SPECIFICATION FOR CARBON STEEL FORGINGS, FOR GENERAL-PURPOSE PIPING

SA-181/SA-181M

(Identical with ASTM Specification A 181/A 181M-95b except for editorial differences in 7.3.2 and 12.6)

1. Scope

1.1 This specification covers nonstandard as-forged fittings, valve components, and parts for general service. Forgings made to this specification are limited to a maximum weight of 10 000 lb [4540 kg]. Larger forgings may be ordered to Specification A 266.

1.2 Two grades of material are covered, designated as Classes 60 and 70, respectively, and are classified in accordance with their chemical composition and mechanical properties as specified in 5.1 and 6.1.

1.3 Class 60 was formerly designated Grade I and Class 70 was formerly designated Grade II.

1.4 This specification is expressed in both inch-pound units and SI units. However, unless the order specifies the applicable "M" specification designation (SI units), the material shall be furnished to inch-pound units.

1.5 The values stated in either inch-pound units or SI units are to be regarded as standard. Within the text, 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.

2. Referenced Documents

2.1 *ASTM Standards:*

A 266 Specification for Forgings, Carbon Steel, for Pressure Vessel Components

A 275/A 275M Test Method for Magnetic Particle Examination of Steel Forgings

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

A 700 Practices for Packaging, Marking, and Loading Methods for Steel Products for Domestic Shipment

A 751 Test Methods, Practices, and Terminology for Chemical Analysis of Steel Products

A 788 Specification for Steel Forgings, General Requirements

E 165 Test Methods for Liquid Penetrant Inspection Method

E 709 Guide for Magnetic Particle Examination

2.2 *ASME Boiler and Pressure Vessel Code:*

Section IX, Welding Qualifications

Section VIII, Pressure Vessels, Div. 1

2.3 *Military Standard:*

MIL-STD-163 Steel Mill Products, Preparation for Shipment and Storage

2.4 *AIAG Standard:*

AIAG B-5 02.00 Primary Metals Identification Tag Application Standard

3. Ordering Information

3.1 It is the purchaser's responsibility to specify in the purchase order all ordering information necessary to purchase the needed material. Examples of such information include but are not limited to the following:

3.1.1 Quantity,

3.1.2 Dimensions (Tolerances and surface finishes should be included),

3.1.3 Specification number (The year date should be included) and class,

3.1.4 Supplementary requirements, and

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3.1.5 Additional requirements (See 4.6, 12.2, 10, 12.7, 17.2, 18.1, 18.2, and 11.1).

4. Materials and Manufacture

4.1 The steel shall be made by the open-hearth, basic-oxygen, or electric-furnace process and shall be fully killed.

4.2 A sufficient discard shall be made from source material to secure freedom from injurious piping and undue segregation.

4.3 The material shall be forged as close as practicable to the specified shape and size.

4.4 Except for flanges of all types, hollow, cylindrically shaped parts may be machined from hot-rolled or forged bar, provided that the axial length of the part is approximately parallel to the metal flow lines of the stock. Other parts, excluding flanges of all types, up to and including NPS 4 may be machined from hot-rolled or forged bar. Elbows, return bends, tees, and header tees shall not be machined directly from bar stock.

4.5 Except as permitted in 4.4, the finished product shall be a forging as defined in the Terminology section (exclusively) of Specification A 788.

4.6 When specified in the order, the manufacturer shall submit for approval of the purchaser a sketch showing the shape of the rough forging before machining.

4.7 Forgings shall be protected against sudden or too rapid cooling from the rolling or forging while passing through the critical range.

4.8 Heat treatment is neither required nor prohibited, but when applied, heat treatment shall consist of tempering, annealing, normalizing, or normalizing and tempering.

5. Chemical Composition

5.1 *Cast or Heat Analysis*— An analysis of each cast or heat shall be made by the manufacturer to determine the percentages of the elements specified in Table 1. The analysis shall be made from a test sample taken preferably during the pouring of the cast or heat. The chemical composition thus determined shall conform to the requirements in Table 1.

5.2 *Product Analysis:*

5.2.1 The purchaser may make a product analysis on forgings supplied to this specification by any of the commonly accepted methods that will positively identify the material. Samples for analysis may be taken from midway between center and surface of solid forgings, midway between inner and outer surfaces of hollow forgings, midway between center and surface of full-size prolongations, or from broken mechanical test specimens. The chemical composition thus determined shall conform to Table 1 within the permissible variations of Table 2.

5.2.2 Test Methods, Practices, and Terminology A 751 shall apply.

6. Mechanical Properties

6.1 The material shall conform to the requirements as to tensile properties prescribed in Table 3.

6.2 Testing shall be performed in accordance with Test Methods and Definitions A 370.

7. Workmanship, Finish, and Appearance

7.1 The forgings shall be free of injurious imperfections as defined below and shall have a workmanlike finish. At the discretion of the inspector representing the purchaser, finished forgings shall be subject to rejection if surface imperfections acceptable under 7.3 are not scattered but appear over a large area in excess of what is considered a workmanlike finish.

