...                      | N 0.10–0.16  |
| F 309H                       | S30909          | 0.04–0.10          | 2.00      | 0.045      | 0.030  | 1.00      | 12.0–15.0         | 22.0–24.0 | ...        | ...                    | ...                      | ...  |
| F 310                        | S31000          | 0.25               | 2.00      | 0.045      | 0.030  | 1.00      | 19.0–22.0         | 24.0–26.0 | ...        | ...                    | ...                      | ...  |
| F 310H                       | S31009          | 0.04–0.10          | 2.00      | 0.045      | 0.030  | 1.00      | 19.0–22.0         | 24.0–26.0 | ...        | ...                    | ...                      | ...  |
| F 310MoLN                    | S31050          | 0.030              | 2.00      | 0.030      | 0.015  | 0.40      | 21.0–23.0         | 24.0–26.0 | 2.00–3.00  | ...                    | ...                      | N 0.10–0.16  |
| F 316                        | S31600          | 0.08               | 2.00      | 0.045      | 0.030  | 1.00      | 10.0–14.0         | 16.0–18.0 | 2.00–3.00  | ...                    | ...                      | N 0.10   |
| F 316H                       | S31609          | 0.04–0.10          | 2.00      | 0.045      | 0.030  | 1.00      | 10.0–14.0         | 16.0–18.0 | 2.00–3.00  | ...                    | ...                      | ...  |
| F 316L                       | S31603          | 0.030              | 2.00      | 0.045      | 0.030  | 1.00      | 10.0–15.0         | 16.0–18.0 | 2.00–3.00  | ...                    | ...                      | N 0.10   |
| F 316N                       | S31651          | 0.08               | 2.00      | 0.045      | 0.030  | 1.00      | 11.0–14.0         | 16.0–18.0 | 2.00–3.00  | ...                    | ...                      | N 0.10–0.16  |
| F 316LN                      | S31653          | 0.030              | 2.00      | 0.045      | 0.030  | 1.00      | 11.0–14.0         | 16.0–18.0 | 2.00–3.00  | ...                    | ...                      | N 0.10–0.16  |
| F 316Ti                      | S31635          | 0.08               | 2.00      | 0.045      | 0.030  | 1.00      | 10.0–14.0         | 16.0–18.0 | 2.00–3.00  | ...                    | ...                      | 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 <sup>M</sup> | ...                      | ...  |
| 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<br>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<br>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 | ...        | ...                    | ...                      | ...  |
| F 321H                       | S32109          | 0.04–0.10          | 2.00      | 0.045      | 0.030  | 1.00      | 9.0–12.0          | 17.0–19.0 | ...        | ...                    | κ                        | ...  |





