



Designation: A1099/A1099M – 20

Standard Specification for Modified Alloy Steel Forgings, Forged Bar, and Rolled Bar Commonly Used in Oil and Gas Pressure Vessels¹

This standard is issued under the fixed designation A1099/A1099M; 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 reappraisal. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reappraisal.

1. Scope*

1.1 This specification covers modified high-strength alloy steel forgings and rolled and forged bar for oil and gas pressure vessels and oilfield equipment. See [Appendix XI](#). Oil and gas product specifications for which this material is intended include, but are not limited to, the following:

1.1.1 API 6A Specification for Wellhead and Christmas Tree Equipment and Errata,

1.1.2 API RP 6AR Recommended Practice for Repair and Remanufacture of Wellhead and Christmas Tree Equipment,

1.1.3 API 16A Specification for Drill-Through Equipment,

1.1.4 API 16R Specification for Marine Drilling Riser Couplings,

1.1.5 API 17D Specification for Subsea Wellhead and Tree Equipment and Errata,

1.1.6 API 8C Specification for Drilling and Production Hoisting Equipment.

1.2 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.

1.3 In the case of conflict between a requirement of this specification and a requirement of referenced general specifications, this specification takes precedence. In the case of conflict between a requirement of the product specification or a requirement of this specification and a more stringent requirement of the purchase order or contract, the purchase order or contract requirements shall not take precedence if they, in any way, violate the requirements of the product specification or this specification, for example, by the waiving of a test requirement or by making a test requirement less stringent. In the case of conflict in terminology between API standards and Terminology [A941](#), Terminology [A941](#) definitions shall be applied.

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 [A01.06](#) on Steel Forgings and Billets.

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1.4 *Units*—The values stated in either SI units or inch-pound units are to be regarded separately as standard. 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 nonconformance with the standard.

1.5 This specification is expressed in both inch-pound units and in SI units; however, unless the purchase order or contract specifies the applicable *M* specification designation (SI units), the inch-pound units shall apply.

1.6 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

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 *ASTM Standards:*²

[A370 Test Methods and Definitions for Mechanical Testing of Steel Products](#)

[A388/A388M Practice for Ultrasonic Examination of Steel Forgings](#)

[A534 Specification for Carburizing Steels for Anti-Friction Bearings](#)

[A700 Guide for Packaging, Marking, and Loading Methods for Steel Products for Shipment](#)

[A788/A788M Specification for Steel Forgings, General Requirements](#)

[A941 Terminology Relating to Steel, Stainless Steel, Related Alloys, and Ferroalloys](#)

[A961/A961M Specification for Common Requirements for](#)

² For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

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

Steel Flanges, Forged Fittings, Valves, and Parts for Piping Applications

A991/A991M Test Method for Conducting Temperature Uniformity Surveys of Furnaces Used to Heat Treat Steel Products

A1058 Test Methods for Mechanical Testing of Steel Products—Metric

E10 Test Method for Brinell Hardness of Metallic Materials

E21 Test Methods for Elevated Temperature Tension Tests of Metallic Materials

E45 Test Methods for Determining the Inclusion Content of Steel

E110 Test Method for Rockwell and Brinell Hardness of Metallic Materials by Portable Hardness Testers

E112 Test Methods for Determining Average Grain Size

E165/E165M Practice for Liquid Penetrant Testing for General Industry

E381 Method of Macroetch Testing Steel Bars, Billets, Blooms, and Forgings

E1444/E1444M Practice for Magnetic Particle Testing for Aerospace

E1820 Test Method for Measurement of Fracture Toughness

2.2 *API Standards*.³

API 6A Specification for Wellhead and Christmas Tree Equipment

API RP 6AR Recommended Practice for Repair and Remanufacture of Wellhead and Christmas Tree Equipment

API 8C Specification for Drilling and Production Hoisting Equipment

API 16A Specification for Drill-Through Equipment

API 16R Specification for Marine Drilling Riser Couplings

API 17D Specification for Subsea Wellhead and Tree Equipment

API RP 6HT Heat Treatment and Testing of Large Cross-Section and Critical Section Components

