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Standard Specification for Carbon Steel Forgings for Piping Applications[1]

This standard is issued under the fixed designation A 105/A105M; 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 Department of Defense.

1. Scope

1.1 This specification[2] covers forged carbon steel piping components for ambient- and higher-temperature service in pressure systems. Included are flanges, fittings, valves, and similar parts ordered either to dimensions specified by the purchaser or to dimensional standards such as the ANSI and API specifications referenced in Section 2. 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. Tubesheets and hollow cylindrical forgings for pressure vessel shells are not included within the scope of this specification. Although this specification covers some piping components machined from rolled bar and seamless tubular products, (see 4.4) it does not cover raw material produced in these product forms.

1.2 Supplementary requirements are provided for use when additional testing or inspection is desired. These shall apply only when specified individually by the purchaser in the order.

1.3 Specification A 266/A 266M covers other steel forgings and Specifications A 675, A 695, and A 696 cover other steel bars.

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 are to be regarded separately 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.

NOTE 1—The dimensionless designator NPS (nominal pipe size) has been substituted in this standard for such traditional terms as "nominal diameter," "size," and "nominal size."

2. Referenced Documents

2.1 *ASTM Standards:*

A 266/A 266M Specification for Carbon Steel Forgings for Pressure Vessel Components[3]

A 275/A 275M Test Method for Magnetic Particle Examination of Steel Forgings[3]

A 370 Test Methods and Definitions for Mechanical Testing of Steel Products[3,4,5]

A 675 Specification for Steel Bars, Carbon, Hot–Wrought, Special Quality, Mechanical Properties[3]

A 695 Specification for Steel Bars, Carbon, Hot-Wrought, Special Quality, for Fluid Power Applications[3]

A 696 Specification for Steel Bars, Carbon, Hot-Wrought or Cold-Finished, Special Quality, for Pressure Piping Components[3]

A 751 Test Methods, Practices, and Terminology for Chemical Analysis of Steel Products[3,4,5]

A 788 Specification for Steel Forgings, General Requirements[3]

E 165 Test Method for Liquid Penetrant Examination[6]

E 340 Test Method for Macroetching Metals and Alloys[7]

2.2 *MSS Standards:*

SP-25 Standard Marking System for Valves, Fittings, Flanges and Unions[8]

SP 44 Standard for Steel Pipe Line Flanges[8]

2.3 *ASME Standards:*

Section IX, Welding Qualifications, ASME Boiler and Pressure Vessel Code[9]

B16.5 Dimensional Standards for Steel Pipe Flanges and Flanged Fittings[9]

B16.9 Wrought Steel Buttwelding Fittings[9]

B16.10 Face-to-Face and End-to-End Dimensions of Ferrous Valves[9]

B16.11 Forged Steel Fittings, Socket Weld, and Threaded[9]

[1] 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 A01.22 on Valves, Fittings, Bolting, and Flanges for High Subatmospheric Temperatures.

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[2] For ASME Boiler and Pressure Vessel Code applications see related Specification SA-105 in Section II of that Code.

[3] *Annual Book of ASTM Standards*, Vol 01.05.

[4] *Annual Book of ASTM Standards*, Vol 01.01.

[5] *Annual Book of ASTM Standards*, Vol 01.03.

[6] *Annual Book of ASTM Standards*, Vol 03.03.

[7] *Annual Book of ASTM Standards*, Vol 03.01.

[8] Available from Manufacturers' Standardization Society of the Valve and Fittings Industry, 1815 N. Fort Myer Drive, Arlington, VA 22209.

[9] Available from American Society of Mechanical Engineers, 345 E. 47th St., New York, NY 10017.

