SPECIFICATION FOR PIPING FITTINGS OF WROUGHT CARBON STEEL AND ALLOY STEEL FOR MODERATE AND HIGH-TEMPERATURE SERVICE

01 SA-234/SA-234M

(Identical with ASTM Specification A 234/A 234M-97.)

1. Scope

1.1 This specification covers wrought carbon steel and alloy steel fittings of seamless and welded construction covered by the latest revision of ANSI B16.9, ANSI B16.11, ANSI 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 ANSI and MSS standards shall be furnished in accordance with Supplementary Requirement S9.

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 *ASTM Standards:*

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

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

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

E 165 Test Method for Liquid Penetrant Examination

E 709 Guide for Magnetic Particle Examination

2.2 *ANSI Standards:*

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

2.3 *ASME Boiler and Pressure Vessel Code:*

Section V Nondestructive Examination

Section VIII, Division 1, Pressure Vessels

Section IX Welding Qualifications

2.4 *MSS Standards:*

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

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2.5 *ASNT Standard:*

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

3. Ordering Information

3.1 It is the purchaser's responsibility to specify in the purchase order all ordering information necessary to purchase the needed material. Examples of such information include, but are not limited to, the following:

3.1.1 Quantity,

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

3.1.3 Steel composition by grade and class designation,

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 Specification number (the year date should be included),

3.1.6 Supplementary requirements, and

3.1.7 Additional requirements, if any (see 4.1, 6.5, 14.2, and 16.1).

4. Materials

4.1 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.

4.2 A starting material specification that specifically requires the addition of any element beyond those listed for the materials in Tables 1 and 2 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.

5. Manufacture

5.1 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.

5.2 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.

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 6. All caps machined from bar stock shall be examined by liquid penetrant or magnetic particle in accordance with S3 or S4.

5.3 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 6 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 and 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, WP22 Class 1, and WP22 Class 3 shall be done after forming.

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

5.5 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.

5.6 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 S3 or S4. 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 12 on Surface Quality. After the removal of

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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. Heat Treatment

6.1 *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-treated fittings shall be treated according to the following procedures:

NOTE 2 — Heat treatment temperatures specified are metal (part) temperatures.

6.1.1 *Full Annealing* — Fittings shall be uniformly reheated to a temperature above the transformation range and after being held for a sufficient time at this temperature, cooled slowly to a temperature below the transformation range.

6.1.2 *Isothermal Annealing* — Isothermal annealing as applied to fittings shall involve austenitizing a ferrous alloy and then cooling to and holding within the range of temperature at which the austenite transforms to a relatively soft ferrite-carbide aggregate.

6.1.3 *Normalizing* — Fittings shall be uniformly reheated to a temperature above the transformation range and subsequently cooled in air at room temperature.

6.1.4 *Tempering and Post-Weld Heat Treatment* — Fittings shall be reheated to the prescribed temperature below the transformation range, held at temperature for the greater of ½ h or 1 h/in. [2.4 min/mm] of thickness at the thickest section and cooled in the furnace or in still air.

6.1.5 *Stress Relieving* — Fittings shall be uniformly heated; temperature shall not vary by more than ±25°F [±14°C] from the selected stress relieving temperature.

6.2 *WPB, WPC, and WPR Fittings:*

6.2.1 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. If the manufacturer elects to heat treat such fittings, it shall be by one of the procedures defined in 6.1 through 6.1.4.

6.2.2 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.

6.2.3 WPB, WPC, and WPR fittings 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 such as elbows, tees, header tees, reducers and lap joint stub ends, NPS 12 and under, shall not require heat treatment after forming a locally heated portion of the fitting.

6.2.4 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].

6.2.5 WPB, WPC, and WPR fittings produced by fusion welding and having a nominal wall thickness at the welded joint of ¾ in. [19 mm] or greater shall be post-weld heat treated at 1100 to 1250°F [595 to 675°C], or in accordance with 6.2.6.

6.2.6 At the option of the manufacturer, WPB and WPC fittings produced by any of the methods in Section 5 may be annealed, normalized, or normalized and tempered.

6.3 *Fittings Other than WPB, WPC, and WPR:*

6.3.1 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].

