Designation: A 727/A 727M – 02 (Reapproved 2007)

Standard Specification for Carbon Steel Forgings for Piping Components with Inherent Notch Toughness[1]

This standard is issued under the fixed designation A 727/A 727M; 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[2] covers forged carbon steel piping components intended primarily for service in pressure piping systems from −20 to +650 °F [−30 to +345 °C] where inherent notch toughness is desired, but where notch toughness testing is not required. Included are forged or ring-rolled flanges, forged fittings, and valves made to specified dimensions, or to dimensional standards such as the ASME and API specifications referenced in Section 2.

1.2 This specification is limited to forgings with maximum finished section thicknesses no larger than 2 in. [51 mm].

1.3 It shall be the responsibility of the purchaser to determine whether material meeting the requirements of this specification is satisfactory for the service application.

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

NOTE 1—There are no provisions for impact testing in this specification. When impact testing is required, refer to Specification A 350/A 350M.

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

1.6 The values stated in either inch-pound units or SI units 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.

2. Referenced Documents

2.1 In addition to those reference documents listed in Specification A 961/A 961M, the following list of standards apply to this specification.

2.2 *ASTM Standards:* [3]

A 350/A 350M Specification for Carbon and Low-Alloy Steel Forgings, Requiring Notch Toughness Testing for Piping Components

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

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

A 961/A 961M Specification for Common Requirements for Steel Flanges, Forged Fittings, Valves, and Parts for Piping Applications

E 59 Practice for Sampling Steel and Iron for Determination of Chemical Composition[4]

2.3 *ASME Boiler and Pressure Vessel Codes:*[5]

Section II, Materials Specifications, Part C

SFA 5.5 Low-Alloy Steel Covered Arc-Welding Electrodes

B 16.5 Steel Pipe Flanges and Flanged Fittings

B 16.10 Face-to-Face and End-to-End Dimensions of Ferrous Valves

B 16.11 Forged Steel Fittings, Socket-Welding and Threaded

B 16.30 Unfired Pressure Vessel Flange Dimensions

2.4 *API Standards:*[6]

600 Steel Gate Valves with Flanged or Butt-Welding Ends

602 Compact Design Carbon Steel Gate Valves for Refinery Use

[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 A01.22 on Steel Forgings and Wrought Fittings for Piping Applications and Bolting Materials for Piping and Special Purpose Applications.

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[2] For ASME Boiler and Pressure Vessel Code applications see related Specification SA-727 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] Withdrawn.

[5] Available from American Society of Mechanical Engineers (ASME), ASME International Headquarters, Three Park Ave., New York, NY 10016-5990, http://www.asme.org.

[6] Available from American Petroleum Institute (API), 1220 L. St., NW, Washington, DC 20005-4070, http://api-ec.api.org.

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605 Large Diameter Carbon Steel Flanges

2.5 *MSS Standard:*[7]

MSS SP-25 Standard Marking System for Valves, Fittings, Flanges, and Unions

3. General Requirements and Ordering Information

3.1 Product furnished to this specification shall conform to the requirements of Specification A 961/A 961M, including any supplementary requirements that are indicated in the purchase order. Failure to comply with the requirements of Specification A 961/A 961M constitutes nonconformance with this specification. In case of a conflict between the requirements of this specification and Specification A 961/A 961M, this specification shall prevail.

3.2 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:

3.2.1 Additional requirements (see 15.1 and 15.2).

4. Materials and Manufacture

4.1 The steel shall be made by one or more of the following processes: open-hearth, basic-oxygen, or electric-furnace, and shall be fully killed, fine-grain practice.

4.2 Forgings shall be manufactured from ingots, blooms, billets, slabs, or bars. These items shall be forged, rolled, or strandcast.

4.3 A sufficient discard shall be made from the ingot to secure freedom from injurious piping and undue segregation.

4.4 The finished product shall be a forging as defined by the Terminology section of Specification A 788/A 788M.

5. Heat Treatment

5.1 Following plastic working, the forging manufacturer shall heat treat the forgings by normalizing, or normalizing and tempering, or quenching and tempering.

5.1.1 *Normalizing*—The procedure for normalizing shall consist of uniformly heating the forgings to a temperature between 1550 and 1700 °F [845 and 925 °C], holding a sufficient time to attain uniform temperature throughout, and cooling in still air. The forging shall be at a temperature below 1000 °F [540 °C] before heating for normalizing.