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B16.34 Valves-Flanged, Threaded and Welding End[9]
B16.47 Large Diameter Steel Flanges[9]
2.4 *API Standards:*
API-600 Flanged and Butt-Welding-End Steel Gate Valves[10]
API-602 Compact Design Carbon Steel Gate Valves for Refinery Use[10]
2.5 *AWS Standard:*
AWSA 5.1 Mild Steel Covered Arc-Welding Electrodes[11]

3. Ordering Information

3.1 It is the purchaser's responsibility to specify in the purchase order all ordering information as 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 Size and pressure class or dimensions (Tolerances and surface finishes should be included),

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

3.1.4 Supplementary requirements, and

3.1.5 Additional requirements (See Table 1 footnotes, 12.1, and 16.2).

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 bar, forged bar, or seamless tubular materials provided that the axial length of the part is approximately parallel to the metal flow lines of the stock. Other parts (up to and including NPS 4) not including flanges 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 by 4.4, the finished product shall be a forging as defined in the Terminology Section of Specification A 788.

5. Heat Treatment

5.1 Heat treatment is not a mandatory requirement of this specification except for the following piping components:

5.1.1 Flanges above Class 300,[12]

5.1.2 Flanges of special design where the design pressure at the design temperature exceeds the pressure-temperature ratings of Class 300, Group 1.1,

5.1.3 Flanges of special design where the design pressure or design temperature are not known,

[10] Available from American Petroleum Institute, 2101 L St. N.W., Washington, DC 20037.

[11] Available from American Welding Society, 550 LeJeune Rd., P.O. Box 351040, Miami, FL 33135.

[12] For definition of Class 300, see ASME B16.5.

TABLE 1 Chemical Requirements

NOTE—For each reduction of 0.01 % below the specified carbon maximum (0.35 %), an increase of 0.06 % manganese above the specified maximum (1.05 %) will be permitted up to a maximum of 1.35 %.

Element	Composition, %
Carbon	0.35 max
Manganese	0.60–1.05
Phosphorus	0.035 max
Sulfur	0.040 max
Silicon	0.10–0.35
Copper	0.40 max[A]
Nickel	0.40 max[A]
Chromium	0.30 max[A,B]
Molybdenum	0.12 max[A,B]
Vanadium	0.05 max
Columbium	0.02 max

[A] The sum of copper, nickel, chromium and molybdenum shall not exceed 1.00 %.
[B] The sum of chromium and molybdenum shall not exceed 0.32 %.

5.1.4 Piping components other than flanges which meet both of the following criteria: (*1*) over NPS 4 and (*2*) above Class 300, and

5.1.5 Piping components of Special Class[13] other than flanges which meet both of the following criteria: (*1*) over NPS 4 and (*2*) when the working pressure at the operating temperature exceeds the tabulated values for Special Class 300, Group 1.1.

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5.2 Heat treatment when required by 5.1 shall be annealing, normalizing, or normalizing and tempering or quenching and tempering.

5.2.1 *Annealing*—The procedure for annealing shall consist of allowing the forgings immediately after forging or rolling, to cool to a temperature below 1000°F [538°C]. They shall then be reheated to a temperature between 1550°F [843°C] and 1700°F [927°C] to refine the grain (a group thus reheated being known as an "annealing charge") and allowed to cool uniformly in the furnace.

5.2.2 *Normalizing*—The procedure for normalizing shall consist of allowing the forgings, immediately after forging or rolling, to cool to a temperature below 1000°F [538°C]. They shall then be uniformly reheated to a temperature between 1550°F [843°C] and 1700°F [927°C] to refine the grain (a group thus reheated being known as a "normalizing charge") and allowed to cool in air.

5.2.3 *Tempering*—The procedure for tempering shall consist of heating the forgings to a temperature between 1100°F [593°C] and the lower transformation temperature for a minimum of ½ h/in. [½ h/25.4 mm] of maximum section thickness.

5.2.4 *Quenching*—The procedure for quenching shall consist of either (*1*) fully austenitizing the forgings followed by quenching in a suitable liquid medium or (*2*) using a multiple stage procedure whereby the forging is first fully austenitized and rapidly cooled, then reheated to partially reaustenitize, followed by quenching in a suitable liquid medium. All quenched forgings shall be tempered as prescribed in 5.2.3.

