



# Standard Specification for High-Strength Quenched and Tempered Low-Alloy Steel Forged Fittings and Parts for Pressure Vessels<sup>1</sup>

This standard is issued under the fixed designation A 592/A 592M; 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.

## 1. Scope

1.1 This specification<sup>2</sup> covers high-strength quenched and tempered low-alloy steel forged fittings and parts for pressure vessels. The maximum thickness of forgings under this specification shall be 1½ in. [38 mm] for Grade A, and 3¾ in. [95 mm] for Grades E and F (4 in. [102 mm] maximum as heat treated).

NOTE 1—These grades are similar to corresponding grades in Specification A 517/A 517M.

1.2 Welding technique is of fundamental importance and it is presupposed that welding procedures will be in accordance with approved methods for the class of material used.

1.3 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.

1.4 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:

A 370 Test Methods and Definitions for Mechanical Testing of Steel Products<sup>3</sup>

A 517/A 517M Specification for Pressure Vessel Plates, Alloy Steel, High-Strength, Quenched and Tempered<sup>4</sup>

A 788 Specification for Steel Forgings, General Requirements<sup>5</sup>

<sup>1</sup> This specification is under the jurisdiction of ASTM Committee A-1 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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<sup>2</sup> For ASME Boiler and Pressure Vessel Code applications see related Specification SA-592/SA-592M in Section II of that Code.

<sup>3</sup> Annual Book of ASTM Standards, Vol 01.03.

<sup>4</sup> Annual Book of ASTM Standards, Vol 01.04.

<sup>5</sup> Annual Book of ASTM Standards, Vol 01.05.

E 112 Test Methods for Determining the Average Grain Size<sup>6</sup>

## 3. Ordering Information and General Requirements

3.1 In addition to the ordering information required by Specification A 788, the purchaser shall include with the inquiry and order a detailed drawing, a sketch, or written description of the forging.

3.2 Material supplied to this specification shall conform to the requirements of Specification A 788, 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 A 788, the requirements of this specification shall prevail.

## 4. Materials and Manufacture

4.1 *Melting Process*—The steel shall be made in accordance with the Melting Process Section of Specification A 788.

4.2 *Grain Size*—The steel shall be fully killed, fine grained (ASTM No. 5 or finer), as determined in accordance with Test Methods E 112, Plate IV.

4.3 *Discard*—Sufficient discard shall be made from each ingot to ensure freedom from piping and excessive segregation.

4.4 The finished product shall be a hot-worked forging as defined by Specification A 788, and shall be forged as close as practicable to the finished shape and size.

## 5. Heat Treatment

5.1 After forging and before reheating, the forgings shall be cooled to provide substantially complete transformation of austenite. Heat treatment for properties shall consist of heating the forgings to not less than 1650°F [900°C], quenching in a liquid medium, and tempering at 1150°F [620°C] minimum, with a holding time of 1 h/in. [1 h/25 mm] minimum, but in no case less than ½ h. Forgings with sections over 2½ to 4 in. [65 to 100 mm] inclusive, shall be liquid quenched from a

<sup>6</sup> Annual Book of ASTM Standards, Vol 03.01.

temperature not less than 1750°F [955°C] prior to the above treatment for properties.

**6. Chemical Requirements**

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

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

**7. Mechanical Requirements**

7.1 The forgings as represented by tension tests shall conform to the requirements prescribed in Table 2. Charpy V-notch impact specimens shall have a lateral expansion opposite the notch of not less than 0.015 in. (15 mils) [0.38 mm]. In addition the values of energy absorption in foot-

**TABLE 2 Tensile Requirements**

	Up to 2½ in. [65 mm], incl	Over 2½ in. to 4 in. [65 to 100 mm], incl
Tensile strength, psi (MPa)	115 000 to 135 000 [795 to 930]	105 000 to 135 000 [725 to 930]
Yield strength (0.2 % offset), min, psi [MPa]	100 000 [690]	90 000 [620]
Elongation in 2 in. [50 mm], min, %	18	17
Reduction of area, min, %	45	40

pounds (or joules) and the fracture appearance in percent shear shall be recorded and reported for information.

7.2 *Sampling:*

7.2.1 Samples for mechanical test specimens shall be removed after the quenching and tempering heat treatment. The purchaser shall specify any additional thermal treatments that shall be given to the test specimens in addition to the heat treatment specified in 5.1. (This is intended to simulate thermal treatments which may subsequently be performed by the fabricator.)

7.2.2 Samples shall be removed so that the test specimens will have their major axes parallel to the direction of major working of the forging.

7.2.3 Test specimens may be machined from a production forging, or prolongation thereof, or from special forged blocks suitably worked and heat treated with the production forgings. Such special blocks shall be obtained from the ingot, slab, or billet and be reduced by forging in a manner similar to that for the products to be represented. The maximum reduction for a special test block shall not exceed the minimum reduction of the forgings represented, and its thickness shall not be less than the maximum thickness of the forgings represented. If a forging is tested, the tests must represent the maximum section thickness in the lot. All test specimens shall be located at the mid-plane of the thickness and at least *T* from any second surface of the production forging or test block. (*T* equals the maximum thickness of the forging.)

