



Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service¹

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This standard has been approved for use by agencies of the Department of Defense.

1. Scope *

1.1 This specification² covers wrought carbon steel and alloy steel fittings of seamless and welded construction covered by the latest revision of ASME B16.9, B16.11, B16.28, MSS SP-79, and MSS SP-95. These fittings are for use in pressure piping and in pressure vessel fabrication for service at moderate and elevated temperatures. Fittings differing from these ASME and MSS standards shall be furnished in accordance with Supplementary Requirement S58 of Specification A 960.

1.2 Optional supplementary requirements are provided for fittings where a greater degree of examination is desired. When desired, one or more of these supplementary requirements may be specified in the order.

1.3 This specification does not cover cast welding fittings or fittings machined from castings. Cast steel welding fittings are governed by Specifications A 216/A 216M and A 217/A 217M.

1.4 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.

1.5 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 960, the following list of standards apply to this specification.

2.2 ASTM Standards:

A 216/A 216M Specification for Steel Castings, Carbon, Suitable for Fusion Welding, for High-Temperature Service³

A 217/A 217M Specification for Steel Castings, Martensitic Stainless and Alloy, for Pressure-Containing Parts Suitable for High-Temperature Service³

A 960 Specification for Common Requirements for Wrought Steel Piping Fittings⁴

2.3 ASME Standards:⁵

B16.9 Steel Butt-Welding Fittings

B16.11 Forged Steel Fittings, Socket Welding and Threaded

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

2.4 ASME Boiler and Pressure Vessel Code:⁵

Section V Nondestructive Examination

Section VIII, Division 1, Pressure Vessels

Section IX Welding Qualifications

2.5 MSS Standards:⁶

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

MSS SP-79 Socket Welding Reducer Inserts

MSS SP-95 Swage(d) Nipples and Bull Plugs

2.6 ASNT Standard:

SNT-TC-1A(1984) Recommended Practice for Nondestructive Testing Personnel Qualification and Certification⁷

3. Ordering Information

3.1 See Specification A 960.

4. General Requirements

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

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-234 in Section II of that Code.

³ *Annual Book of ASTM Standards*, Vol 01.02.

⁴ *Annual Book of ASTM Standards*, Vol 01.01.

⁵ Available from ASME International, Three Park Avenue, New York, NY 10016-5990.

⁶ Available from Manufacturers Standardization Society of the Valve and Fittings Industry, 1815 N. Fort Myer Drive, Arlington, VA 22209.

⁷ Available from American Society for Nondestructive Testing, 4153 Arlington Plaza, Columbus, OH 43228-0518.

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

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Failure to comply with the requirements of Specification A 960 constitutes non-conformance with this specification. In case of a conflict between the requirements of this specification and Specification A 960, this specification shall prevail.

5. Materials

5.1 The material for fittings shall consist of killed steel, forgings, bars, plates, seamless or fusion-welded tubular products with filler metal added and shall conform to the chemical requirements of Table 1. Unless otherwise specified for carbon steel plates, the steel may be made to either coarse grain or fine grain practice. Grade WP9 shall be made to fine grain practice.

5.2 A starting material specification that specifically requires the addition of any element beyond those listed for the materials in Table 1 for the applicable grade of material is not permitted. This does not preclude the use of deoxidizers or the judicious use of elements for grain size control.

6. Manufacture

6.1 Forging or shaping operations may be performed by hammering, pressing, piercing, extruding, upsetting, rolling, bending, fusion welding, machining, or by a combination of two or more of these operations. The forming procedure shall be so applied that it will not produce injurious imperfections in the fittings.

NOTE 1—Fittings NPS-4 and under may be machined from hot-forged or rolled, cold-sized, and straightened bar stock having the chemical composition of the Grade in Table 1 and the mechanical properties of the Grade in Table 2. Heat treatment shall be in accordance with Section 7. All caps machined from bar stock shall be examined by liquid penetrant or magnetic particle in accordance with S52 or S53 in Specification A 960.