TABLE 2 Continued

| Grade/Identification Symbol          | UNS Designation | Composition, % |           |            |        |           |           |           |            |                           |                        |   |
|--------------------------------------|-----------------|----------------|-----------|------------|--------|-----------|-----------|-----------|------------|---------------------------|------------------------|---|
|                                      |                 | Carbon         | Manganese | Phosphorus | Sulfur | Silicon   | Nickel    | Chromium  | Molybdenum | Niobium <sup>B</sup>      | Titanium               | Other Elements  |
| F 347                                | S34700          | 0.08           | 2.00      | 0.045      | 0.030  | 1.00      | 9.0–13.0  | 17.0–20.0 | ...        | L                         | ...                    | ...   |
| F 347H                               | S34709          | 0.04–0.10      | 2.00      | 0.045      | 0.030  | 1.00      | 9.0–13.0  | 17.0–20.0 | ...        | M                         | ...                    | ...   |
| F347LN                               | S34751          | 0.005–0.020    | 2.00      | 0.045      | 0.030  | 1.00      | 9.0–13.0  | 17.0–19.0 | ...        | 0.20–0.50 <sup>N</sup>    | ...                    | 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 <sup>N</sup>    | ...                    | Cu 2.50–3.50<br>B 0.001–0.005<br>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<br>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<br>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<br>V 0.10–0.30<br>Cu 3.0–4.0                |
| 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<br>–1.00           | ...                    | Cu 0.50–1.00<br>N 0.18–0.25                             |
| 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    | ...                       | ...                    | Co 0.03–0.08<br>Cu 0.50                                 |
| 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<br>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<br>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<br>Cu 1.00–2.50<br>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<br>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<br>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<br>Min<br>0.40<br>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<br>Cu 0.75                                 |
| 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<br>Cu 0.75<br>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 <sup>O</sup> | Cu 0.75<br>Al 0.25–0.60 <sup>O</sup><br>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 <sub>2</sub> 0.10–0.20 <sup>F</sup><br>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 <sub>2</sub> 0.15–0.25 <sup>F</sup><br>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<br>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<br>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<br>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<br>Cu 0.20–0.80                             |
| 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    | ...                       | ...                    | W 1.50–2.50<br>N 0.20–0.30<br>Cu 0.50–1.00              |
| 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    | ...                       | ...                    | W 0.50–1.00 <sup>O</sup><br>Cu 1.20–2.00<br>W 0.80–1.20 |
| 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 0.23–0.33<br>N 0.20–0.35<br>Cu 0.50–3.00              |



TABLE 2 Continued

| Grade/Identification Symbol | UNS Designation | Composition, % |           |            |        |         |           |           |            |                      |          |                             |
|-----------------------------|-----------------|----------------|-----------|------------|--------|---------|-----------|-----------|------------|----------------------|----------|-----------------------------|
|                             |                 | Carbon         | Manganese | Phosphorus | Sulfur | Silicon | Nickel    | Chromium  | Molybdenum | Niobium <sup>B</sup> | Titanium | Other Elements              |
| 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<br>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<br>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<br>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<br>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<br>W 2.10–2.50  |

<sup>A</sup> 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.

<sup>B</sup> Niobium and columbium are interchangeable names for the same element and both names are acceptable for use in A01.22 specifications.

<sup>C</sup> Grade F 2 was formerly assigned to the 1 % chromium, 0.5 % molybdenum grade which is now Grade F 12.

<sup>D</sup> 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.

<sup>E</sup> Applies to both heat and product analyses.

<sup>F</sup> 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.

<sup>G</sup> The ratio of Titanium to Nitrogen shall be  $\geq 3.5$ . 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).

<sup>H</sup> 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 %.

<sup>I</sup> Grade F 316Ti shall have a titanium content not less than five times the carbon plus nitrogen content and not more than 0.70 %.

<sup>J</sup> 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 %.

<sup>K</sup> 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 %.

<sup>L</sup> 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 %.

<sup>M</sup> 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 %.

<sup>N</sup> 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.

<sup>O</sup> % Cr + 3.3 × % (Mo + ½ W) + 16 × % N = 41 min.

<sup>P</sup> Chromium Nickel Balance is defined as CNB = (Cr+6Si+4Mo+1.5W+11V+5Nb+9Ti+12Al) – (40C+30N+4Ni+2Mn+1Cu).

<sup>Q</sup> Al + Ti shall be 0.85 % min; 1.20 % max.

<sup>R</sup> The method of analysis for nitrogen shall be a matter of agreement between purchaser and manufacturer.

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  $\frac{1}{4} T$  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 ( $2t$ ) from any second surface. However, the test depth shall not be nearer to one treated surface than  $\frac{3}{4}$  in. [19 mm] and to the second treated surface than  $1\frac{1}{2}$  in. [38 mm]. This method of test specimen location would normally apply to contour-forged parts, or parts with thick cross-sectional areas where  $\frac{1}{4} T \times T$  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  $\frac{1}{2}$ -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.

TABLE 3 Tensile and Hardness Requirements<sup>A</sup>

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