Designation: A 707/A 707M – 02 (Reapproved 2007)

Standard Specification for Forged Carbon and Alloy Steel Flanges for Low-Temperature Service[1]

This standard is issued under the fixed designation A 707/A 707M; 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 covers forged carbon and alloy steel flanges intended primarily for petroleum and gas pipelines in areas subject to low ambient temperatures. Included are flanges to specified dimensions or to dimensional standards such as those MSS, ASME, and API specifications that are referenced in Section 2.

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

1.3 Eight grades, four yield-strength classes, and three different notch toughness levels are included.

1.4 The availability of a particular size of flange of a specific grade and class is limited only by the capability of the composition to meet the specified mechanical property requirements. However, current practice normally limits the following:

(a) Grade L1 to Classes 1 and 2,
(b) Grade L2 to Classes 1, 2, and 3,
(c) Grade L3 to Classes 1, 2, and 3,
(d) Grade L4 to Classes 1, 2, and 3,
(e) Grade L7 to Classes 1 and 2, and
(f) Grades L5, L6, and L8 are generally available in any class.

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:* [2]

A 388/A 388M Practice for Ultrasonic Examination of Heavy Steel Forgings

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

2.3 *MSS Standards:*

SP 44 Steel Pipeline Flanges[3]

2.4 *API Standard:*

605 Large Diameter Carbon Steel Flanges[4]

2.5 *ASME Boiler and Pressure Vessel Code:*

Section VIII Division I, Part UG-84[5]

Section IX Welding Qualifications[5]

2.6 *ASME Standard:*

B 16.5 Dimensional Standards for Steel Pipe Flanges and Flanged Fittings[5]

2.7 *AWS Standards:*

A 5.1 Mild Steel Covered Electrodes[6]

A 5.5 Low-Alloy Steel Covered Arc-Welding Electrodes[6]

3. Terminology

3.1 *Definitions:*

[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.

Current edition approved March 1, 2007. Published April 2007. Originally approved in 1974. Last previous edition approved in 2002 as A 707/A 707M – 02.

[2] 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.

[3] 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.

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

[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 Welding Society (AWS), 550 NW LeJeune Rd., Miami, FL 33126, http://www.aws.org.

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3.1.1 *flakes*—short discontinuous internal fissures attributed to stresses produced by localized transformation and decreased solubility of hydrogen during cooling after hot working.

3.1.2 *linear surface imperfection (or indication)*—an imperfection or indication with a length at least three times its width.

4. Ordering Information

4.1 It is the purchaser's responsibility to specify in the purchase order all ordering information necessary to purchase the needed material. In addition to the ordering information guide lines in Specification A 961/A 961M, orders should include the following information:

4.1.1 Additional requirements (see Table 1 footnotes, 9.2.2, 9.3, 11.5, 17.1, 21.1, and 21.2).

5. General Requirements

5.1 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 general requirements of Specification A 961/A 961M constitutes nonconformance with this specification. In case of conflict between the requirements of this specification and Specification A 961/A 961M, this specification shall prevail.

6. Manufacture

6.1 The steel shall meet the melting practice of Specification A 961/A 961M.

6.2 The finished product shall be a forging as defined by 3 (only) of Specification A 788/A 788M.

7. Heat Treatment

7.1 After forging and before reheating for heat treatment, the forging shall be allowed to cool substantially below the transformation range. The method of cooling shall be such as to ensure against the development of cracks, flakes, etc.

7.2 All material shall be heat treated by annealing, normalizing, precipitation hardening, quenching-and-tempering, normalizing-and-tempering, normalizing-and-precipitation hardening, or quenching-and-precipitation hardening.

7.2.1 The procedures for the various heat treatments are as given in Specification A 961/A 961M except as defined in the following:

7.2.1.1 *Precipitation Hardening*—Consists of heating to a temperature between 1000 and 1250°F [538 and 677°C], holding at temperature for not less than ½ h, and then cooling at any convenient rate.