6.3.2 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 6.3.1.

6.3.3 Fittings in all thicknesses produced by fusion welding after the heat treatment specified in 6.3.1 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 ½ in. [13 mm] or greater.

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6.3.4 Except when Supplementary Requirement S12 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.

6.4 *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.

6.5 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, WP12 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.

7. Chemical Composition

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

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 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.

7.4 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.

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.

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

8.1.2 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.

8.2 One tension test shall be made on each heat of material and in the same condition of heat treatment as the finished fittings it represents. The sample thickness shall not vary more than $\frac{1}{4}$ in. [6 mm] from the fitting wall thickness it represents.

8.3 When cold-formed fittings are furnished, samples of the raw material shall be normalized or stress relieved as required in 6.2.4. Tension tests conducted on these heat-treated samples shall be considered to be the tensile properties of the cold-formed fittings.

8.4 Records of the tension tests shall be certification that the material of the fitting meets the tensile requirements of this specification provided the heat treatments are the same. If the raw material was not tested, or the fitting is not in the same condition of heat treatment, the fitting manufacturer shall perform the required test on material representative of the finished fitting from each heat of starting material.

9. Hardness

9.1 Fittings shall be capable of meeting the following hardness requirements, if tested:

9.1.1 Fittings of Grades WP5, WP9, and WPR — 217 HB maximum.

9.1.2 Fittings of Grade WP91 — 248 HB maximum.

9.1.3 Fittings of all other grades — 197 HB maximum.

9.2 When actual hardness testing of the fittings is required, see Supplementary Requirement S8.

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10. Hydrostatic Tests

10.1 Hydrostatic testing is not required by this specification.

10.2 All fittings shall be capable of withstanding without failure, leakage, or impairment of their serviceability, a hydrostatic test pressure equal to that prescribed for the specified matching pipe of equivalent material.

11. Dimensions

11.1 Butt-welding fittings and butt-welding short radius elbows and returns purchased in accordance with this specification shall conform to the dimensions and tolerances given in the latest revision of ANSI B16.9 and B16.28, respectively. Steel socket-welding and threaded fittings purchased in accordance with this specification shall conform to the sizes, shapes, dimensions, and tolerances specified in the latest revision of ANSI B16.11 or MSS SP-79.

11.2 Fittings of size or shape differing from these standards, but meeting all other requirements of this specification may be furnished in accordance with Supplementary Requirement S9.

12. Surface Quality

12.1 Fittings supplied under this specification shall be examined visually. Selected typical surface discontinuities shall be explored for depth. The fittings shall be free of surface discontinuities that penetrate more than 5% of the specified nominal wall thickness, except as defined in 12.3 and 12.4, and shall have a workmanlike finish.

12.2 Surface discontinuities deeper than 5% of the specified nominal wall thickness, except as defined in 12.3 and 12.4, shall be removed by the manufacturer by machining or grinding to sound metal, and the repaired areas shall be well faired. The wall thickness at all points shall be at least $87\frac{1}{2}$% of the specified nominal wall thickness, and the diameters at all points shall be within the specified limits.

12.3 Surface checks (fish scale) deeper than $\frac{1}{64}$ in. [0.4 mm] shall be removed.

12.4 Mechanical marks deeper than $\frac{1}{16}$ [1.6 mm] shall be removed.

12.5 When the removal of a surface discontinuity reduces the wall thickness below $87\frac{1}{2}$% 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

13.1 The fittings manufacturer may weld repair fittings, subject to the approval of the purchaser, provided the composition of the welding material is suitable for the composition of the metal being welded. Repair by welding shall not be permitted when the depth of the discontinuity exceeds $33\frac{1}{3}$% of the nominal wall thickness or the length exceeds 25% of the nominal diameter of the fittings. Discontinuities shall be completely removed before welding. All welds shall be made by welders, welding operators, and welding procedures qualified under the provisions of ASME Section IX and heat treated after welding in accordance with Section 6.

14. Inspection

14.1 The manufacturer shall afford the purchaser's inspector all reasonable facilities necessary to satisfy him that the material is being furnished in accordance with this specification. Inspection by the purchaser shall not interfere unnecessarily with the manufacturer, unless otherwise agreed to.