5.1.2 *Quenching*—The procedure for quenching shall consist of uniformly heating the forging to a temperature between 1550 and 1700 °F [845 and 925 °C], holding a sufficient time to attain uniform temperature throughout, and quenching into a suitable liquid medium. The forging shall be at a temperature below 1000 °F [540 °C] before heating for quenching.

5.1.3 *Tempering*—The procedure for tempering shall consist of reheating the forging subsequent to normalizing or quenching to a temperature of at least 1100 °F [595 °C], but not above the lower transformation temperature, for 30 min/in. [30 min/25 mm] of maximum section thickness, with minimum holding time at tempering temperature not less than 30 min.

6. Chemical Composition

6.1 The steel shall conform to the requirements as to chemical composition prescribed in Table 1.

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

7. *Mechanical Requirements* Mechanical Requirements

7.1 *Tension Tests*:

7.1.1 *Requirements*—The material shall conform to requirements for tensile properties prescribed in Table 2.

7.1.1.1 The test specimen shall be obtained from a rough or finished production forging, or prolongation thereof, or it may be obtained from separately forged test blanks from the same heat of steel as the production forging. The test blank shall be reduced by forging in a manner similar to that for the products represented, shall receive approximately the same hot working and reduction, be of the same nominal thickness, and receive the same heat treatment as the finished products represented. The test material shall be treated in the same furnace at the same time as the forging it represents, subject to the requirements of 7.1.2.1.

7.1.2 *Number of Tests*—One tension test at room temperature shall be made for each nominal wall thickness ± ¼ in. [± 6 mm] from each heat in each heat treatment charge.

7.1.2.1 If heat treatment is performed in either a continuous or a batch-type furnace controlled within ± 25 °F [± 14 °C] of the required heat-treatment temperature, and equipped with

TABLE 1 Chemical Requirements

Elements	Composition, %
Carbon	
Heat Analysis	0.25 max
Product Analysis	0.28 max
Manganese	
Heat Analysis	0.90 to 1.35
Product Analysis	0.84 to 1.41
Phosphorus	
Heat Analysis	0.035 max
Product Analysis	0.043 max
Sulfur	
Heat Analysis	0.025 max
Product Analysis	0.033 max
Silicon	
Heat Analysis	0.15 to 0.30
Product Analysis	0.13 to 0.32
Nickel	
Heat Analysis	0.40[A]
Product Analysis	0.43
Chromium	
Heat Analysis	0.30[A,B]
Product Analysis	0.34
Molybdenum	
Heat Analysis	0.12[A,B]
Product Analysis	0.13
Copper	
Heat Analysis	0.40[A]
Product Analysis	0.43
Columbium (Nb)	
Heat Analysis	0.02
Product Analysis	0.03
Vanadium	
Heat Analysis	0.05
Product Analysis	0.055

[A] The sum of copper, nickel, chromium and molybdenum shall not exceed 1.00 % on heat analysis.

[B] The sum of chromium and molybdenum shall not exceed 0.32 % on heat analysis.

[7] Available from Manufacturers Standardization Society of the Valve and Fittings Industry (MSS), 127 Park St., NE, Vienna, VA 22180-4602, http://www.mss-hq.com.

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TABLE 2 Tensile Requirements

Tensile strength, ksi [MPa]	60.0 to 85.0 [415 to 585]
Yield strength, min, ksi [MPa][A]	36.0 [250]
Elongation in 2 in. or 50 mm, min, %	22
Reduction of area, min, %	30

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

recording pyrometers so that complete records of heat treatment are available and if the same heat treating cycles are used on the forgings represented by the tension test, then one tension test per nominal wall thickness ± ¼ in. [± 6 mm] from each heat shall be required, instead of one tension test per nominal wall thickness from each heat in each heat-treatment charge.

7.1.3 *Test Locations and Orientations*—The test specimen shall be removed from the midwall of the heaviest section of the forging or test blank.

7.1.3.1 The test specimen shall have its longitudinal axis located parallel to the direction of major working of the forging or test blank, except for flanges and rings the test specimen shall be in the tangential direction.

7.1.4 *Test Method*—Testing shall be performed in accordance with Test Methods and Definitions A 370 using the largest feasible of the round specimens. The gage length for measuring elongation shall be four times the diameter of the test section.