TABLE 1 Chemical Requirements

Element	Grade							
	L1[A]	L2[A]	L3	L4	L5	L6	L7[B]	L8
Carbon, max, %								
Heat analysis	0.20	0.30	0.22	0.18	0.07	0.07	0.20	0.20
Product analysis	0.23	0.33	0.25	0.20	0.09	0.09	0.22	0.22
Manganese, %								
Heat analysis	0.60-1.50	0.60-1.35	1.15–1.50	0.45–0.65	0.40–0.70	1.85–2.20	0.90 max	0.20–0.40
Product analysis	0.55-1.60	0.55-1.45	1.05–1.60	0.40–0.70	0.35–0.75	1.75–2.30	1.00 max	0.15–0.45
Phosphorus, max, %								
Heat analysis	0.030	0.030	0.025	0.025	0.025	0.025	0.025	0.020
Product analysis	0.035	0.035	0.030	0.030	0.030	0.030	0.030	0.025
Sulfur, max, %								
Heat analysis	0.030	0.030	0.025	0.025	0.025	0.025	0.025	0.020
Product analysis	0.040	0.040	0.035	0.035	0.035	0.035	0.035	0.025
Silicon, max, %								
Heat analysis	0.35	0.35	0.30	0.35	0.35	0.15	0.35	0.35
Product analysis	0.37	0.37	0.32	0.37	0.37	0.17	0.37	0.37
Chromium, %								
Heat analysis	0.30 max	0.30 max	0.30 max	0.30 max	0.60–0.90	0.30 max	0.30 max	1.50–2.00
Product analysis	0.34 max	0.34 max	0.34 max	0.34 max	0.56–0.94	0.34 max	0.34 max	1.44–2.06
Nickel, %								
Heat analysis	0.40 max	0.40 max	0.40 max	1.65–2.00	0.70–1.00	0.40 max	3.2–3.7	2.8–3.9
Product analysis	0.43 max	0.43 max	0.43 max	1.60–2.05	0.67–1.03	0.43 max	3.18–3.82	2.68–3.97
Molybdenum, %								
Heat analysis	0.12 max	0.12 max	0.12 max	0.20–0.30	0.15–0.25	0.25–0.35	0.12 max	0.40–0.60
Product analysis	0.13 max	0.13 max	0.13 max	0.19–0.33	0.14–0.28	0.22–0.38	0.13 max	0.35–0.65
Vanadium, %								
Heat analysis	0.05 max	0.05 max	0.04–0.11	0.05 max	0.05 max	0.05 max	0.05 max	0.05 max
Product analysis	0.06 max	0.06 max	0.03–0.13	0.06 max	0.06 max	0.06 max	0.06 max	0.06 max
Nitrogen, %								
Heat analysis	...	...	0.010–0.030	...	...	...	...	...
Product analysis	...	...	0.005–0.035	...	...	...	...	...
Copper, %								
Heat analysis	0.40 max	0.40 max	0.20 min[C]	0.40 max	1.00–1.30	0.40 max	0.40 max	0.40 max
Product analysis	0.43 max	0.43 max	0.18 min[C]	0.43 max	0.95–1.35	0.43 max	0.43 max	0.43 max
Columbium, %								
Heat analysis	0.02 max	0.02 max	0.02 max	0.02 max	0.03 min	0.06–0.10	0.02 max	0.02 max
Product analysis	0.03 max	0.03 max	0.03 max	0.03 max	0.02 min	0.05–0.11	0.03 max	0.03 max

[A] The sum of copper, nickel, chromium, and molybdenum shall not exceed 1.00 % on heat analysis.
[B] The sum of chromium, molybdenum and vanadium shall not exceed 0.32 % on heat analysis.
[C] When specified.

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8. Chemical Composition

8.1 A chemical heat analysis in accordance with Specification A 961/A 961M shall be made and conform to the requirements as to chemical composition prescribed in Table 1. Leaded steels shall not be permitted.

9. Mechanical Requirements

9.1 The material in the weld neck shall conform to the mechanical property requirements prescribed in Table 2.

9.2 For the purpose of determining conformance with Table 2, mechanical testing requirements shall confrom to Specification A 961/A 961M.

9.2.1 For flanges smaller than 24 in. [610 mm] in size, the forged test blanks shall be at least 2 in. [50 mm] wide by 2 in. [50 mm] thick by 12 in. [300 mm] in length. The test specimens shall be taken with their longitudinal axes parallel to the length of the test blank.

9.2.2 For flanges 24 in. [610 mm] and larger in size, the test blank dimensions and orientation of test specimens with respect to the test blank shall be subject to agreement.

9.3 Specimens shall be obtained from the midwall of the thinnest section of the hub of the flange or ¾ in. [19 mm] from the surface of the test blank. The orientation of specimens taken from a flange shall be subject to agreement.

10. Hardness Requirements

10.1 A sufficient number of hardness measurements shall be made to ensure that the hardness values are within the ranges prescribed in Table 2. The number of flanges to be tested shall be as agreed upon between the manufacturer and the purchaser. The purchaser may verify that the requirement has been met by testing at any location on the flange, provided such testing does not render the flange useless.

11. Impact Requirements

11.1 The material in the weld neck shall conform to the requirements as to impact properties prescribed in Table 2 if the weld neck section is ¼ in. [6 mm] or greater in thickness.