7.2 *Depth of Injurious Imperfections* — Selected typical linear and other typical surface imperfections shall be explored for depth. When the depth encroaches on the minimum wall thickness of the finished forging, such imperfections shall be considered injurious.

7.3 *Machining or Grinding Imperfections Not Classified as Injurious* — Surface imperfections not classified as injurious shall be treated as follows:

7.3.1 Forgings showing seams, laps, tears, or slivers not deeper than 5% of the nominal wall thickness or $^{1}/_{16}$ in. [1.6 mm], whichever is less, need not have these imperfections removed. If the imperfections require removal, they shall be removed by machining or grinding.

7.3.2 Mechanical marks or abrasions and pits shall be acceptable without grinding or machining provided the depth does not exceed the limitations set forth in

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7.2 and if not deeper than $^{1}/_{16}$ in. [1.6 mm]. If such imperfections are deeper than $^{1}/_{16}$ in. [1.6 mm] but do not encroach on the minimum wall thickness of the forging they shall be removed by grinding to sound metal.

7.3.3 When imperfections have been removed by grinding or machining, the outside dimension at the point of grinding or machining may be reduced by the amount removed. Should it be impracticable to secure a direct measurement, the wall thickness at the point of grinding, or at imperfections not required to be removed, shall be determined by deducting the amount removed by grinding, from the nominal finished wall thickness of the forging, and the remainder shall not be less than the minimum specified or required wall thickness.

8. Number of Tests

8.1 One tension test shall be made from each heat.

8.2 If any test specimen is defectively machined, it may be discarded and another specimen substituted.

9. Retests

9.1 When one or more representative test specimens do not conform to specification requirements for the tested characteristic, only a single retest for each nonconforming characteristic may be performed to establish product acceptability. Retests shall be performed on twice the number of representative specimens that were originally nonconforming. When any retest specimen does not conform to specification requirements for the characteristic in question, the lot represented by that specimen shall be rejected, heat-treated or reheat-treated in accordance with 4.8, and tested in accordance with Sections 6, 8, and 10.

10. Test Specimens

10.1 The tension test specimens shall be machined to the form and dimensions of the standard 2 in. [50 mm] gage length tension test specimen shown in Fig. 4 of Test Methods and Definitions A 370, except as specified in 10.2.

10.2 In the case of small sections which will not permit the taking of standard test specimen specified in 10.1, the tension test specimen shall be as large as feasible and its dimensions shall be proportional to those shown in Fig. 4 of Test Methods and Definitions A 370. The gage length for measuring elongation shall be four times the diameter of the specimen.

10.3 For the purpose of determining conformance to Table 3, specimens shall be obtained from the production forgings, or from separately forged test blanks prepared from the stock used to make the finished product. Such test blanks shall receive approximately the same working as the finished product.

11. Reports of Testing

11.1 Upon request of the purchaser in the contract or order, a report of the test results and chemical analyses shall be furnished. The specification designation included on reports of testing shall include year of issue and revision letter, if any.

12. Repair by Welding

12.1 Repair welding, by the manufacturer, is permissible for parts made to dimensional standards such as those of ANSI or equivalent standards.

12.2 Prior approval of the purchaser shall be required to weld repair special parts made to the purchaser's requirements.

12.3 The welding procedure and welders shall be qualified in accordance with Section IX of the ASME Boiler and Pressure Vessel Code.

12.4 The composition of the weld deposits shall be similar to the base metal and in accordance with the procedure qualification for the applicable material. Welding shall be accomplished with a weld procedure designed to produce low hydrogen in the weldment. Short-circuit gas metal arc welding is permissible only with the approval of the purchaser.

12.5 Unacceptable imperfections shall be removed by mechanical means or thermal cutting or gouging methods. Cavities prepared for welding shall be examined by one of the following methods to verify removal of the imperfection:

12.5.1 Magnetic particle examination in accordance with Test Method A 275 or Guide E 709.

12.5.2 Liquid penetrant examination in accordance with Test Method E 165.

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12.6 Weld repaired area(s) shall be blended uniformly to the base metal and shall be examined by the same method used for 12.5.

12.7 Repair by welding shall neither exceed 10 % of the surface area of the part, nor $33^{1}/_{3}$ % of the wall thickness of the finished product at the location of repair, without prior approval of the purchaser.

13. Marking of Forgings

13.1 Identification marks consisting of the manufacturer's symbol or name (Note), designation of service rating, Specification number, grade, and size shall be legibly forged or stamped on each forging, and in such a position as not to injure the usefulness of the forgings. The specification number marked on the forgings need not include specification year of issue and revision letter.