14.2 Other tests, when required by agreement, shall be made from material of the lots covered in the order.

15. Rejection and Rehearing

15.1 Material that fails to conform to the requirements of this specification may be rejected. Rejection should 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.

15.2 Fittings that develop defects in shopworking or application operations may be rejected. Upon rejection, the manufacturer shall be notified promptly in writing.

16. Certification

16.1 When requested by the purchaser, the manufacturer shall provide a certificate of compliance to this specification. In addition, if requested to provide test reports, the manufacturer shall also provide the following where applicable.

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16.1.1 Chemical analysis results, Section 7 (Table 1). When the amount of an element is less than 0.02%, the analysis for that element may be reported as "<0.02%."

16.1.2 Tensile property results, Section 8 (Table 2), report the yield strength and ultimate strength in ksi [MPa] and elongation in percent,

16.1.3 Hardness acceptable in accordance with Section 9,

16.1.4 Type heat treatment, if any, Section 6,

16.1.5 Seamless or welded,

16.1.6 Starting material, specifically pipe, plate, etc.,

16.1.7 Statement regarding radiographic or ultrasonic examination, 5.3, and

16.1.8 Any supplemental testing required by the purchase order.

16.2 Letters of compliance and test reports shall state the specification number, year of issue, revision letter (if any), grade and class of the fittings.

16.3 A Material Test Report, Certificate of Inspection, or similar document printed from or used in electronic form from an electronic data interchange (EDI) transmission shall be regarded as having the same validity as a counterpart printed in the certifier's facility. The content of the EDI transmitted document must meet the requirements of the invoked ASTM standard(s) and conform to any existing EDI agreement between the purchaser and the supplier. Notwithstanding the absence of a signature, the organization submitting the EDI transmission is responsible for the content of the report.

17. Product Marking

17.1 All fittings shall have the prescribed information stamped or otherwise suitably marked on each fitting in accordance with the Standard Marking System for Valves, Fittings, Flanges and Unions (MSS SP-25, latest edition).

17.2 The prescribed information for butt-welding fittings shall be: The manufacturer's name or trademark (see Note 3), schedule number or nominal wall thickness designation, size, fitting designation in accordance with Annex A1 and the heat number or the manufacturer's heat identification.

NOTE 3 — For purposes of identification marking, the manufacturer is considered the organization that certifies the piping component complies with this specification.

17.3 The prescribed information for threaded or socket-welding fittings shall be: The manufacturer's name or trademark (see Note 3), pressure class or schedule number and fitting designation in accordance with Annex A1, and the heat number or the manufacturer's heat identification.

17.4 Specification number, year of issue and revision letter are not required to be marked on fittings.

17.5 *Bar Coding* — In addition to the requirements in 17.1, 17.2, 17.3, and 17.4, 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 pipe fittings – steel; piping applications; pressure-containing parts; pressure vessel service; temperature service applications – elevated

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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
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	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	0.15 max	0.30–0.60	0.040	0.030	0.50 max	4.0–6.0	0.44–0.65	. . .	. . .	. . .
WP9	0.15 max	0.30–0.60	0.030	0.030	0.25–1.00	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

[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%.

TABLE 2
TENSILE REQUIREMENTS

NOTE — 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, WP9	WPR	WP11 CL3, WP22 CL3	WP91	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]	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]	32 [220]

	Elongation Requirements					
	Grades					
	All Grades except WPR and WP91		WPR		WP91	
	Longitudinal	Transverse	Longitudinal	Transverse	Longitudinal	Transverse
Elongation:						
Standard round specimen, or small proportional specimen, min % in 4 D	22	14	20	. . .	20	. . .
Rectangular specimen for wall thickness $^{5}/_{16}$ in. [7.94 mm] and over, and for all small sizes tested in full section; min % in 2 in. [50 mm]	30	20[A]	28	. . .	. . .	. . .
Rectangular specimen for wall thickness less than $^{5}/_{16}$ in. [7.94 mm]; min % in 2 in. [50 mm] ($^{1}/_{2}$ in. [12.7 mm] wide specimen)	[B]	[B]	[B]	. . .	. . .	. . .