2.3 *ASNT Standard*.⁴

ANST SNT-TC-1A Topical Outlines for Qualification of Nondestructive Testing Personnel

2.4 *SAE Standards*.⁵

AMS 2750 Pyrometry

AMS-H-6875 Process for Heat Treatment of Steel

2.5 *ISO Standard*.⁶

ISO 6506 Metallic Materials—Brinell Hardness Test—Part 1: Test Method

2.6 *Norsok Standard*.⁷

Norsok M-650 Qualification of Manufacturers of Special Materials

2.7 *British Standard*.⁸

BS 7448-1 Method for Determination of K_{Ic} , Critical CTOD and Critical J Values of Metallic Materials

3. Ordering Information and General Requirements

3.1 *General*:

3.1.1 Quantity (mass), length, or number of pieces;

3.1.2 Name of material (forgings or rolled or forged bar);

3.1.3 ASTM International specification designation and year date to which the product is to be furnished and certified as meeting or as capable of meeting;

3.1.4 Condition (as forged, as rolled, annealed, normalized, normalized, re-austenitized, liquid quenched and tempered, austenitized, and liquid quenched and tempered);

3.1.5 Grade, class, and type designations;

3.1.6 Dimensions;

3.1.7 Shape and finish characteristics;

3.1.8 Test location, a drawing or sketch may be used to show test locations, when applicable;

3.1.9 American Petroleum Institute (API) product specification, when applicable; and

3.1.10 Any supplementary requirements.

3.2 Material supplied to this specification shall conform to the requirements of Specifications **A961/A961M** or **A788/A788M**, which outline additional ordering information, manufacturing requirements, testing and retesting methods and procedures, marking, certification, product analysis variations, and additional supplementary requirements. Specification **A961/A961M** shall apply to bar and forged bar as defined in Specification **A961/A961M** and Specification **A788/A788M** shall apply to forgings and forged bar unless otherwise stated.

4. Melting

4.1 In addition to the melting and forging requirements of Specifications **A961/A961M** and **A788/A788M**, which may be supplemented by supplementary requirements, the following conditions apply:

4.1.1 Material shall be produced by electric arc furnace or induction melting, followed by a secondary process including ladle refining and degassing, for example, argon oxygen decarburization (AOD), vacuum oxygen decarburization (VOD) or vacuum arc degassing (VAD), vacuum tank degassing, and RH (Ruhstahl Heraeus) or DH (Dortmund-Horde) degassing. Material may be secondarily remelted by vacuum arc remelting (VAR) or electroslag remelting (ESR).

4.1.2 Material shall be fully killed.

4.1.3 Material shall meet the fine austenitic grain size requirements as stated in 9.1.1.1.

5. Hot Working

5.1 The total hot work reduction ratio shall be 4:1 minimum.

5.1.1 Total hot work reduction ratio for bars:

5.1.1.1 The cross-sectional area of the original ingot or strand divided by the cross-sectional area of the finished bar.

⁸ Available from British Standards Institution (BSI), 389 Chiswick High Rd., London W4 4AL, U.K., <http://www.bsigroup.com>.

³ Available from American Petroleum Institute (API), 1220 L. St., NW, Washington, DC 20005-4070, <http://www.api.org>.

⁴ Available from American Society for Nondestructive Testing (ASNT), P.O. Box 28518, 1711 Arlington Ln., Columbus, OH 43228-0518, <http://www.asnt.org>.

⁵ Available from SAE International (SAE), 400 Commonwealth Dr., Warrendale, PA 15096, <http://www.sae.org>.

⁶ Available from International Organization for Standardization (ISO), ISO Central Secretariat, BIBC II, Chemin de Blandonnet 8, CP 401, 1214 Vernier, Geneva, Switzerland, <http://www.iso.org>.

⁷ Available from the Norsk Søkkel Konkuranseposisjon, www.standard.no.

