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Standard Specification for Wrought High-Strength Low-Alloy Steel Butt-Welding Fittings[1]

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1. Scope

1.1 This specification covers wrought high-strength low-alloy steel butt-welding fittings of seamless and electric fusion-welded construction covered by the latest revisions of ANSI B16.9, ANSI 16.28, and MSS-SP-75. Butt-welding fittings differing from these ANSI and MSS standards shall be furnished in accordance with Supplementary Requirement S9. These fittings are for use in high-pressure gas and oil transmission and distribution systems.

1.2 Optional supplementary requirements are provided for fittings when a greater degree of examination is desired. One or more of the supplementary requirements may be specified in the order.

1.3 This specification does not cover cast-welding fittings or fittings machined from castings.

1.4 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 this specification. Unless the order specifies the applicable "M" specification designation (SI units), the material shall be furnished to inch-pound units.

2. Referenced Documents

2.1 *ASTM Standards:*

A 370 Test Methods and Definitions for Mechanical Testing of Steel Products[2]

A 530/A 530 M Specification for General Requirements for Specialized Carbon and Alloy Steel Pipe[2]

A 751 Test Methods, Practices, and Terminology for Chemical Analysis of Steel Products[2]

E 165 Test Method for Liquid Penetrant Examination[3]

E 709 Practice for Magnetic Particle Examination[3]

2.2 *ANSI Standards:*

B16.9 Steel Butt-Welding Fittings[4]

B16.28 Wrought Steel Butt-Welding Short Radius Elbows and Returns[4]

2.3 *AWS Standard:*

AWS 5.18 Specification for Carbon Steel Metals for Gas Shielded Arc Welding[5]

2.4 *ASME Boiler and Pressure Vessel Code:*[6]

Section V, Nondestructive Examination

Section VIII, Division 1, Pressure Vessels

Section IX, Welding Qualifications

2.5 *MSS Standards:*

MSS-SP-25 Standard Marking System for Valves, Fittings, Flanges and Unions[7]

MSS-SP-75 Specification for High Test Wrought Butt-Welding Fittings[7]

2.6 *ASNT Standard:*

SNT-TC-1A(1984) Recommended Practice for Nondestructive Testing Personnel Qualification and Certification[8]

3. Ordering Information

3.1 Orders for material under this specification shall include the following information:

3.1.1 Quantity, number of fittings of each kind,

3.1.2 Description of fitting and nominal dimensions (standard or special),

3.1.3 Grade Symbol,

3.1.4 Construction, seamless or welded (unless seamless or welded construction is specified by the purchaser either may be furnished at the option of the supplier),

3.1.5 Supplementary requirements, if any,

3.1.6 Specification designation and year of issue,

3.1.7 Additional requirements, if any (see 17.6), and

3.1.8 Requirements for certification of test report.

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[1] This specification is under the jurisdiction of ASTM Committee A-1 on Steel, Stainless Steel, and Related Alloysand is the direct responsibility of Subcommittee A01.22on Steel Forgings and Wrought Fittings for Piping Applications and Bolting Materials for Piping and Special Purpose Applications.

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

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

[4] Available from American National Standards Institute, 11 West 42nd St., 13th Floor, New York, NY 10036.

[5] Available from American Welding Society, 550 N. W. Lajeune Rd., Miami, FL 33135.

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

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

[8] Available from American Society for Nondestructive Testing, 4153 Arlingate Plaza, P.O. Box 28518, Columbus, OH 43228-0518.

4. Materials and Manufacture

4.1 The material for fittings shall be fully killed fine-grain material made by a melting process that is intended to produce rounded, well dispersed, fine sulphide inclusions, that promote good notch toughness, assists in the resistance to hydrogen induced cracking, and for weldability suitable for field welding.

4.2 Starting materials shall consist of plate, sheet, forgings, forging quality bar, and seamless or fusion-welded tubular products with filler metal added. The chemical composition shall conform to Table 1.

4.3 A starting material that specifically requires the addition of any element beyond those listed in Table 1 is not permitted. This does not preclude the use of deoxidizers.

4.4 Starting material shall not require a preheat for field welding provided that the restrictions of ASME Boiler and Pressure Vessel Code, Section VIII, Paragraph UW-30 are complied with.

4.5 Forging or shaping operations may be performed by hammering, pressing, piercing, extruding, upsetting, rolling, bending, fusion, welding, machining, or by a combination of these operations. Fittings machined from bar shall be restricted to NPS-4 or smaller. Elbows, return bends, tees, and header tees shall not be machined directly from bar stock.