TABLE 2 Mechanical Requirements

Property	Class 1	Class 2	Class 3	Class 4
Yield strength[A] min, ksi [MPa]	42 [290]	52 [360]	60 [415]	75 [515]
Tensile strength, min, ksi [MPa]	60 [415]	66 [455]	75 [515]	90 [620]
Elongation in 2 in. or 50 mm, min, %	22	22	20	20
Reduction of area, min, %	40	40	40	40
Hardness, HBN	149–207	149–217	156–235	179–265
Cv energy absorption,[B,C] min, avg, ft·lbf [J]	30 [41]	40 [54]	50 [68]	50 [68]
C_v energy absorption,[B,D] min, ft·lbf [J]	24 [33]	32 [43]	40 [54]	40 [54]

[A] 0.2 % offset.

[B] For a set of three full-size [10 by 10 mm] Charpy V-notch specimens. Acceptance values for sub-size specimens are reduced in proportion to the reduction in width of the specimen.

[C] These requirements are intended to minimize fracture initiation. They are not intended to give assurance against fracture propagation. If minimization of fracture propagation is of interest, consideration should be given to specifying Supplementary Requirement S7 at the operating temperature.

[D] Minimum impact energy permitted for one specimen only of a set of three specimens.

11.2 For the purpose of determining conformance with Table 2, specimens shall be obtained from production flanges after heat treatment or from separately forged test blanks prepared from the stock used to make the forgings. Such test blanks shall conform to the requirements of Specification A 961/A 961M.

11.3 Specimens shall be obtained from a location on the flange or test blank that represents the midwall of the weld neck if the thickness of the weld neck is 2 in. [50 mm] or less. If the thickness is greater than 2 in. [50 mm], the specimen location shall be midway between a surface and the center of thickness. Specimens taken from a flange shall be oriented longitudinally with respect to the bore of the flange.

11.4 One test (three specimens) shall be made from each heat in each heat treatment charge.

11.5 Unless otherwise specified, the test temperature shall be as specified in Table 3.

12. Product Analysis

12.1 The purchaser may make a product analysis on flanges supplied to this specification in accordance with Specificaiton A 961/A 961M.

13. Ultrasonic Examination

13.1 Each flange weld neck 24 in. [610 mm] and larger in diameter shall be ultrasonically examined over 100 % of the area within 2 in. [50 mm] of the welding end.

13.2 Longitudinal wave examination using a 2¼ MHz transducer 1 to 1⅛ in. [25 to 29 mm] in diameter or 1 in. square [25 mm square] shall be used. Examination shall be in accordance with the general requirements of Practice A 388/A 388M.

13.3 Any area giving an indication equal to or larger than the signal received from a ¼-in. [6-mm] flat-botton hole shall be cause for rejection. Multiple indications with an amplitude exceeding 50 % of the indication from the calibration hole, accompanied by a loss of back reflection exceeding 50 %, shall also be cause for rejection. Any indication that results in a complete loss of back reflection shall be cause for rejection.

14. Tension Tests

14.1 Tensile requirements shall comply with Specification A 961/A 961M where one tension test shall be made from each heat in each heat treating charge.

TABLE 3 Impact Test Temperatures[A]

Grade	Test Temperature (Unless Otherwise Specified), °F [°C]
L1	−20 [−29]
L2	−50 [−46]
L3	−50 [−46]
L4	−80 [−62]
L5	−80 [−62]
L6	−80 [−62]
L7	−100 [−73]
L8	−100 [−73]

[A] These temperatures are the lowest test temperatures that are commonly acceptable by the producer. If the minimum design temperature is higher, specifying the higher temperature as the test temperature will generally result in increased availability of a specific grade in greater thicknesses.

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14.1.1 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.

15. Hydrostatic Tests

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

16. Retreatment

16.1 If the results of the mechanical property or impact tests do not conform to the requirement specified, the manufacturer may reheat treat the flanges as applicable and repeat the tests specified.

17. Workmanship, Finish, and Appearance

17.1 In addition to the requirements of Specification A 961/A 961M, the flanges shall be free of injurious imperfections as defined below and shall have a workmanlike finish.

17.1.1 *Welding End*— The machined bevel shall be visually examined. Any lamination extending into the weld bevel and having a transverse dimension exceeding ¼ in. [6 mm] shall be considered injurious.

17.1.2 *Hub Section*—Linear imperfections with a length in excess of ⅛ in. [3 mm] and other imperfections such as slivers, sharp notches, gouges, scores, pits, etc., shall be considered injurious.