5.1.1.2 The cross-section resulting in the lowest hot work reduction ratio shall be used.

5.1.2 Total hot work ratio for forgings (forging reduction ratio):

5.1.2.1 The product of the reduction ratios for each hot work operation including the original starting material reduction and each subsequent hot work operation. When the cross section of the starting material or forged part varies, the cross section resulting in the lowest calculated hot work reduction ratio shall be used.

5.2 Forgings shall have a surface finish adequate for intended inspection as stated in Specification **A788/A788M**.

6. Heat Treatment

6.1 When a heat-treated condition is not specified, any heat treatment shall be at the option of the manufacturer.

6.2 When the heat-treated condition is specified, the following apply:

6.2.1 Forgings and bars shall be normalized, re-austenitized followed by liquid quench and temper or alternatively, austenitized, followed by liquid quench and tempered.

6.2.2 Forgings and bars shall be allowed to cool down to a temperature below 200°C [400°F] before commencing any operation of heat treatment cycle. This includes before a normalizing cycle.

6.2.3 Forgings shall be near net shape before quenching. The rough machine dimensions (or near net shape forging dimensions) before quenching shall comply with the purchaser's near net shape drawings. When drawings are not available, the forging supplier shall adhere as close as possible to the

recommended practices of API RP 6HT. When no drawings or instructions are provided by the purchaser, it is the responsibility of the manufacturer to meet the required mechanical properties.

6.3 Heat treatment equipment calibration and furnace surveys shall be in accordance with API 6A Annex M or API 16A Annex A. Alternatively, heat treatment equipment survey and calibration may be performed in accordance with an internationally recognized industry standard such as SAE AMS 2750, SAE-H-AMS 6875, Test Method **A991/A991M** (uniformity survey), or Norsok M650 provided that the supplier demonstrates that the requirements of API 6A or API 16A have been exceeded. Induction heating equipment survey and calibration shall be in accordance with the manufacturer's written procedures.

6.4 Heat treatment of bars, forgings, and forged bars shall be performed in a furnace meeting the requirements of **6.3**. See API RP 6HT for additional guidance.

6.5 The heat treatment temperatures shall be in accordance with **Table 1**.

7. Chemical Composition

7.1 *Heat Analysis*—The heat analysis as determined by the steel producer as being representative of a heat of steel (see Terminology **A941**) meeting the composition of a grade shown in **Table 2**. Additions of nonspecified elements are not allowed.

7.2 *Product Analysis*—The manufacturer shall perform a product analysis in accordance with Specifications **A961/A961M** or **A788/A788M** from a bar, forged bar, or forging