NOTE 1 — For purposes of identification marking, the manufacturer is considered the organization that certifies the piping component was manufactured, sampled, and tested in accordance with this specification and the results have been determined to meet the requirements of this specification.

13.2 *Bar Coding* — In addition to the requirements in 13.1, bar coding is acceptable as a supplementary identification method. The purchaser may specify in the order a specific bar coding system to be used. The bar coding system, if applied at the discretion of the supplier, should be consistent with one of the published industry standards for bar coding. If used on small parts, the bar code may be applied to the box or a substantially applied tag.

14. Inspection

14.1 The manufacturer shall afford the purchaser's inspector all reasonable facilities necessary to satisfy him that the material is being produced and furnished in accordance with this specification. Mill inspection by the purchaser shall not interfere unnecessarily with the manufacturer's operations. All tests and inspections shall be made at the place of manufacture, unless otherwise agreed to.

15. Rejection

15.1 Each forging that develops injurious defects during shop working or application shall be rejected and the manufacturer notified.

16. Rehearing

16.1 Samples representing material rejected by the purchaser shall be preserved until disposition of the claim has been agreed upon between the manufacturer and the purchaser.

17. Packaging, Marking, and Loading for Shipment

17.1 Packaging, marking, and loading for shipment shall be in accordance with Practices A 700.

17.2 When specified in the contract or order, and for direct procurement by or direct shipment to the government, when level A is specified, preservation, packaging, and packing shall be in accordance with the Level A requirements of MIL-STD-163.

18. Certificate of Compliance

18.1 When specified in the purchase order or contract, a producer's or supplier's certification shall be furnished to the purchaser that the material was manufactured, sampled, tested, and inspected in accordance with this specification and has been found to meet the requirements. The specification designation included on certificates of compliance shall include year of issue and revision letter, if any.

18.2 When specified in the purchase order or contract, a report of the test results shall be furnished.

19. Keywords

19.1 pipe fittings; steel; piping applications; pressure containing parts; steel forgings; carbon; steel valves

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TABLE 1
CHEMICAL REQUIREMENTS

Element	Composition, % Classes 60 and 70
Carbon, max	0.35
Manganese, max	1.10[A]
Phosphorus, max	0.05
Silicon, max	0.10–0.35
Sulfur, max	0.05

[A] Manganese may be increased to 1.35% max provided the carbon is reduced 0.01% for each 0.06% increase in manganese over the limit shown in the table.

TABLE 2
PERMISSIBLE VARIATIONS IN PRODUCT ANALYSIS

NOTE 1 — Product cross-sectional area (taken at right angles to the axis of the original ingot or billet) is defined as either:
(a) maximum cross-sectional area of rough machined forging (excluding boring),
(b) maximum cross-sectional area of the unmachined forging, or
(c) maximum cross-sectional area of the billet, bloom or slab.

	Permissible Variations over the Maximum Limit or Under the Minimum Limit, %				
	200 in.^{2} [1290 cm^2] and under	Over 200 to 400 in.^{2} [1290 to 2580 cm^2] incl	Over 400 to 800 in.^{2} [2580 to 5160 cm^2] incl	Over 800 to 1600 in.^{2} [5160 to 10 320 cm^2]	Over 1600 in.^{2} [10 320 cm^2]
Manganese					
Up to and including 0.90	0.04	0.05	0.06	0.07	0.08
0.91 and over	0.06	0.07	0.08	0.08	0.09
Phosphorus	0.008	0.010	0.010	0.015	0.015
Sulfur	0.010	0.010	0.010	0.015	0.015
Silicon	0.03	0.04	0.04	0.05	0.06

TABLE 3
TENSILE REQUIREMENTS

	Class 60	Class 70
Tensile strength, min, ksi [MPa]	60 [415]	70 [485]
Yield strength,[A] min, ksi [MPa]	30 [205]	36 [250]
Elongation in 2 in. [50 mm], min, %	22	18
Reduction of area, min, %	35	24

[A] Determined by either the 0.2% offset method or the 0.5% extension-under-load method.

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SUPPLEMENTARY REQUIREMENTS

S1. Carbon Equivalent

S1.1 The maximum carbon equivalent based on heat analysis shall be as follows:

	Maximum Carbon Equivalent Value	
Class	Maximum Section Thickness Less Than or Equal to 2 in.	Maximum Section Thickness Greater Than 2 in.
60	0.45	0.46
70	0.47	0.48

S1.2 Determine the carbon equivalent (CE) as follows:

$$CE = Mn/6 + (Cr + Mo + V)/5 + (Ni + Cu)/15$$

S1.3 A lower maximum carbon equivalent may be agreed upon between the supplier and the purchaser.

S1.4 When this Supplementary Requirement is invoked, all elements in the carbon equivalent formula shall be analyzed and the amounts reported.

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