6.2 All welds including welds in tubular products from which fittings are made shall be (1) made by welders, welding operators, and welding procedures qualified under the provisions of ASME Section IX, (2) heat treated in accordance with Section 7 of this specification, and (3) radiographically examined throughout the entire length of each weld in accordance with Article 2, ASME Section V with acceptance limits in accordance with Paragraph UW-51 of ASME Section VIII, Division 1 of the ASME Boiler & Pressure Vessel Code. In place of radiographic examination, welds may be ultrasonically examined in accordance with Appendix 12 of Section VIII. The NDE of welds in Grades WPB, WPC, WP1, WP11 Class 1, WP11 Class 2, WP11 Class 3, WP12 Class 1, WP12 Class 2, and WPR may be performed either prior to or after forming. NDE of welds in Grades WP5, WP9, WP91, WP911, WP22 Class 1, and WP22 Class 3 shall be done after forming.

6.3 Personnel performing NDE examinations shall be qualified in accordance with SNT-TC-1A.

TABLE 1 Chemical Requirements

NOTE 1—All requirements are maximum unless otherwise indicated.

NOTE 2—Where an ellipsis (...) appears in this table, there is no requirement.

| Grade and Marking Symbol ^A | Composition, % | | | | | | | | | |
|---------------------------------------|----------------|-----------|-----------------|-------------|-----------|-----------|------------|-----------|-----------|---|
| | Carbon | Manganese | Phosphorus, max | Sulfur, max | Silicon | Chromium | Molybdenum | Nickel | Copper | Others |
| WPB ^{B,C,D,E,F} | 0.30 max | 0.29–1.06 | 0.050 | 0.058 | 0.10 min | 0.40 max | 0.15 max | 0.40 max | 0.40 max | Vanadium 0.08 max Columbium 0.02 max |
| WPC ^{C,D,E,F} | 0.35 max | 0.29–1.06 | 0.050 | 0.058 | 0.10 min | 0.40 max | 0.15 max | 0.40 max | 0.40 max | Vanadium 0.08 max Columbium 0.02 max |
| WP1 | 0.28 max | 0.30–0.90 | 0.045 | 0.045 | 0.10–0.50 | ... | 0.44–0.65 | ... | ... | ... |
| WP12 CL1, WP12 CL2 | 0.05–0.20 | 0.30–0.80 | 0.045 | 0.045 | 0.60 max | 0.80–1.25 | 0.44–0.65 | ... | ... | ... |
| WP11 CL1 | 0.05–0.15 | 0.30–0.60 | 0.030 | 0.030 | 0.50–1.00 | 1.00–1.50 | 0.44–0.65 | ... | ... | ... |
| WP11 CL2, WP11 CL3 | 0.05–0.20 | 0.30–0.80 | 0.040 | 0.040 | 0.50–1.00 | 1.00–1.50 | 0.44–0.65 | ... | ... | ... |
| WP22 CL1, WP22 CL3 | 0.05–0.15 | 0.30–0.60 | 0.040 | 0.040 | 0.50 max | 1.90–2.60 | 0.87–1.13 | ... | ... | ... |
| WP5 CL1, WP5 CL3 | 0.15 max | 0.30–0.60 | 0.040 | 0.030 | 0.50 max | 4.0–6.0 | 0.44–0.65 | ... | ... | ... |
| WP9 CL1, WP9 CL3 | 0.15 max | 0.30–0.60 | 0.030 | 0.030 | 1.00 max | 8.0–10.0 | 0.90–1.10 | ... | ... | ... |
| WPR | 0.20 max | 0.40–1.06 | 0.045 | 0.050 | ... | ... | ... | 1.60–2.24 | 0.75–1.25 | ... |
| WP91 | 0.08–0.12 | 0.30–0.60 | 0.020 | 0.010 | 0.20–0.50 | 8.0–9.5 | 0.85–1.05 | 0.40 max | ... | Vanadium 0.18–0.25 Columbium 0.06–0.10 Nitrogen 0.03–0.07 Aluminum 0.04 max |
| WP911 | 0.09–0.13 | 0.30–0.60 | 0.020 | 0.010 | 0.10–0.50 | 8.5–10.5 | 0.90–1.10 | 0.40 max | ... | Vanadium 0.18–0.25 Columbium 0.060–0.10 Nitrogen 0.04–0.09 Aluminum 0.04 max Boron 0.0003–0.006 Tungsten 0.90–1.10 |

^A When fittings are of welded construction, the grade and marking symbol shown above shall be supplemented by letter "W".

