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

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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 A961/A961M, the following list of standards apply to this specification:

2.2 *ASTM Standards:*[2]
A388/A388M Practice for Ultrasonic Examination of Steel Forgings
A788/A788M Specification for Steel Forgings, General Requirements
A961/A961M 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 5.5 Low-Alloy Steel Covered Arc-Welding Electrodes[6]

[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 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.

***A Summary of Changes section appears at the end of this standard**

3. Terminology

3.1 *Definitions:*

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 A961/A961M, orders should include the following information:

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

5. General Requirements

5.1 Product furnished to this specification shall conform to the requirements of Specification A961/A961M, including any supplementary requirements that are indicated in the purchase order. Failure to comply with the general requirements of Specification A961/A961M constitutes nonconformance with this specification. In case of conflict between the requirements of this specification and Specification A961/A961M, this specification shall prevail.

6. Manufacture

6.1 The steel shall meet the melting practice of Specification A961/A961M.

6.2 The finished product shall be a forging as defined by 3 (only) of Specification A788/A788M.

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 A961/A961M except as defined in the following:

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.

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.

8. Chemical Composition

8.1 A chemical heat analysis in accordance with Specification A961/A961M 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 conform to Specification A961/A961M.

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.

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, HBW	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. 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.

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 A961/A961M.

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 Specification A961/A961M.

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 A388/A388M.

13.3 Any area giving an indication equal to or larger than the signal received from a ¼-in. [6-mm] flat-bottom hole shall be cause for rejection. Multiple indications with an amplitude

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.