



Standard Specification for Carbon Steel and Low-Alloy Steel Pressure-Vessel- Component Forgings with Mandatory Toughness Requirements¹

This standard is issued under the fixed designation A 765/A 765M; 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 specification² covers heat-treated carbon steel and alloy steel forgings with mandatory toughness requirements. These forgings are intended for pressure vessels, feedwater heaters, and similar uses.

1.2 These forgings include tube sheets, covers, channel barrels, integral forged channels, rings, nozzles, flanges, and similar parts.

1.3 All grades are considered weldable under proper conditions.

1.4 The maximum thickness of forgings produced to this specification is limited only by the capacity of the selected grade to respond to any heat treatment specified and to meet the specified mechanical tests, including impact tests at the specified temperature.

1.5 Material supplied to this specification shall conform to the requirements of Specification **A 788/A 788M**, which outlines additional ordering information, manufacturing requirements, testing and retesting methods and procedures, marking, certification, product analysis variations, and additional supplementary requirements.

1.6 If the requirements of this specification are in conflict with the requirements of Specification **A 788/A 788M**, the requirements of this specification shall prevail.

1.7 The values stated in either inch-pound units or SI [metric] units are to be regarded separately as the standard; within the text and tables, the SI units are shown in brackets. The values stated in each system are not exact equivalents; therefore, each system must be used independently of the other. Combining values from the two systems may result in nonconformance with the specification.

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

2. Referenced Documents

2.1 ASTM Standards:³

A 275/A 275M Practice for Magnetic Particle Examination of Steel Forgings

A 370 Test Methods and Definitions for Mechanical Testing of Steel Products

A 388/A 388M Practice for Ultrasonic Examination of Heavy Steel Forgings

A 788/A 788M Specification for Steel Forgings, General Requirements

E 112 Test Methods for Determining Average Grain Size

E 165 Test Method for Liquid Penetrant Examination

2.2 ASME Standards:⁴

ASME Boiler and Pressure Vessel Code

3. Ordering Information

3.1 In addition to the ordering information requirements of Specification **A 788/A 788M**, a detailed sketch or written description of the forging and the method of selecting the test location (see **6.2**) should be supplied to the producer, when appropriate areas of significant in-service loading of the forging need to be designated.

3.2 The required impact test temperature should be supplied if different than the temperature listed in **Table 3**, otherwise the impact test shall be conducted at the temperature listed in **Table 3** for the chosen Grade.

3.3 If a hubbed tube sheet is to be supplied for ASME Boiler and Pressure Code Application Supplementary Requirement S12 of Specification **A 788/A 788M** shall be specified.

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–765/SA–765M 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, 345 E. 47th St., New York, NY 10017.

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

TABLE 1 Chemical Requirements

	Composition, %				
	Grade I	Grade II	Grade III	Grade IV	Grade V
Carbon, max	0.30	0.30	0.20	0.20	0.30
Manganese	0.60 to 1.35	0.60 to 1.35	0.90 max	1.00–1.60	0.60–1.35
Phosphorus, max	0.020	0.020	0.020	0.020	0.020
Sulfur, max	0.020	0.020	0.020	0.020	0.020
Silicon	0.15 to 0.35	0.15 to 0.35	0.15 to 0.35	0.15–0.50	0.15–0.35
Nickel, max ^A	0.50	0.50	3.3 to 3.8	0.50 max	1.0–2.0
Vanadium, max	0.05	0.05	0.05	0.06	0.03
Aluminum, max	0.05	0.05	0.05	0.05	0.05
Chromium, ^A max	0.40	0.40	0.20	0.40	0.30
Molybdenum, ^A max	0.10	0.10	0.06	0.10	0.12
Copper, max	0.35	0.35	0.35	0.35	0.35

^A Intentional additions of Cr, Mo, and Ni up to the specified maximum are permitted to be made to Grades I, II, and IV by the manufacturer.

3.4 If steel is required to be vacuum degassed, Supplementary Requirement S8 of Specification **A 788/A 788M** should be specified.