^B Fittings made from bar or plate may have 0.35 max carbon.

^C Fittings made from forgings may have 0.35 max carbon and 0.35 max silicon with no minimum.

^D For each reduction of 0.01 % below the specified carbon maximum, an increase of 0.06 % manganese above the specified maximum will be permitted, up to a maximum of 1.35 %.

^E The sum of Copper, Nickel, Chromium, and Molybdenum shall not exceed 1.00 %.

^F The sum of Chromium and Molybdenum shall not exceed 0.32 %.

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TABLE 2 Tensile Requirements

NOTE 1—Where an ellipsis (...) appears in this table, there is no requirement.

| Grade and Marking Symbol | WPB | WPC, WP11 CL2, WP12 CL2 | WP1 | WP11 CL1, WP22 CL1, WP5 CL1 WP9 CL1 | WPR | WP11 CL3, WP22 CL3 WP5 CL3 WP9 CL3 | WP91 | WP911 | WP12 CL1 |
|---|--------------------|-------------------------------|--------------------|--|--------------------|---|---------------------|---------------------|--------------------|
| Tensile strength, range ksi [MPa] | 60–85 [415–585] | 70–95 [485–655] | 55–80 [380–550] | 60–85 [415–585] | 63–88 [435–605] | 75–100 [520–690] | 85–110 [585–760] | 90–120 [620–840] | 60–85 [415–585] |
| Yield strength, min, ksi [MPa] (0.2 % offset or 0.5 % extension- under-load) | 35 [240] | 40 [275] | 30 [205] | 30 [205] | 46 [315] | 45 [310] | 60 [415] | 64 [440] | 32 [220] |

Elongation Requirements

Grades

| All Grades except WPR, WP91, and WP911 | | WPR | | WP91 WP911 | |
|---|-----------------|-------------------|-----------------|-------------------|-----------------|
| Longi- tudinal | Trans- verse | Longi- tudinal | Trans- verse | Longi- tudinal | Trans- verse |

Elongation:

Standard round specimen, or small proportional specimen, min % in 4 D
 Rectangular specimen for wall thickness $\frac{5}{16}$ in. [7.94 mm] and over,
 and for all small sizes tested in full section; min % in 2 in. [50 mm]
 Rectangular specimen for wall thickness less than $\frac{5}{16}$ in. [7.94 mm];
 min % in 2 in. [50 mm] ($\frac{1}{2}$ -in. [12.7-mm] wide specimen)

| | | | | | |
|----------|-----------------|----------|-----|-----|-----|
| 22 | 14 | 20 | ... | 20 | ... |
| 30 | 20 ^A | 28 | ... | ... | ... |
| <i>B</i> | <i>B</i> | <i>B</i> | ... | ... | ... |

^A WPB and WPC fittings manufactured from plate shall have a minimum elongation of 17 %.

^B For each $\frac{1}{32}$ in. [0.79 mm] decrease in wall thickness below $\frac{5}{16}$ in. [7.94 mm], a deduction of 1.5 % for longitudinal and 1.0 % for transverse from the values shown above is permitted. The following table gives the minimum value for various wall thicknesses.