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

[B] For each $^{1}/_{32}$ in. [0.79 mm] decrease in wall thickness below $^{5}/_{16}$ 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		WPR	
in.	[mm]	Longitudinal	Transverse	Longitudinal	Transverse
$^{5}/_{16}$ (0.312)	7.94	30.0	20.0	28.0	. . .
$^{9}/_{32}$ (0.281)	7.14	28.5	19.0	26.5	. . .
$^{1}/_{4}$ (0.250)	6.35	27.0	18.0	25.0	. . .
$^{7}/_{32}$ (0.219)	5.56	25.5	. . .	23.5	. . .
$^{3}/_{16}$ (0.188)	4.76	24.0	. . .	22.0	. . .
$^{5}/_{32}$ (0.156)	3.97	22.5	. . .	20.5	. . .
$^{1}/_{18}$ (0.125)	3.17	21.0	. . .	19.0	. . .
$^{3}/_{32}$ (0.094)	2.38	19.5	. . .	17.5	. . .
$^{1}/_{16}$ (0.062)	1.59	18.0	. . .	16.0	. . .

NOTE — This table gives the computed minimum % elongation value for each $^{1}/_{32}$ 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	Equation
Longitudinal	$E = 48t + 15.00$
Transverse	$E = 32t + 10.00$

where:

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

t = actual thickness of specimen, in. [mm].

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SUPPLEMENTARY REQUIREMENTS

These requirements shall not be considered unless specified in the order, in which event, the supplementary requirements specified shall be made at the place of manufacture, unless otherwise agreed upon, at the purchaser's expense. The test specified shall be witnessed by the purchaser's inspector before shipment of material, if so specified in the order.

S1. Product Analysis

S1.1 A product analysis shall be made from each heat of base metal and, if of welded construction, from each lot number of welding material of the fittings offered for delivery. The analysis shall conform to the requirements specified in Section 7. (See Note S1.1.)

NOTE S1.1 — If the results of any of the tests specified in S1 or S2 do not conform to the requirements, retests may be made at the manufacturer's expense on additional fittings or representative test pieces of double the original number from the same heat or lot as defined in S1 or S2, each of which shall conform to the requirements specified.

S2. Tension Test

S2.1 One tension test shall be made on one fitting or representative test piece (see Note S2.1) per lot (see Note S3.1) of fittings. If the fittings are of welded construction, the tension specimen shall include the weld and shall be prepared so that the weld is at the midlength location of the specimen. However, in no case shall the tensile properties of the finished fittings be less than the requirements listed in Table 2. (See Note S1.1.)

NOTE S2.1 — *Representative Test Piece:* Where the test specimen for the tension test cannot be taken from a fitting due to size limitations, a representative test piece shall be obtained. The test piece shall be from the same heat and heat treated in the same batch or charge as the fittings it represents and shall have approximately the same amount of working. In addition, test pieces representing fittings manufactured from bars, plate, or forgings shall have a cross section equal to the greatest cross section of the fitting; and test pieces representing fittings manufactured from pipe shall have a wall thickness equal to those of the fitting. The test piece for fittings of welded construction shall be prepared to the same weld procedures and from the same heats of material as the fittings it represents.

NOTE S3.1 — A lot shall consist of all fittings of the same type, size, and wall thickness, manufactured from one heat of material (and, if welding is performed, using one lot number of electrodes or one heat of weld wire and one lot number of flux), heat treated in either a continuous or batch-type furnace controlled within a range ±25°F [±14°C] and equipped with recording pyrometers so that complete records of heat treatment are available.

S3. Liquid Penetrant Examination

S3.1 All surfaces shall be liquid penetrant examined in accordance with Test Method E 165. Acceptance limits shall be specified by the purchaser. Personnel performing the examination shall be qualified in accordance with SNT-TC-1A.

S4. Magnetic-Particle Examination

S4.1 All accessible surfaces shall be magnetic particle examined in accordance with Guide E 709. Acceptance limits shall be specified by the purchaser. Personnel performing the examination shall be qualified in accordance with SNT-TC-1A.

S5. Hydrostatic Test

S5.1 A hydrostatic test shall be applied as agreed upon between the manufacturer and purchaser.

