



Designation: A336/A336M – 21

Standard Specification for Alloy Steel Forgings for Pressure and High-Temperature Parts¹

This standard is issued under the fixed designation A336/A336M; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the U.S. Department of Defense.

1. Scope*

1.1 This specification² covers ferritic steel forgings for boilers, pressure vessels, high-temperature parts, and associated equipment.

1.2 Forgings made of steel grades listed in Specification [A335/A335M](#), may also be ordered under this specification. The chemical, tensile, heat treatment, and marking requirements of Specification [A335/A335M](#) shall apply, except the forging shall conform to the chemical requirements of Tables 1 and 2 of Specification [A335/A335M](#) only with respect to heat analysis. On product analysis they may deviate from these limits to the extent permitted in [Table 1](#) of this specification.

1.3 Supplementary Requirements S1 to S9 are provided for use when additional testing or inspection is desired. These shall apply only when specified individually by the purchaser in the order.

1.4 Unless the order specifies the applicable “M” specification designation, the material shall be furnished to the inch-pound units.

1.5 Specification A336/A336M formerly included austenitic steel forgings, which are now found in Specification [A965/A965M](#).

1.6 The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system are not necessarily exact equivalents; therefore, to ensure conformance with the standard, each system shall be used independently of the other, and values from the two systems shall not be combined.

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:³

[A275/A275M Practice for Magnetic Particle Examination of Steel Forgings](#)

[A335/A335M Specification for Seamless Ferritic Alloy-Steel Pipe for High-Temperature Service](#)

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

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

[A965/A965M Specification for Steel Forgings, Austenitic, for Pressure and High Temperature Parts](#)

[E165/E165M Practice for Liquid Penetrant Testing for General Industry](#)

2.2 ASME Boiler and Pressure Vessel Code:⁴

[Section III Nuclear Power Plant Components](#)

[Section IX Welding and Brazing Qualifications](#)

2.3 AWS Specifications:⁵

[A5.5/A5.5M Low-Alloy Steel Electrodes for Shielded Metal Arc Welding](#)

[A5.23/A5.23M Low-Alloy Steel Electrodes and Fluxes for Submerged Arc Welding](#)

[A5.28/A5.28M Low-Alloy Steel Electrodes for Gas Shielded Arc Welding](#)

[A5.29/A5.29M Low-Alloy Steel Electrodes for Flux Cored Arc Welding](#)

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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² For ASME Boiler and Pressure Vessel Code applications, see related Specification SA-336/SA-336M in Section II of that Code.

³ For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard’s Document Summary page on the ASTM website.

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

⁵ Available from American Welding Society (AWS), 8669 NW 36 St., #130, Miami, FL 33166-6672, <http://www.aws.org>.

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



TABLE 1 Tensile Requirements

	Ferritic Steels																				
	Grade																				
	F1	F11, Class 2	F11, Class 3	F11, Class 1	F12	F5	F5A	F9	F6	F6NM	F21, Class 3	F21, Class 1	F22, Class 3	F22, Class 1	F91, Type 1 and Type 2	F911	F92	F3V	F3VCb	F22V	
Tensile strength, ksi [MPa]	70-95 [485-660]	70-95 [485-660]	75-100 [515-690]	60-85 [415-585]	70-95 [485-660]	60-85 [415-585]	80-105 [550-725]	85-110 [585-760]	85-110 [585-760]	115-140 [790-965]	75-100 [515-690]	60-85 [415-585]	75-100 [515-690]	60-85 [415-585]	90-120 [620-830]	90-120 [620-830]	90-120 [620-830]	85-110 [585-760]	85-110 [585-760]	85-110 [585-760]	85-110 [585-760]
Yield strength, min, ksi [MPa]	40 [275]	40 [275]	45 [310]	30 [205]	40 [275]	36 [250]	50 [345]	55 [380]	55 [380]	90 [620]	45 [310]	30 [205]	45 [310]	30 [205]	60 [415]	64 [440]	64 [440]	60 [415]	60 [415]	60 [415]	60 [415]
Elongation in 2 in. or 50 mm, min, %	20	20	18	20	20	20	19	20	18	15	19	20	19	20	20	20	20	18	18	18	18
Reduction of area, min, %	40	40	40	45	40	40	35	40	35	45	40	45	40	45	40	40	45	45	45	45	45

3. Ordering Information and General Requirements

3.1 In addition to the ordering information required by Specification **A788/A788M**, the purchaser should include with the inquiry and order the following information:

3.1.1 A drawing or sketch that shows test locations when the testing is in accordance with **8.2.1.3**.

3.1.2 The intended use of forgings if **5.1** is applicable.

3.2 Material supplied to this specification shall conform to the requirements of Specification **A788/A788M**, which outlines additional ordering information, manufacturing requirements, testing and retesting methods and procedures, marking, certification, product analysis variations, and additional supplementary requirements.