4. Heat Treatment for Mechanical Properties

4.1 Heat treatment shall consist of one of the following heat treatment options of the manufacturer's choice.

4.1.1 Normalize and temper.

4.1.2 Double normalize, wherein the second austenitizing temperature is at the same or lower temperature than the first, followed by tempering.

4.1.3 Quench and temper, with the option of adding a preliminary normalize before austenitizing for quenching in a suitable liquid medium. The type of cooling medium used shall be reported.

4.1.4 Use of an intercritical heat treatment cycle in accordance with Specification **A 788/A 788M** in which cooling from the full and partial austenitization stages may be done by liquid quenching or air cooling. The method of cooling and type of quench medium, if used, shall be reported.

4.1.5 The minimum tempering temperature shall be 1100°F [590°C].

5. Chemical Requirements

5.1 *Heat Analysis*—The heat analysis obtained from sampling in accordance with Specification **A 788/A 788M** shall comply with **Table 1**.

5.2 *Product Analysis*—The purchaser may use the product analysis provision of Specification **A 788/A 788M** to obtain a product analysis from a forging representing each heat or multiple heat.

6. Mechanical Requirements

6.1 *General Requirements*—The forgings shall conform to the tension test requirements of **Table 2**. The forgings shall also conform to the impact test requirements of **Table 3**. The largest obtainable round tension test specimen as specified in Test Methods and Definitions **A 370** shall be used. Impact specimens shall be Charpy V-notch, Type A, as in Test Methods and

Definitions **A 370**. The usage of subsize impact specimens must have prior purchaser approval.

6.1.1 When agreed upon between the purchaser and the producer and specified on the order, impact tests may be made at temperatures different from those shown in **Table 3** provided the test temperature is at least as low as the intended service temperatures and the provided impact energy requirements of **Table 3** are met. Such forgings shall be suitably marked in accordance with **9.1** to identify the test temperature.

6.2 *Test Location*—Test coupons shall be taken so that the longitudinal axis and mid-length of tension and impact test specimens shall be positioned in accordance with one of the following methods:

6.2.1 *Method 1*—Forgings with 2 in. [50 mm] maximum thickness. The specimens shall have their longitudinal axis at the midthickness or the center of the cross section and with the midlength of the specimen at least 2 in. [50 mm] from any second surface.

6.2.2 *Method 2*—Grade I and Grade II forgings with thicknesses greater than 2 in. up to 4 in. [50 to 100 mm] inclusive, or Grade III and IV forgings with thicknesses greater than 2 in. up to 6 in. [50 to 150 mm] inclusive. The specimens shall have their longitudinal axis at least $\frac{1}{4} T$ of maximum heat-treated thickness from any surface and with the midlength of the specimen at least one T from any second surface. This is normally referred to as $\frac{1}{4} T$ by T when T is the maximum heat-treated thickness. A thermal buffer may be used to adhere to the condition in **6.3**. Unless otherwise agreed upon, the following limitation for heat-treated thickness shall apply:

Grade	in. [mm], min	in. [mm], max
I	2 [50]	4 [100]
II	2 [50]	4 [100]
III	2 [50]	6 [150]
IV	2 [50]	6 [150]
V	2 [50]	6 [150]

(Classes 1 and 2)

6.2.3 *Method 3*—For forgings thicker than described in Method 2 (**6.2.2**):

6.2.3.1 Prior to heat treatment the forging shall be machined to a purchaser supplied or approved drawing that indicates the locations of significant in-service loading in the finished part. The mechanical test specimens shall be located as an integral part of the forging such that the mid-point of the gauge length of the tension test specimen and the area under the notch of the impact specimens are located no closer than the dimension t from one heat treated surface and $2t$ from any other heat treated surface where t is the dimension from the area of significant loading to the heat treated surface, or $\frac{3}{4}$ in. [20 mm] whichever is the greater.

6.2.4 *Method 4*—This method shall be limited to forgings with a rough machined weight of not more than 1000 lb [455 kg]. Separate test forging when agreed upon between the purchaser and the supplier. Test coupons representing forgings from one heat and one heat treatment lot may be taken from a separately forged piece under the following conditions:

6.2.4.1 The separate test forging shall be of the same heat of material and shall be subjected to substantially the same reduction and working as the production forging it represents.