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

This standard is issued under the fixed designation A 860/A 860M; 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 wrought high-strength low-alloy steel butt-welding fittings of seamless and electric fusion-welded construction covered by the latest revisions of ASME B16.9, ASME 16.28, and MSS-SP-75. Butt-welding fittings differing from these ASME and MSS standards shall be furnished in accordance with Supplementary Requirement S58 of Specification A 960/A 960M. 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:* [2]

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

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

A 960/A 960M Specification for Common Requirements for Wrought Steel Piping Fittings

2.2 *ASME Standards:*[3]

B16.9 Steel Butt-Welding Fittings

B16.28 Wrought Steel Buttwelding Short Radius Elbows and Returns

2.3 *AWS Standard:*

AWS 5.18 Specification for Carbon Steel Metals for Gas Shielded Arc Welding[4]

2.4 *ASME Boiler and Pressure Vessel Code:*[3]

Section V, Nondestructive Examination

Section VIII, Division 1, Pressure Vessels

Section IX , Welding and Brazing Qualifications

2.5 *MSS Standards:*[5]

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

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

2.6 *American Society of Nondestructive Testing:*[6]

SNT-TC-1A Recommended Practice for Nondestructive Testing Personnel Qualification and Certification

3. Ordering Information

3.1 In addition to the requirements of Specification A 960/A 960M, the following ordering information applies:

3.1.1 Grade Symbol,

3.1.2 Requirements for certification of test report.

4. General Requirements

4.1 Product furnished to this specification shall conform to the requirements of Specification A 960/A 960M, including any supplementary requirements that are indicated in the

[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 American Society of Mechanical Engineers (ASME), ASME International Headquarters, Three Park Ave., New York, NY 10016-5990.

[4] Available from The American Welding Society (AWS), 550 NW LeJeune Rd., Miami, FL 33126.

[5] Available from Manufacturers Standardization Society of the Valve and Fittings Industry (MSS), 127 Park St., NE, Vienna, VA 22180-4602.

[6] Available from The American Society for Nondestructive Testing (ASNT), P.O. Box 28518, 1711 Arlingate Ln., Columbus, OH 43228-0518.

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purchase order. Failure to comply with the general requirements of Specification A 960/A 960M constitutes nonconformance with this specification. In case of conflict between the requirements of this specification and Specification A 960/A 960M, this specification shall prevail.

5. Materials and Manufacture

5.1 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.

5.2 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.

5.3 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.

5.4 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.

5.5 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.

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

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

5.6.2 Heat treated in accordance with Section 6 of this specification, and

5.6.3 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	
Carbon	0.20[A]	
Manganese	1.00–1.45	All values are maximum unless a range is stated
Phosphorus	0.030	
Sulfur	0.010	
Silicon	0.15–0.40[B]	
Nickel	0.50[C]	
Chromium	0.30[C]	
Molybdenum	0.25[C]	
Copper	0.35[C]	
Titanium	0.05	
Vanadium	0.10	
Columbium	0.04	
Vanadium plus Columbium	0.12	
Aluminum	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 %.

5.7 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.

5.8 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 S69 or S70 of Specification A 960/A 960M. 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 12.1 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.

5.9 All caps machined from bar stock shall be examined by liquid penetrant or magnetic particle in accordance with Supplementary Requirements S69 or S70 of Specification A 960/A 960M, and with personnel qualifications, acceptance criteria, and marking as in 5.8.

6. Heat Treatment

6.1 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 normalizing, quenching, and tempering or stress relieving in accordance with Specification A 960/A 960M.

7. Chemical Composition

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

7.2 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.

7.3 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 Specification A 960/A 960M for product analysis limits as applicable.

7.4 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, Test Methods, Practices, and Terminology A 751 shall apply.

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

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

7.6 Weld metal used in the construction of the fittings shall conform to the tensile and impact requirements of 9.4 and 8.1 after heat treatment in accordance with Section 6. 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.

7.7 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 %.

8. Notch Toughness Properties

8.1 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.

8.2 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.

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

9. Tensile Requirements

9.1 The tensile properties of the fitting material shall conform to the requirements listed in Table 2.

9.2 Tension test specimens shall be taken from a fitting after final heat treatment or from a test piece of the same heat and nominal thickness that was heat treated in a furnace charge with the fittings they represent.

9.3 One tensile test is required for each heat of fittings of the same section thickness, and heat treated in either a continuous or batch-type furnace, controlled within a range of 50°F [28°C] and equipped with recording pyrometers.

9.4 In addition, fittings containing welds shall have one center-weld tension test made with the axis transverse to the weld seam for each heat of filler metal, or each heat of filler metal and batch of flux for submerged arc welds, for fittings of the same section thickness and heat treated in either a continuous or batch-type furnace controlled within a range of 50°F [28°C] and equipped with recording pyrometers. Only the ultimate tensile strength need meet the minimum requirement of Table 2.

10. Hardness Requirements

10.1 Fittings shall have a maximum hardness of 22 HRC (235 HB).

11. Dimensions

11.1 Dimensional requirements for NPS 14 and smaller butt-welding fittings are provided in ASME B16.9 and B16.28.

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 5⁄16 in. [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 5⁄16 in. [7.94 mm]; min, % 2 in. [50 mm]. Width of specimen 1½ in. [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 5⁄16 in. [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.

