

# Standard Specification for Pressure Vessel Plates, Alloy Steel, Manganese- Molybdenum and Manganese-Molybdenum-Nickel

## 1. Scope

1.1 This specification covers manganese-molybdenum and manganese-molybdenum-nickel alloy steel plates intended particularly for welded boilers and other pressure vessels.

1.2 Plates under this specification are available in four grades having different strength levels as follows:

Grade	Tensile Strength, ksi [MPa]	Type
A	75–95 [515–655]	manganese-molybdenum
B	80–100 [550–690]	manganese-molybdenum
C	80–100 [550–690]	manganese-molybdenum-nickel
D	80–100 [550–690]	manganese-molybdenum-nickel

1.3 The maximum thickness of plates is limited only by the capacity of the chemical composition to meet the specified mechanical property requirements. The minimum thickness is limited to 0.25 in. [6.5 mm].

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 the specification.

## 2. Referenced Documents

### 2.1 ASTM Standards:

A20/A20M Specification for General Requirements for Steel Plates for Pressure Vessels

A435/A435M Specification for Straight-Beam Ultrasonic Examination of Steel Plates

A577/A577M Specification for Ultrasonic Angle-Beam Examination of Steel Plates

A578/A578M Specification for Straight-Beam Ultrasonic Examination of Rolled Steel Plates for Special Applications

## 3. General Requirements and Ordering Information

3.1 Material supplied to this material specification shall conform to Specification A20/A20M. These requirements outline the testing and retesting methods and procedures, permitted variations in dimensions, and mass, quality and repair of defects, marking, loading, and ordering information.

3.2 In addition to the basic requirements of this specification, certain supplementary requirements are available when additional control, testing, or examination is required to meet end use requirements. The purchaser is referred to the listed supplementary requirements in this specification and to the detailed requirements in Specification A20/A20M.

3.3 Coils are excluded from qualification to this specification until they are processed into finished plates. Plates produced from coil means plates that have been cut to individual lengths from coil. The processor directly controls, or is responsible for, the operations involved in the processing of coils into finished plates. Such operations include decoiling, leveling, cutting to length, testing, inspection, conditioning, heat treatment (if applicable), packaging, marking, loading for shipment, and certification.

NOTE 1—For plates produced from coil and furnished without heat treatment or with stress relieving only, three test results are reported for each qualifying coil. Additional requirements regarding plates from coil are described in Specification A20/A20M.

3.4 If the requirements of this specification are in conflict with the requirements of Specification A20/A20M, the requirements of this specification shall prevail.

## 4. Materials and Manufacture

4.1 *Steelmaking Practice*—The steel shall be killed and shall conform to the fine grain size requirement of Specification A20/A20M.



## 5. Heat Treatment

5.1 Plates 2 in. [50 mm] and under in thickness are normally supplied in the as-rolled condition. Plates may be ordered normalized or stress relieved, or both.

5.2 Plates over 2 in. [50 mm] in thickness shall be normalized.

5.3 When normalizing plates 4 in. [100 mm] or over in thickness, the cooling rate may be accelerated by air blasting or liquid quenching followed by tempering in the temperature range from 1100 to 1300°F [595 to 705°C] to obtain mechanical properties comparable to those developed by normalizing plates in the lesser thicknesses.

5.4 If approved by the purchaser, for plates less than 4 in. [100 mm] in thickness, cooling rates faster than those obtained by cooling in air are permissible for improvement of toughness, provided the plates are subsequently tempered in the temperature range from 1100 to 1300°F [595 to 705°C].

## 6. Chemical Composition

6.1 The steel shall conform to the chemical requirements shown in Table 1 unless otherwise modified in accordance with

Supplementary Requirement S17, Vacuum Carbon-Deoxidized Steel, in Specification A20/A20M.

## 7. Mechanical Properties

7.1 *Tension Test Requirements*—The plates, as represented by the tension test specimens, shall conform to the requirements given in Table 2.

7.1.1 For accelerated cooled plates with a nominal thickness of ¾ in. [20 mm] or less, the 1½-in. [40-mm] wide rectangular specimen may be used for the tension test, and the elongation may be determined in a 2-in. [50-mm] gage length that includes the fracture and that shows the greatest elongation.