TABLE 1 Heat Treatment Temperatures

| Material | Normalizing ^A | Austenitizing ^A | Quench Media | Tempering Minimum ^B |
|---------------------------|----------------------------|--------------------------------|-------------------|--------------------------------|
| F220F or F220FA Class 75 | 1675–1750°F [900–950°C] | 1650–1725°F [900–950°C] | Water/polymer/oil | 1225°F [650°C] |
| F220F or F220FA Class 80 | 1675–1750°F [900–950°C] | 1650–1725°F [900–950°C] | Water/polymer/oil | 1200°F [650°C] |
| F220F or F220FA Class 85 | 1675–1750°F [900–950°C] | 1650–1725°F [900–950°C] | Water/polymer/oil | 1175°F [625°C] |
| F220F or F220FA Class 105 | 1675–1750°F [900–950°C] | 1650–1725°F [900–950°C] | Water/polymer/oil | 1100°F [600°C] |
| 4130OF Class 95 | 1600–1700°F [875–925°C] | 1575–1650°F [850–900°C] | Water/polymer/oil | 1125°F [600°C] |
| 4130OF Class 110 | 1600–1700°F [875–925°C] | 1575–1650°F [850–900°C] | Water/polymer/oil | 1075°F [575°C] |
| 4130OF Class 125 | 1600–1700°F [875–925°C] | 1575–1650°F [850–900°C] | Water/polymer/oil | 1050°F [575°C] |
| 8630OF Class 75 | 1600–1700°F [875–925°C] | 1575–1650°F [850–900°C] | Water/polymer/oil | 1225°F [650°C] |
| 8630OF Class 80 | 1600–1700°F [875–925°C] | 1575–1650°F [850–900°C] | Water/polymer/oil | 1200°F [650°C] |
| 8630OF Class 85 | 1600–1700°F [875–925°C] | 1575–1650°F [850–900°C] | Water/polymer/oil | 1200°F [650°C] |
| 8630OF Class 95 | 1600–1700°F [875–925°C] | 1575–1650°F [850–900°C] | Water/polymer/oil | 1075°F [575°C] |
| 8630OF Class 100 | 1600–1700°F [875–925°C] | 1575–1650°F [850–900°C] | Water/polymer/oil | 1075°F [575°C] |
| 8630OF Class 110 | 1600–1700°F [875–925°C] | 1575–1650°F [850–900°C] | Water/polymer/oil | 1050°F [575°C] |
| 8630OF Class 120 | 1600–1700°F [875–925°C] | 1575–1650°F [850–900°C] | Water/polymer/oil | 1050°F [575°C] |
| 8630OF Class 135 | 1600–1700°F [875–925°C] | 1575–1650°F [857.2–898.8°C] | Water/polymer/oil | 1025°F [550°C] |

^A Temperature uniformity shall be ±25°F [±14°C] for normalizing and austenitizing.

^B Temperature uniformity shall be ±15°F [±8°C] for tempering.



TABLE 2 Grade Chemical Composition^A

| Grade | C | Mn | P | S | Si | Cr | Mo | Ni | Cu | V | Ti | Al | Sn | As | Sb | Pb | Bi | N | H | O | Nb (Cb) | B |
|--------|---------------|---------------|-------|-------|---------------|---------------|---------------|---------------|------|------|-------|-------|-------|-------|-------|-------|-------|--------|----------|-----------|---------------|--------|
| F220F | 0.10– 0.15 | 0.30– 0.60 | 0.015 | 0.010 | 0.15– 0.50 | 2.0– 2.50 | 0.87– 1.13 | 0.50 | 0.25 | 0.04 | 0.025 | 0.055 | 0.015 | 0.020 | 0.020 | 0.010 | 0.010 | 0.0120 | 2 PPM | 25 PPM | 0.02 | 0.0005 |
| F220FA | 0.15– 0.20 | 0.40– 0.80 | 0.015 | 0.010 | 0.50 | 2.0– 2.50 | 0.90– 1.10 | 0.50 | 0.25 | 0.04 | 0.025 | 0.055 | 0.015 | 0.020 | 0.020 | 0.010 | 0.010 | 0.0120 | 2 PPM | 25 PPM | 0.01 | 0.0005 |
| 41300F | 0.25– 0.33 | 0.60– 0.90 | 0.015 | 0.010 | 0.20– 0.35 | 1.20– 1.50 | 0.65– 0.75 | 0.25 | 0.25 | 0.04 | 0.025 | 0.055 | 0.015 | 0.020 | 0.020 | 0.010 | 0.010 | 0.0120 | 2 PPM | 25 PPM | 0.02– 0.05 | 0.0005 |
| 86300F | 0.27– 0.33 | 0.80– 0.95 | 0.015 | 0.010 | 0.20– 0.35 | 0.85– 1.00 | 0.35– 0.45 | 0.80– 0.90 | 0.25 | 0.04 | 0.025 | 0.055 | 0.015 | 0.020 | 0.020 | 0.010 | 0.010 | 0.0120 | 2 PPM | 25 PPM | 0.02 | 0.0005 |

^ANotes: (1) Chemical composition by weight %. (2) Specified values are considered maximum unless otherwise specified. (3) Calcium may be added for inclusion shape control. Amount of calcium shall not exceed 0.005 %.

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