7.2 *Hardness Test*:

7.2.1 *Requirements*—If the production forgings are liquid-quenched and tempered, hardness of the forgings shall not exceed 187 HB after heat treatment. The purchaser may verify that the requirement has been met by testing at any location on the forgings provided such testing does not render the forgings useless.

8. Heat Analysis

8.1 An analysis of each heat of steel shall be made from samples taken preferably during the pouring of the heat. The results shall conform to Table 1.

9. Product Analysis

9.1 A product analysis may be made by the purchaser on samples taken in accordance with Practice E 59. The results shall conform to Table 1.

10. Hydrostatic Test

10.1 Forgings manufactured under this specification shall be capable of passing a hydrostatic test compatible with the rating of the finished forging. Such tests shall be conducted by the forging manufacturer only when Supplementary Requirement S8 in Specification A 961/A 961M is specified.

11. Rework and Retreatment

11.1 If the results of mechanical tests do not conform to the requirements specified, the manufacturer may reheat treat the forgings represented, and shall retest to the applicable requirements.

11.2 Individually tested forgings meeting all requirements shall be acceptable.

12. Repair by Welding

12.1 Repair of defects by welding shall be permitted at the discretion of the forging manufacturer.

12.2 Repair by welding shall be made using welding procedures and welders qualified in accordance with Section IX of the ASME Boiler and Pressure Vessel Code. When forgings are heat treated after repair welding, the qualification test plates shall be subjected to the same heat treatment. The mechanical properties of the qualification test plates shall conform to Section 7.

12.3 Only electrode classifications with the -A1 designator shall be used (for example, E71T1-A1). SMAW, GMAW, FCAW or GTAW may be used. The GMAW process is limited to either the spray transfer or pulsed arc process. The FCAW process is limited to repair of carbon or carbon-molybdenum base materials only. Electrodes shall conform to the applicable AWS A5 electrode specification.

12.4 Forgings repair welded in the normalized, normalized and tempered, or the quenched and tempered conditions shall be stress-relieved after repair welding at 1100 °F [595 °C] minimum, but not higher than the temperature previously used for tempering the base metal of the same forging, or shall be reheat treated in accordance with Section 5.

13. Inspection

13.1 All tests and inspections shall be made at the place of manufacture, unless otherwise agreed, except for product analysis (see 9.1).

14. Rejection and Rehearing

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

15. Certification

15.1 For forgings made to specified dimensions, when agreed to by the purchaser, and for forgings made to dimensional standards, application of identification marks as required in Section 16 shall be the certification that the forgings have been furnished in accordance with the requirements of this specification.

15.2 When test reports are required, they shall include certification that all requirements of this specification have been met. The reports shall show the results of all required tests, the heat number or manufacturer's heat identification, a description of the heat treatment used, and shall be traceable to the forging represented. The specification designation included on test reports shall include year of issue and revision letter, if any.

16. Product Marking

16.1 Identification marks consisting of the specification designation, manufacturer's name or symbol, (Note 2) the heat number or manufacturer's heat identification, size, and service rating, if applicable, shall be permanently placed on each forging in a position that will not affect the usefulness of the forging. When size does not permit complete marking, identification marks may be omitted in the sequence specified in

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SP-25, except that the word "steel" shall not be substituted for the specification designation. The specification number marked on the forgings need not include specification year of issue and revision letter.

NOTE 2—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.

16.1.1 If the forgings have been quenched and tempered the letters "QT" shall be stamped on the forgings following the Specification designation.

16.1.2 Forgings repaired by welding shall be marked with the letter "W" following the specification designation.

16.2 When test reports are required, additional marks shall be used as necessary to identify the part with the test report.

16.3 *Bar Coding*—In addition to the requirements in 16.1 and 16.2, bar coding is acceptable as a supplemental 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.

17. Keywords

17.1 carbon equivalent; pipe fittings; steel; piping applications; pressure containing parts; steel flanges; steel forgings; carbon; steel valves; temperature service applications; low

SUPPLEMENTARY REQUIREMENTS

One or more of the following supplementary requirements shall be applied only when specified by the purchaser in the inquiry, contract, or order. Details of these supplementary requirements shall be agreed upon in writing by the manufacturer and purchaser. Supplementary requirements shall in no way negate any requirement of the specification.

S1. Carbon Equivalent

S1.1 The maximum carbon equivalent, based on heat analysis shall be 0.45 for forgings with a maximum section thickness of 2 in. or less, and 0.46 for forgings with a maximum section thickness of greater than 2 in.

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

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

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

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