SPECIFICATION FOR HIGH-STRENGTH QUENCHED AND TEMPERED LOW-ALLOY STEEL FORGED FITTINGS AND PARTS FOR PRESSURE VESSELS

SA-592/SA-592M

(Identical with ASTM Specification A592/A592M-04(2009).)

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1. Scope

1.1 This specification 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 4 in. [100 mm] for Grades E and F.

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

1.2 Although no provision is made for supplementary requirements in this standard, the supplementary requirements in Specification A 788 may be considered by the purchaser.

1.3 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.

1.4 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.

1.5 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

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

A 788 Specification for Steel Forgings, General Requirements

E 112 Test Methods for Determining the Average Grain Size

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 the following information:

3.1.1 A detailed drawing, a sketch, or written description of the forging.

3.1.2 The charpy impact test temperature if a test temperature lower than 32°F [0°C] is required.

3.1.3 Additional heat treatment cycles to be applied to the mechanical test specimens following removal from the heat-treated forging or special forged test block.

3.1.4 Required supplementary requirement(s) from specification A 788.

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. Failure to comply with the requirements of Specification A 788 constitutes non-conformance with this specification.

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.

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, and to Table 3 for lateral expansion opposite the notch in Charpy V-notch impact tests. In addition, for the Charpy impact test, the values of energy absorption in foot-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 heat treated test specimens. (This is intended to simulate subsequent thermal treatments which may 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 an ingot, slab, or billet from the same heat as the forgings they represent and shall be reduced by forging in a manner similar to that for the products to be represented. The forging reduction for a special test block shall not exceed the minimum forging 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, the mid length position of the gauge length ffoor tension test specimens, or the notch of the Charpy V-notch impact test specimens shall be at least *T* from any second surface of the production forging or test block, where T equals the maximum heat treated thickness of the forging.

7.3 *Number of Tests and Retests:*

7.3.1 *Number of Tests, and Test Temperature:*

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 Test Method A 370 and Specification A 788.

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].

7.4 *Test Methods* — Tension and impact tests shall be made in accordance with the latest issue of Test Methods and Definitions A 370.

8. Repair Welding

8.1 Repair welding of forgings may be permitted but onlyat 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; fittings—steel; pressure vessel service; quenched and tempered steel; steel forgings—alloy

TABLE 1
CHEMICAL REQUIREMENTS

Element	Composition, %		
	Grade A[A]	Grade E[A]	Grade F[A]
Carbon	0.15–0.21	0.12–0.20	0.10–0.20
Manganese	0.80–1.10	0.40–0.70	0.60–1.00
Phosphorus, max	0.025	0.025	0.025
Sulfur, max	0.025	0.025	0.025
Silicon	0.40–0.80	0.20–0.35	0.15–0.35
Nickel	...	...	0.70–1.00
Chromium	0.50–0.80	1.40–2.00	0.40–0.65
Molybdenum	0.18–0.28	0.40–0.60	0.40–0.60
Vanadium	...	[B]	0.03–0.08
Titanium	...	0.04–0.10	...
Zirconium	0.05–0.15	...	...
Copper	...	0.20–0.40	0.15–0.50
Boron	0.0025 max	0.0015–0.005	0.002–0.006

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

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

TABLE 3
CHARPY IMPACT TEST REQUIREMENTS

All Grades and Thicknesses	15 mils (0.015 in.) [0.38 mm][A]

[A] Minimum value for each of three specimens. See 7.3.3.