18. Repair by Welding

18.1 Repair of imperfections shall be permitted only with the approval of the purchaser. When approved, the limitations and requirements of Specification A 961/A 961M shall apply:

18.1.1 In addition, the deposited weld metal shall be capable of producing welds with mechanical and impact test properties as specified in Table 2 at the test temperature specified in Table 3 for the base metal after the thermal treatments in 18.1.2. SMAW (using only low-hydrogen electrodes), GMAW, FCAW or GTAW may be used. Electrodes shall conform to the applicable AWS A5 electrode specification. The GMAW process is limited to either the spray transfer or pulsed arc process. FCAW process is limited to repair of carbon or carbon-molybdenum base materials only. Welding procedures shall be qualified in accordance with Section IX and Paragraph UG-84, Section VIII, Div. 1, of the Code.

18.1.2 All flanges repaired by welding shall be thermally treated after repair by either complete reheat treatment or post-weld heat treatment.

18.1.3 Indications discovered by ultrasonic inspection shall be reinspected in accordance with Section 13 after reheat treatment.

19. Inspection

19.1 Inspection provisions of Specification A 961/A 961M apply.

20. Rejection and Rehearing

20.1 Each flange that develops injurious imperfections during shop working or application shall be rejected and the manufacturer notified.

20.2 Purchaser shall comply with provisions of Specification A 961/A 961M.

21. Certification

21.1 For flanges made to specified dimensions, when agreed upon by the purchaser, and for flanges made to dimensional standards, application of identification marks as required in 22.1 shall be the certification that the flanges have been furnished in accordance with the requirements of the specification.

21.2 When test reports are required, they shall include certification that all requirements of this specification have been met, the results of all required tests, and description of heat treatment including temperature ranges, times, mode of cooling, and the heat number or manufacturer's heat identification. The specification designation included on test reports shall include year of issue and revision letter, if any.

22. Product Marking

22.1 In addition to the marking requirements of Specification A 961/A 961M, the impact test temperature shall be legibly stamped on each flange.

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.

22.1.1 If the flanges have been quenched-and-tempered or quenched-and-aged the letters QT or QA, as applicable, shall be stamped on the flanges following the ASTM designation.

22.1.2 Forgings repaired by welding shall be marked with the letter "W" following the ASTM designation.

22.2 When test reports are required, the markings shall include such other markings as necessary to identify the part with the test report.

22.3 *Bar Coding*—In addition to the requirements in 22.1 and 22.2, 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.

23. Keywords

23.1 carbon equivalent; piping applications; pressure containing parts; residual elements; steel flanges; steel forgings, alloy; steel forgings, carbon; temperature service applications; low

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SUPPLEMENTARY REQUIREMENTS

In addition to any of the supplementary requirements of Specification A 961/A 961M, the following supplementary requirements shall apply only when specified by the purchaser in the order:

S1. Ultrasonic Examination

S1.1 Flanges smaller than 24 in. [610 mm] shall be ultrasonically examined in accordance with Section 13.

S2. Additional Tension and Impact Tests

S2.1 In addition to the requirements of Sections 9, 10, 11 and 14, one tension specimen and one set of impact specimens shall be obtained from a representative flange at a location agreed upon between the manufacturer and purchaser. The results of these specimens shall comply with the requirements of Table 3 and Table 1 and shall be reported to the purchaser.

S3. Carbon Equivalent

S3.1 The maximum carbon equivalent, based on heat analysis, for Grades L1, L2, and L3 shall be as shown in Table S3.1:

S3.2 Determine the carbon equivalent (CE) as follows:

TABLE S3.1 Maximum Carbon Equivalent Value

Class	Maximum Thickness Less Than or Equal to 2 in.	Maximum Thickness Greater Than 2 in.
1	0.45	0.46
2	0.45	0.46
3	0.47	0.48

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

S3.3 A lower maximum carbon equivalent may be agreed upon between the supplier and the purchaser.

S4. Notch Toughness, 50 % Shear FATT Minimum

S4.1 In addition to the requirements of Section 11, the impact specimens shall exhibit a minimum of 50 % shear fracture appearance at the temperature specified on the order.

S5. Additional Ultrasonic Test Requirement

S5.1 In addition to the requirements of Section 13, flanges shall be tested by the angle beam method in accordance with Practice A 388/A 388M. Testing shall be limited to an area within 2 in. [50 mm] of the welding end. Acceptance limits shall be as agreed upon between the manufacturer and purchaser.

S6. Notch Toughness, Measurement, and Reporting of Percent Shear and Lateral Expansion

S6.1 In addition to the requirements of Section 11, percent shear and mils of lateral expansion shall be measured and reported for informational purposes.

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