6. Chemical Composition

6.1 The steel shall conform to the chemical requirements

[13] For definition of special class, see ASME B16.34.

specified in Table 1. Test Methods, Practices, and Terminology A 751 shall apply.

6.2 Steels to which lead has been added shall not be used.

7. Cast or Heat (Formerly Ladle) Analysis

7.1 An analysis of each heat of steel shall be made from samples taken, preferably during the pouring of the heat, and the results shall conform with Table 1.

8. Product Analysis

8.1 The purchaser may make a product analysis on forgings supplied to this specification. 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 tolerances stated in Table 2.

9. Mechanical Properties

9.1 The material shall conform to the mechanical property requirements prescribed in Table 3 and Table 4.

9.2 For the purpose of determining conformance with Table 3 and Table 4, specimens shall be obtained from production forgings after heat treatment, when heat treatment is required, 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. The test blanks shall be heat treated with the finished product.

9.3 For normalized, normalized and tempered, or quenched and tempered forgings, the central axis of the test specimen shall correspond to the 1/4 *T* plane or deeper position, where *T* is the maximum heat-treated thickness of the represented forging. In addition, for quenched andtempered forgings, the midlength of the test specimen shall be at least *T* from any second heat-treated surface. When section thickness does not permit this positioning, the test specimen shall be positioned as near as possible to the prescribed location.

TABLE 3 Mechanical Requirements[A]

Tensile strength, min, psi [MPa]	70 000 [485]
Yield strength, min, psi [MPa][B]	36 000 [250]
Elongation in 2 in. or 50 mm, min, %:	
Basic minimum elongation for walls 5/16 in. [7.9 mm] and over in thickness, strip tests.	30
When standard round 2-in. or 50-mm gage length or smaller proportionally sized specimen with the gage length equal to 4D is used	22
For strip tests, a deduction for each 1/32 -in. [0.8-mm] decrease in wall thickness below 5/16 in. [7.9 mm] from the basic minimum elongation of the percentage points of Table 4	1.50[C]
Reduction of area, min, %[D]	30
Hardness, HB, max	187

[A] For small forgings, see 9.4.4.
[B] Determined by either the 0.2 % offset method or the 0.5 % extension-under-load method.
[C] See Table 4 for computed minimum values.
[D] For round specimens only.

9.4 *Tension Tests*:

9.4.1 One tension test shall be made for each heat of as-forged components.

9.4.2 One tension test shall be made from each heat-treating charge. If more than one heat is included in such a charge, each heat shall be tested.

9.4.2.1 When the heat-treating temperatures are the same and the furnaces (either batch or continuous type), are controlled within ±25°F [±14°C] and equipped with recording pyrometers so that complete records of heat treatment are available, then one tension test from each heat is required instead of one test from each heat in each heat-treatment charge. The test specimen material shall be included with a furnace charge.

9.4.3 Testing shall be performed in accordance with Test Methods and Definitions A 370. The largest feasible round specimen as described in Test Methods and Definitions A 370 shall be used except when hollow cylindrically shaped parts are machined from seamless tubulars. The gage length for measuring elongation shall be four times the diameter of the

TABLE 2 Permissible Variations in Product Analysis

NOTE—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] incl	Over 1600 in.^{2} [10 320 cm^2]
Carbon	0.02	0.03	0.04	0.05	0.05
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
Copper	0.03	0.03	0.03	0.03	0.03
Nickel	0.03	0.03	0.03	0.03	0.03
Chromium	0.04	0.04	0.04	0.04	0.04
Molybdenum	0.01	0.01	0.01	0.01	0.01
Vanadium	0.01	0.01	0.01	0.01	0.01
Colombium	0.01	0.01	0.01	0.01	0.01