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11.2 Dimensional requirements for butt-welding fittings larger than NPS 14 through NPS 48 are provided by MSS-SP-75.

11.3 Fittings of a size or shape differing from the standards in 11.1 and 11.2, but meeting all the other requirements of this specification, may be furnished in accordance with Supplementary Requirement S58 of Specification A 960/A 960M.

11.4 Fittings that do not have a thickness or yield strength, or both, that are equal to the mating pipe, are acceptable provided the welding end preparations comply with MSS-SP-75, Figs. 3(a), (b), and (c) and the fitting welding-end thickness is at least equal to the pipe wall thickness times the ratio of the specified minimum yield strength of the pipe and the minimum tested yield strength of the fitting.

12. Workmanship, Finish and Appearance

12.1 The requirements of Specification A 960/A 960M apply except as modified as follows: The wall thickness at all points shall be at least 93½ % of the specified nominal wall thickness, and the diameters at all points shall be within the specified limits.

12.2 When the removal of a surface discontinuity reduces the wall thickness below 93½ % of the specified nominal wall thickness at any point, the fitting shall be subject to rejection or to repair as provided in Section 13.

13. Repair by Welding (Base Metal)

13.1 Repair welding by the manufacturer is permissible in accordance with Specification A 960/A 960M and the following:

13.1.1 The deposited weld metal shall conform to the requirements of 7.4 and 7.5. Electrodes for the shielded metal-arc process shall be of the low-hydrogen type.

13.1.2 After repair welding, sections thicker than 1 in. [25 mm] also shall be radiographed in accrodance with 5.6.

13.1.3 All fittings repaired by welding shall be thermally treated after repair by either complete reheat treatment or post-weld heat treatment at least 50°F [28°C] below the tempering temperature if tempering has been performed.

13.1.4 Indications discovered by nondestructive examination shall, after reheat treatment, be again examined by the same NDE method as used in the original determination.

14. Hydrostatic Test

14.1 Hydrostatic testing is not required by this specification.

14.2 All fittings shall be capable of withstanding, after installation, without failure, leakage, or impairment of serviceability, a hydrostatic test pressure of 100 % based on minimum yield strength of the material grade, wall thickness, and outside diameter ordered in Section 3. The hydrostatic pressure shall be calculated in accordance with Barlow's equation:

$$P = 2S \cdot \frac{t}{D}$$

where:

P = hydrostatic pressure,
S = specific yield strength, min,
t = nominal wall thickness, and
D = outside diameter.

15. Rejection and Rehearing

15.1 Material that fails to conform to the requirements of this specification may be rejected. Rejection shall be reported to the producer or supplier promptly in writing. In case of dissatisfaction with the results of the tests, the producer or supplier may make claim for a rehearing.

16. Certification

16.1 When requested by the purchaser, the manufacturer shall provide a certificate of compliance to this specification (including year date). In addition, if requested to provide test reports, the manufacturer shall also provide the following, when applicable:

16.1.1 Chemical analysis results, when (Section 7 and Table 1), base metal only, and

16.1.2 Tensile property results, (Section 9 and Table 2), the yield strength and ultimate strength in ksi, and elongation in percent for the base metal. Transverse-weld tensile strength shall be reported in ksi.

16.1.3 Impact test results, (Section 8 and Table 2), base metal and weld metal, specimen size, and test temperature,

16.1.4 Type heat treatment, (Section 6),

16.1.5 Radiographic examination results, and

16.1.6 Any supplemental testing required by the purchase order.

17. Product Marking

17.1 Identification marking shall consist of the Manufacturer's symbol or name (Note Note 1), specification number (year date not needed), grade symbol, size and nominal wall thickness or schedule, and heat code identification. In addition, quench and tempered fittings shall be marked with the symbol QT, and cold-formed tees shall be marked as prescribed in 5.8.

NOTE 1—For purposes of identification marking, the manufacturer is considered the organization that certifies the piping component complies with this specification.

17.2 Fittings that have been repaired by welding shall be marked with the letter W following the designation number.

17.3 Marking shall be by low-stress die stamps or interrupted dot stamps and shall be in accordance with MSS-SP-25.

17.4 If the impact test temperature is other than −50°F [−46°C], it shall be marked on the fitting.

17.5 If extra yield strength or wall thickness is used in a compensatory manner as described in 11.4 of this specification, the fitting shall be marked with both the minimum wall measured at the welding ends of the fitting and the actual yield and specified yield as illustrated in the following:

Manufacturer	Designation	$\frac{\text{Actual YS}}{\text{Specified YS}}$	Diameter
MNFR	AXXX	$\frac{Z}{Y}$	16
Specified wall	Actual wall	Heat code	Heat treatment
0.95	0.98	QQR	QT

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where:
Z = actual yield strength, and
Y = specified minimum yield strength.

17.6 *Bar Coding*—In addition to the requirements in 17.1, 17.2, 17.3, 17.4, and 17.5, 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 fittings, the bar code may be applied to the box or a substantially applied tag.

18. Keywords

18.1 high-strength low-alloy steel; pipe fittings; steel; piping applications; pressure-containing parts

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