| Wall Thickness | | Grades | | | |
|------------------------|------|---------------------------------------|------------|--------------|----------------|
| | | All Grades except WPR, WP91 and WP911 | | WPR | WP91 and WP911 |
| in. | [mm] | Longitudinal | Transverse | Longitudinal | Longitudinal |
| $\frac{5}{16}$ (0.312) | 7.94 | 30.0 | 20.0 | 28.0 | 20 |
| $\frac{3}{32}$ (0.281) | 7.14 | 28.5 | 19.0 | 26.5 | 19 |
| $\frac{1}{4}$ (0.250) | 6.35 | 27.0 | 18.0 | 25.0 | 18 |
| $\frac{7}{32}$ (0.219) | 5.56 | 25.5 | ... | 23.5 | 17 |
| $\frac{3}{16}$ (0.188) | 4.76 | 24.0 | ... | 22.0 | 16 |
| $\frac{5}{32}$ (0.156) | 3.97 | 22.5 | ... | 20.5 | 15 |
| $\frac{1}{8}$ (0.125) | 3.17 | 21.0 | ... | 19.0 | 14 |
| $\frac{3}{32}$ (0.094) | 2.38 | 19.5 | ... | 17.5 | 13 |
| $\frac{1}{16}$ (0.062) | 1.59 | 18.0 | ... | 16.0 | 12 |

Note—This table gives the computed minimum % elongation value for each $\frac{1}{32}$ in. [0.79 mm] decrease in wall thickness. Where the wall thickness lies between two values above, the minimum elongation value is determined by the following equations:

Direction of Test

Longitudinal
Transverse

Equation

$$E = 48t + 15.00$$

$$E = 32t + 10.00$$

where:

E = elongation in 2 in. or [50 mm], %, and
t = actual thickness of specimen, in. [mm].

6.4 The welded joints of the fittings shall be finished in accordance with the requirements of Paragraph UW-35 (a) of ASME Section VIII, Division 1.

6.5 All butt-weld tees manufactured by cold-forming method(s) shall be liquid penetrant or magnetic particle examined by one of the methods specified in Supplementary Requirement S52 or S53 in Specification A 960. This examination shall be performed after final heat treat. 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 13 on Surface Quality. After the removal of any crack, the tee(s) shall be re-examined by the original method. Acceptable tees shall be marked with the symbol PT or MT, as applicable, to indicate compliance.

6.6 Stubends may be produced with the entire lap added by the welding of a ring, made from plate or bar of the same alloy grade and composition, to the outside of a straight section of pipe, provided the weld is double welded, is a full penetration

joint, satisfies the requirements of 6.2 for qualifications and 7.3.3 for post weld heat treatment.

7. Heat Treatment

7.1 *Heat Treatment Procedures*—Fittings, after forming at an elevated temperature, shall be cooled to a temperature below the critical range under suitable conditions to prevent injuries by too rapid cooling, but in no case more rapidly than the cooling rate in still air. Heat treatment temperatures specified are metal (part) temperatures. Heat-treated fittings shall be treated according to paragraph 7 in Specification A 960.

7.2 WPB, WPC, and WPR Fittings:

7.2.1 Hot-formed WPB, WPC, and WPR fittings upon which the final forming operation is completed at a temperature above 1150°F [620°C] and below 1800°F [980°C] need not be heat treated provided they are cooled in still air.

7.2.2 Hot-formed or forged WPB, WPC, and WPR fittings finished at temperature in excess of 1800°F [980°C] shall subsequently be annealed, normalized, or normalized and tempered. Hot-forged fittings NPS 4 or smaller need not be heat treated.

7.2.3 WPB, WPC, and WPR fittings over NPS 12, produced by locally heating a portion of the fitting stock to any temperature for forming, shall be subsequently annealed, normalized, or normalized and tempered. Fittings NPS 12 and under shall not require heat treatment after forming a locally heated portion of the fitting.

7.2.4 Cold-formed WPB, WPC, and WPR fittings, upon which the final forming operation is completed at a temperature below 1150°F [620°C], shall be normalized, or shall be stress relieved at 1100 to 1275°F [595 to 690°C].

7.2.5 WPB, WPC, and WPR fittings produced by fusion welding and having a nominal wall thickness at the welded joint of 3/4 in. [19 mm] or greater shall be post-weld heat treated at 1100 to 1250°F [595 to 675°C], or in accordance with 7.2.6.