7.3 *Number of Tests and Retests:*

7.3.1 *Number of Tests:*

7.3.1.1 One room-temperature tension test and one set of three Charpy V-notch specimens shall be made to represent the maximum section from each heat in each heat-treatment charge. Impact tests shall be conducted at the temperature specified on the order, but no higher than 32°F [0°C].

7.3.1.2 One grain size test shall be made from each heat.

7.3.2 *Retests of Tension Specimens*—If the results of tension tests do not conform to the requirements specified, retests are permitted, as outlined in 7.3.2.1, 7.3.2.2, and 7.3.2.3.

7.3.2.1 If the percentage of elongation of a tension test specimen is less than that prescribed in Table 2, and any part of the fracture is outside the middle half of the gage length, indicated by scribe marks on the test specimens, a single retest shall be allowed.

7.3.2.2 If a test specimen fails to meet the minimum specified requirements due to a flaw, other than a rupture, crack, or flake, a single retest shall be allowed.

7.3.2.3 In the case of failure of the mechanical test specimens to conform to the minimum specified requirements, the

**TABLE 1 Chemical Requirements**

Element	Composition, %		
	Grade A <sup>A</sup>	Grade E <sup>A</sup>	Grade F <sup>A</sup>
Carbon			
Heat	0.15–0.21	0.12–0.20	0.10–0.22
Product	0.13–0.23	0.10–0.22	0.08–0.22
Manganese			
Heat	0.80–1.10	0.40–0.70	0.60–1.00
Product	0.75–1.15	0.37–0.74	0.55–1.05
Phosphorus, max	0.025	0.025	0.025
Sulfur, max	0.025	0.025	0.025
Silicon			
Heat	0.40–0.80	0.20–0.35	0.15–0.35
Product	0.35–0.86	0.18–0.37	0.13–0.37
Nickel			
Heat	...	...	0.70–1.00
Product	...	...	0.67–1.03
Chromium			
Heat	0.50–0.80	1.40–2.00	0.40–0.65
Product	0.46–0.84	1.34–2.06	0.36–0.79
Molybdenum			
Heat	0.18–0.28	0.40–0.60	0.40–0.60
Product	0.15–0.31	0.36–0.64	0.36–0.64
Vanadium			
Heat	...	<sup>B</sup>	0.03–0.08
Product	...	...	0.02–0.09
Titanium			
Heat	...	0.04–0.10	...
Product	...	0.03–0.11	...
Zirconium			
Heat	0.05–0.15	...	...
Product	0.04–0.16	...	...
Copper			
Heat	...	0.20–0.40	0.15–0.50
Product	...	0.17–0.43	0.12–0.53
Boron	0.0025 max	0.0015–0.005	0.002–0.006

<sup>A</sup> Similar to Specification A 517/A 517M Grades A, E, and F, respectively.  
<sup>B</sup> May be substituted for part or all of titanium content on a one for one basis.

manufacturer may reheat treat the forgings. Testing after reheat treatment shall consist of the full number of specimens taken from locations complying with the specification or order.

### 7.3.3 Retests of Impact Specimens:

7.3.3.1 If the lateral expansion value for one specimen is below 0.015 in. [0.38 mm] but not below 0.010 in. [0.25 mm] and the average equals or exceeds 0.015 in. [0.38 mm], a retest of three additional specimens may be made. Each of the three retest specimens must equal or exceed the specified minimum value of 0.015 in. [0.38 mm].

7.3.3.2 If the required lateral expansion values are not obtained in the retest, or if the values in the initial test are below the required values for retest, no further retests are permitted unless the forgings are reheat treated. After reheat treatment a set of three specimens shall be tested and each must equal or exceed the specified minimum value of 0.015 in. [0.38 mm].

7.4 *Test Methods*—Tension and impact tests shall be made in accordance with the latest issue of Test Methods and Definitions A 370. Tension specimens shall be the standard 0.500-in. [12.5-mm] round by 2-in. [50-mm] gage length (see Fig. 5 (Suggested Types of Ends for Standard Round Tension Test Specimens), Test Methods and Definitions A 370). In case

of sections too small to accommodate this standard specimen, the largest practicable small size specimen shown in Fig. 4 shall be used. The impact specimens shall be the Charpy V-notch, as shown in Fig. 10 (Charpy (Simple-Beam) Impact Test) of Test Methods and Definitions A 370.

## 8. Repair Welding

8.1 Repair welding of forgings may be permitted but only at the option of the purchaser. Such repair welds shall be made in accordance with Section IX of the ASME Boiler and Pressure Vessel Code.

## 9. Test Reports

9.1 The certification requirements of Specification A 788 shall apply.

## 10. Product Marking

10.1 Each forging shall be identified in accordance with the Marking Section of Specification A 788.

## 11. Keywords

11.1 high-strength low-alloy steel; pipe fittings—steel; pressure vessel service; quenched and tempered steel; steel forgings—alloy

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