S6. Bar Stock Fittings

S6.1 Bar stock fittings shall not be permitted.

S7. Special Heat Treatment

S7.1 A special heat treatment shall be applied as agreed upon between the manufacturer and the purchaser (Section 6).

S8. Hardness Test

S8.1 If actual hardness testing of the fittings is required, the frequency and the method used shall be as agreed upon between the manufacturer and the purchaser.

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S9. Special Fittings

S9.1 Partial compliance fittings of size or shape not conforming to the dimensional requirements of ANSI B16.9, B16.11, B16.28, MSS SP-79, and MSS SP-95 shall meet all other requirements of this specification. In addition to the marking required by Section 17, the grade designation symbol shall be followed by the symbol "S9."

S10. Heat Treatment of Concentric Reducers

S10.1 Concentric reducers formed by local heating of the fitting shall subsequently be annealed, normalized, or normalized and tempered.

S11. Marking Small Fittings

S11.1 For small products where the space for marking is less than 1 in. [25 mm] in any direction, test reports are mandatory and marking may be restricted to only such symbols or codes as are necessary to identify the parts with test reports.

S11.2 When the configuration or size does not permit marking directly on the fitting, the marking method shall be a matter of agreement between the manufacturer and the purchaser.

S12. Alternative Heat Treatment — Grade WP91

S12.1 Grade WP91 shall be normalized in accordance with 6.3.3 and tempered at a temperature, to be specified by the purchaser, less than 1350°F [730°C]. It shall be the purchaser's responsibility to subsequently temper the entire fitting at 1350°F [730°C] minimum. All mechanical tests shall be made on material heat treated in accordance with 6.3.3. The certification shall reference this supplementary requirement indicating the actual tempering temperature applied. The notation "S12" shall be included with the required marking of the fitting.

S13. Phosphorous and Sulphur Content

S13.1 The phosphorous and sulphur contents of the fittings shall not exceed 0.025%.

S14. Restricted Vanadium Content

S14.1 The vanadium content of the fittings shall not exceed 0.03%.

S15. Carbon Equivalent

S15.1 For grades WPB and WPC, the maximum carbon equivalent (C.E.), based on heat analysis and the following formula, shall be 0.50.

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

S15.2 A lower maximum carbon equivalent may be agreed upon between the purchaser and the supplier.

S15.3 The C.E. shall be reported on the test report.

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ANNEX
(Mandatory Information)

A1. FITTING DESIGNATION FOR MARKING PURPOSES

TABLE A1.1
FITTING DESIGNATION FOR MARKING PURPOSES

Grade	Class	Construction	Mandatory Marking
WPB		W (Welded construction)	WPBW[A]
		S (Seamless construction)	WPB
WPC		W (Welded construction)	WPCW[A]
		S (Seamless construction)	WPC
WP1		W (Welded construction)	WP1W[A]
		S (Seamless construction)	WP1
WP12	CL1	W (Welded construction)	WP12 CL1W[A]
		S (Seamless construction)	WP12 CL1
	CL2	W (Welded construction)	WP12 CL2W[A]
		S (Seamless construction)	WP12 CL2
WP11	CL1	W (Welded construction)	WP11 CL1W[A]
		S (Seamless construction)	WP11 C1
	CL2	W (Welded construction)	WP11 CL2W[A]
		S (Seamless construction)	WP11 CL2
	CL3	W (Welded construction)	WP11 CL3W[A]
		S (Seamless construction)	WP11 CL3
WP22	CL1	W (Welded construction)	WP22 CL1W[A]
		S (Seamless construction)	WP22 CL1
	CL2	W (Welded construction)	WP22 CL2W[A]
		S (Seamless construction)	WP22 CL2
WP5		W (Welded construction)	WP5W[A]
		S (Seamless construction)	WP5
WP9		W (Welded construction)	WP9W[A]
		S (Seamless construction)	WP9
WPR		W (Welded construction)	WP9W[A]
		S (Seamless construction)	WP9
WP91		W (Welded construction)	WP91W[A]
		S (Seamless construction)	WP91

[A] Add "U" to marking if welds are Ultrasonic inspected in lieu of radiography.

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