4.6 All welds including welds in tubular products from which the fittings are made shall be:

4.6.1 Made by welders, welding operators, and welding procedures qualified under the provisions of ASME Boiler and Pressure Vessel Code, Section IX,

4.6.2 Heat treated in accordance with Section 5 of this specification, and

4.6.3 Radiographically examined throughout the entire length of each weld in accordance with Articles 1 and 2 of ASME Boiler and Pressure Vessel Code, Section V with acceptance limits in accordance with Paragraph UW-51 of ASME Boiler and Pressure Vessel Code, Section VIII.

TABLE 1 Chemical Requirements

	Composition %		
	Heat Analysis	Product Analysis	
Carbon	0.20[A]	0.22	
Manganese	1.00–1.45	1.50	All values are maximum unless a range is stated
Phosphorus	0.030	0.030	
Sulfur	0.010	0.010	
Silicon	0.15–0.40[B]	0.10–0.40	
Nickel	0.50[C]	0.60	
Chromium	0.30[C]	0.30	
Molybdenum	0.25[C]	0.25	
Copper	0.35[C]	0.35	
Titanium	0.05	0.05	
Vanadium	0.10	0.10	
Columbium	0.04	0.04	
Vanadium plus Columbium	0.12	0.12	
Aluminum	0.06	0.06	

[A] The carbon equivalent, as calculated by the following formula, shall not exceed 0.42 %:

$$CE = C + \frac{Mn}{6} + \frac{Cr + Mo + V}{5} + \frac{Ni + Cu}{15}$$

[B] If vacuum carbon deoxidation is used, silicon shall not exceed 0.10 % by heat analysis and 0.12 % by product analysis.

[C] The sum of Ni + Cr + Mo + Cu shall not exceed 1.0 %.

4.7 The welded joints of the fittings shall be furnished in accordance with the requirements of Paragraph UW-35(a) of ASME Boiler and Pressure Vessel Code, Section VIII.

4.8 All butt-weld tees manufactured by cold-forming methods shall be liquid penetrant or magnetic particle examined by one of the methods specified in Supplementary Requirements S3 or S4. This examination shall be performed in accordance with a written procedure and shall be performed after final heat treatment. Only the side wall area of the tees need be examined. This area is defined by a circle that covers the area from the weld bevel of the branch outlet to the center line of the body or run. Internal and external surfaces shall be examined when size permits accessibility. No cracks shall be permitted. Other imperfections shall be treated in accordance with Section 11.1 on finish. After the removal of any cracks, the tees shall be re-examined by the original method. Acceptable tees shall be marked with the symbol PT or MT, as applicable, to indicate compliance. NDE personnel shall be qualified in accordance with SNT-TC-1A.

4.9 All caps machined from bar stock shall be examined by liquid penetrant or magnetic particle in accordance with Supplementary Requirements S3 or S4, and with personnel qualifications, acceptance criteria, and marking as in 4.8.

5. Heat Treatment

5.1 All fittings shall be furnished in the heat-treated condition. Fittings formed above the transformation temperature or upon which welding is performed, shall be cooled to below the lower critical temperature prior to heat treatment. Fittings shall subsequently be heat treated by one or more of the following procedures:

5.1.1 *Normalizing*—Fittings shall be uniformly heated to a selected temperature above the transformation range and held at that temperature for a minimum of 30 min. Each fitting shall be uniformly cooled in air.

5.1.2 *Quenching and Tempering*:

5.1.2.1 *Quenching*—Fittings shall be uniformly heated to a selected temperature above the transformation range for at least 30 min and subsequently quenched in a liquid medium to a temperature below 300°F [150°C]. Quench facilities shall be equipped with suitable agitation systems such as mechanical agitation, recirculation pumps, sprays, or controlled overflow, or a combination thereof. The temperature of the water quenchants shall be restricted to a maximum of 120°F [49°C] at the end of the quench. The temperature of oil quenchants shall be maintained between 120 and 160°F [49 and 71°C] using the maximum temperature suggested by the manufacturer. Polymer quenchants shall be controlled to a maximum temperature recommended by the quenchant manufacturer. Baths shall be of adequate type and size to rapidly absorb the heat rejected by the most massive part to be quenched. Quenched fittings shall subsequently be tempered.

5.1.2.2 *Tempering*—Fittings to be tempered shall be heated to the selected temperature between 1150°F [620°C] and the lower critical temperature and held there for the greater of ½h or 1 h/in. [2.4 min/mm] of the thickness at the thickest section and subsequently cooled at any convenient rate.

5.1.3 *Stress Relieving*—The fittings shall be heated to selected temperature below the transformation range, but not

less than 1150°F [620°C], held at temperature for at least 1 h and subsequently cooled at any convenient rate.