7.2.6 At the option of the manufacturer, WPB and WPC fittings produced by any of the methods in Section 6 may be annealed, normalized, or normalized and tempered.

7.3 Fittings Other than WPB, WPC, and WPR:

7.3.1 Fittings of Grades WP1, WP11 Class 1, WP11 Class 2, WP11 Class 3, WP12 Class 1, WP12 Class 2, WP22 Class 1, WP22 Class 3, WP5, and WP9 shall be furnished in the full-annealed, isothermal-annealed, or normalized and tempered condition. If normalized and tempered, the tempering temperature for WP11 Class 1, WP11 Class 2, WP11 Class 3, WP12 Class 1, and WP12 Class 2 shall not be less than 1150°F [620°C]; for Grades WP5, WP9, WP22 Class 1, and WP22 Class 3 the tempering temperature shall not be less than 1250°F [675°C].

7.3.2 Fittings of Grades WP1, WP12 Class 1, or WP12 Class 2 either hot formed or cold formed may be given a final heat treatment at 1200°F [650°C] instead of the heat treatment specified in 7.3.1.

7.3.3 Fittings in all thicknesses produced by fusion welding after the heat treatment specified in 7.3.1 shall be post-weld heat treated at a temperature not less than prescribed above for tempering except that Grade WP1 is required to be post-weld

heat treated only when the nominal wall thickness at the welded joint is 1/2 in. [13 mm] or greater.

7.3.4 Except when Supplementary Requirement S1 is specified by the purchaser, Grade WP91 shall be normalized at 1900°F [1040°C] minimum, and 2000°F [1095°C] maximum, and tempered at 1350°F [730°C] minimum as a final heat treatment.

7.3.5 Grade WP911 shall be normalized in the temperature range of 1900 to 1975°F [1040 to 1080°C], and tempered in the temperature range of 1365 to 1435°F [740 to 780°C] as a final heat treatment.

7.4 *WPB and WPC Fittings Made from Bar*—Cold-finished bars reduced in cross-sectional area more than 10 % by cold drawing or cold rolling are not acceptable for use in the manufacture of these fittings unless the bars have been either stress relieved in the temperature range of 1100 to 1250°F [595 to 675°C], normalized, normalized and tempered, or fully annealed. Mechanical testing must be performed subsequent to the final heat-treating operation.

7.5 Liquid quenching followed by tempering shall be permitted for all grades when approved by the purchaser. Minimum tempering temperature shall be 1100°F [595°C] for WPB, WPC, and WPR, 1150°F [620°C] for Grades WP1, WP11 Class 1, WP11 Class 2, WP11 Class 3, WP 12 Class 1, and WP12 Class 2 and 1250°F [675°C] for Grades WP5, WP9, WP22 Class 1, and WP22 Class 3, and 1350°F (730°C) for Grade WP91 and WP911.

8. Chemical Composition

8.1 The chemical composition of each cast or heat used shall be determined and shall conform to the requirements of the chemical composition for the respective materials listed in Table 1. The ranges as shown have been expanded to include variations of the chemical analysis requirements that are listed in the various specifications for the starting materials (pipe, tube, plate, bar, and forgings) normally used in the manufacturing of fittings to this specification.

8.2 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.

8.3 Weld metal used in the construction of carbon-steel fittings shall be mild steel analysis No. A1 of Table QW-442, Section IX of the ASME Boiler and Pressure Vessel Code, No. A2 may be used for Grade WPCW.

8.4 The molybdenum and chromium content of the deposited weld metal of alloy steel fittings shall be within the same percentage range as permitted for the base metal.

9. Tensile Requirements

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

9.1.1 Specimens cut either longitudinally or transversely shall be acceptable for the tension test.

9.1.2 While Table 2 specifies elongation requirements for both longitudinal and transverse specimens, it is not the intent that both requirements apply simultaneously. Instead, it is intended that only the elongation requirement that is appropriate for the specimen used be applicable.