3.3 If the requirements of this specification are in conflict with the requirements of Specification **A788/A788M**, the requirements of this specification shall prevail.

3.4 For hubbed flatheads and tube sheets ordered for ASME Boiler and Pressure Vessel Code application, Supplementary Requirement S12 of Specification **A788/A788M** shall be specified.

3.5 At the purchaser's request the forgings shall be rough machined before heat treatment (**5.2**).

3.6 For Section III, Part NB of the ASME Boiler and Pressure Vessel Code application, Supplementary Requirement S3 shall be specified.

4. Melting and Forging

4.1 In addition to the melting and forging requirements of Specification **A788/A788M**, which may be supplemented by Supplementary Requirement S8, the following conditions apply:

4.1.1 A sufficient discard shall be made to secure freedom from injurious pipe and undue segregation.

5. Machining

5.1 Forged pressure vessels for steam power service shall have the inner surface machined or ground. Unfired pressure vessels shall have the inner surfaces sufficiently free of scale to permit inspection.

5.2 Unless otherwise specified by the purchaser, when rough machining is performed, it may be done either before or after heat treatment at the manufacturer's option.

6. Heat Treatment

6.1 Except as permitted in **6.1.1** for Grade F22V, and in **6.1.2** for Grade F91 Type 1 and Type 2 and Grade F92, the steel forgings shall be annealed or normalized and tempered but alternatively may be liquid quenched and tempered when mutually agreed upon between the manufacturer and the purchaser. For all grades, normalizing or liquid quenching shall be followed by tempering at a subcritical temperature as shown in **6.1.4**.

6.1.1 Grade F22V forgings shall be normalized and tempered or liquid quenched and tempered at the manufacturer's option.

6.1.1.1 For Grade F22V forgings the minimum austenitizing temperature shall be 1650 °F [900 °C].

6.1.2 Grade F91 Type 1 and Type 2 forgings having any section thickness greater than 3 in. [75 mm] shall be normalized and tempered or liquid quenched and tempered at the manufacturer's option. Grade F92 forgings shall be normalized and tempered or liquid quenched and tempered at the manufacturer's option.

6.1.2.1 For Grade F91 Type 1 and Type 2, F911, and F92 forgings, the austenitizing temperature shall be in the range of 1900 °F to 1975 °F [1040 °C to 1080 °C].

6.1.3 For Grade F6NM the austenitizing temperature shall be 1850 °F [1010 °C] minimum. The tempering temperature range shall be as shown in **6.1.4**.

6.1.4 Except for the following grades, the minimum tempering temperature shall be 1100 °F [595 °C]:

Grade	Tempering Temperature Minimum or Range, °F [°C]
F6	1150 [620]
F6NM	1040–1120 [560–600]
F11, Class 2	1150 [620]
F11, Class 3	1150 [620]
F11, Class 1	1150 [620]
F5, F5a	1250 [675]
F9	1250 [675]
F21, Class 1	1250 [675]
F3V, F3VCb	1250 [675]
F22, Class 1	1250 [675]
F22V	1250 [675]
F91 Type 1 and Type 2, F92	1350–1470 [730–800]
F911	1365–1435 [740–780]
F22, Class 3	1250 [675]

7. Chemical Composition

7.1 *Heat Analysis*—The heat analysis obtained from sampling in accordance with Specification **A788/A788M** and shall comply with **Table 2**.

7.2 *Product Analysis*—The manufacturer shall use the product analysis provision of Specification **A788/A788M** to obtain a product analysis from a forging representing each heat or multiple heat. The product analysis for columbium and calcium for Grade F22V shall conform to the requirements of **Table 2** of this specification. Boron is not subject to product analysis. The purchaser may also make this determination in accordance with Specification **A788/A788M**.

8. Mechanical Properties

8.1 *General Requirements*—The material shall conform to the requirements for mechanical properties prescribed in **Table 1**. The largest obtainable tension test specimen as specified in Test Methods and Definitions **A370** shall be used.

8.2 *Sampling*—The mid-point of the gauge length of tension test specimens and the area under the notch of impact specimens shall be located in accordance with one of the following methods as specified by the purchaser, or suggested by the supplier and approved by the purchaser. Unless otherwise noted, all testing shall be from integral prolongations of the forging.