6. Chemical Composition

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

6.2 The steel shall not contain any unspecified elements for the ordered grade to the extent that it conforms to the requirements of another grade for which that element is a specified element having a required minimum content.

6.3 Analysis of each heat of steel shall be made from a sample taken preferably during the pouring of the heat. The results shall conform to Table 1 for either heat or product analysis limits as applicable.

6.4 The fittings manufacturer shall make a product analysis per heat from either the starting material or from a fitting. The chemical composition thus determined shall conform to Table 1. The product analysis shall be the basis for rejection. For referee purposes, Methods, Practices, and Terminology A 751 shall apply.

6.5 The carbon equivalent of the base metal, as determined by the following formula, shall not exceed 0.42 % for the product analysis:

$$CE = C + \frac{Mn}{6} + \frac{Cr + Mo + V}{5} + \frac{Ni + Cu}{15}$$

6.6 Weld metal used in the construction of the fittings shall conform to the tensile and impact requirements of 8.4 and 7.1 after heat treatment in accordance with Section 5. A chemical analysis shall be performed on deposited weld metal for each heat of filler metal or, for submerged arc welding, each heat of filler metal and batch of flux. The weld metal shall be deposited in accordance with the qualified weld procedure.

6.7 Only the carbon content of the deposited weld-metal composition need comply with the requirements of Table 1. The nickel content of the deposited weld metal shall not exceed 1.0 %.

7. Notch Toughness Properties

7.1 The notch toughness properties of the fittings shall conform to the requirements listed in Table 2. The testing shall be performed in accordance with Test Methods and Definitions A 370. Full size Charpy, V-notch specimens shall be used whenever possible. Small size specimens shall be used only when the material thickness does not permit full size specimens. The impact specimens shall not be flattened after heat treatment. All base metal specimens shall be removed with the axis of the specimens longitudinal to the direction of primary metal flow. Weld-metal specimens shall be specimens with the axis transverse to the weld seam.

7.2 One set of impact tests (three specimens) shall be made to represent the base metal and one set (three specimens) to represent the weld metal on the same frequency as the tension tests.

7.3 The test temperature shall be −50°F [−46°C].

8. Tensile Requirements

8.1 The tensile properties of the fitting material shall conform to the requirements listed in Table 2. The testing shall be performed in accordance with Test Methods and Definitions A 370.

8.2 Tension test specimens shall be taken from a fitting after

TABLE 2 Mechanical Requirements

Property	Grade					
	WPHY 42	WPHY 46	WPHY 52	WPHY 60	WPHY 65	WPHY 70
Yield strength, min[A] 0.2 % offset, ksi [MPa]	42 [290]	46 [315]	52 [360]	60 [415]	65 [450]	70 [485]
Tensile strength, ksi [MPa]	60 [415]	63 [435]	66 [455]	75 [515]	77 [530]	80 [550]
	−85 [585]	− 88 [605]	− 91 [625]	− 100 [690]	− 102 [705]	− 105 [725]
Elongation:						
Standard round specimen, or small-size proportional specimen, min, % in 4D	25	25	25	20	20	20
Rectangular specimen, for section thickness 5⁄16in. [7.94 mm] and over, and for all small sizes tested in full section; min, % in 2 in. [50 mm].	32	32	32	28	28	28
Rectangular specimen for thickness less than 5⁄16in. [7.94 mm]; min, % 2 in. [50 mm]. Width of specimen 1½in. [40 mm].	[B]	[B]	[B]	[B]	[B]	[B]
Toughness:						
$C_v$energy absorption[C]; measured at −50°F [−46°C].						

Size, mm	Average/min, ft·lbs[J]	Lateral Expansion min, MLS[mm]
10 × 10	30/25 [40/34]	25 [0.64]
10 × 7.5	25/21 [34/28]	21 [0.53]
10 × 5	20/17 [27/23]	13 [0.33]

[A] Actual yield strength shall not exceed specified minimum by more than 15 ksi [105 MPa].

[B] For each 1⁄32-in. [0.79 mm] decrease in section thickness below 5⁄16in. [7.94 mm], a deduction of 1.5 % from the elongation value of specimens above 5⁄16 in. [7.94 mm] is permitted. When the section thickness lies between two values defined above, the minimum elongation value is determined by the following equation:

$$E = 48t + 15.00$$

where:

E = elongation % in 2 in. [50 mm], and

t = actual thickness of specimen.

[C] These requirements are intended to minimize fracture initiation. The requirements are not intended to give assurance against fracture propagation.