## 8. Keywords

8.1 alloy steel plate; pressure containing parts; pressure vessel steels; steel plates; steel plates for pressure vessel applications

TABLE 1 Chemical Requirements

Elements	Composition, %			
	Grade A	Grade B	Grade C	Grade D
Carbon, max: <sup>A</sup>				
Up to 1 in. [25 mm], incl, in thickness	0.20	0.20	0.20	0.20
Over 1 to 2 in. [50 mm], incl	0.23	0.23	0.23	0.23
Over 2 in. [50 mm] in thickness	0.25	0.25	0.25	0.25
Manganese:				
Heat analysis	0.95–1.30	1.15–1.50	1.15–1.50	1.15–1.50
Product analysis	0.87–1.41	1.07–1.62	1.07–1.62	1.07–1.62
Phosphorus, max: <sup>A</sup>	0.025	0.025	0.025	0.025
Sulfur, max: <sup>A</sup>	0.025	0.025	0.025	0.025
Silicon:				
Heat analysis	0.15–0.40	0.15–0.40	0.15–0.40	0.15–0.40
Product analysis	0.13–0.45	0.13–0.45	0.13–0.45	0.13–0.45
Molybdenum:				
Heat analysis	0.45–0.60	0.45–0.60	0.45–0.60	0.45–0.60
Product analysis	0.41–0.64	0.41–0.64	0.41–0.64	0.41–0.64
Nickel:				
Heat analysis	...	...	0.40–0.70	0.70–1.00
Product analysis	...	...	0.37–0.73	0.67–1.03

<sup>A</sup> Applies to both heat and product analyses.

NOTE — Where "..." appears there is no requirement.

TABLE 2 Tensile Requirements

	Grade A		Grade B		Grade C		Grade D	
Tensile strength, ksi [MPa]	75–95	[515–655]	80–100	[550–690]	80–100	[550–690]	80–100	[550–690]
Yield strength, min, ksi [MPa]	45	[310]	50	[345]	50	[345]	50	[345]
Elongation in 8 in. [200 mm], min, % <sup>A</sup>	15		15		17		17	
Elongation in 2 in. [50 mm], min, % <sup>A</sup>	19		18		20		20	

<sup>A</sup> See Specification A20/A20M for elongation adjustment.

## SUPPLEMENTARY REQUIREMENTS

Supplementary requirements shall not apply unless specified in the purchase order. A list of standardized supplementary requirements for use at the option of the purchaser is included in Specification A20/A20M. Those that are considered suitable for use with this specification are listed below by title.

- S1. Vacuum Treatment,
- S2. Product Analysis,
- S3. Simulated Post-Weld Heat Treatment of Mechanical Test Coupons,
- S4.1 Additional Tension Test,
- S5. Charpy V-Notch Impact Test,
- S6. Drop Weight Test (for Material 0.625 in. [16 mm] and over in Thickness),
- S7. High-Temperature Tension Test,

- S8. Ultrasonic Examination in accordance with Specification A435/A435M,
- S9. Magnetic Particle Examination,
- S11. Ultrasonic Examination in accordance with Specification A577/A577M,
- S12. Ultrasonic Examination in accordance with Specification A578/A578M, and
- S17. Vacuum Carbon-Deoxidized Steel.

## **SPECIFICATION FOR CARBON STEEL BOLTS AND STUDS, 60 000 PSI TENSILE STRENGTH**



**SA-307**

(Identical with ASTM Specification A307-07b except for the deletion of private label distributor from para. 13.1.1.)



# SPECIFICATION FOR CARBON STEEL BOLTS AND STUDS, 60 000 PSI TENSILE STRENGTH



SA-307

(Identical with ASTM Specification A 307-07b except for the deletion of private label distributor from para. 13.1.1.)

## 1. Scope

**1.1** This specification covers the chemical and mechanical requirements of three grades of carbon steel bolts and studs in sizes  $\frac{1}{4}$  in. through 4 in. The fasteners are designated by “Grade” denoting tensile strength and intended use, as follows:

Grade	Description
Grade A	Bolts and studs having a minimum tensile strength of 60 ksi and intended for general applications,
Grade B	Bolts and studs having a tensile strength of 60 to 100 ksi and intended for flanged joints in piping systems with cast iron flanges, and
Grade C	Replaced by Specification F 1554 Gr. 36

**1.1.1** The term studs includes stud stock, sometimes referred to as threaded rod.

**1.2** This specification does not cover requirements for machine screws, thread cutting/forming screws, mechanical expansion anchors or similar externally threaded fasteners.

**1.3** Suitable nuts are covered in Specification A 563. Unless otherwise specified, the grade and style of nut for each grade of fastener, of all surface finishes, shall be as follows:

Fastener Grade and Size	Nut Grade and Style <sup>A</sup>
A $\frac{1}{4}$ to $1\frac{1}{2}$ in.	A, hex
A over $1\frac{1}{2}$ to 4 in.	A, heavy hex
B $\frac{1}{4}$ to 4 in.	A, heavy hex

<sup>A</sup> Nuts of other grades and styles having specified proof load stresses (Specification A 563, Table 3) greater than the specified grade and style of nut are also suitable.

**1.4** The values stated in inch-pound units are to be regarded as the standard.

**1.5** Supplementary Requirement S1 of an optional nature is provided, which describes additional restrictions

to be applied when bolts are to be welded. It shall apply only when specified in the inquiry, order, and contract.

**1.6** Terms used in this specification are defined in Terminology F 1789 unless otherwise defined herein.

## 2. Referenced Documents

### 2.1 ASTM Standards:

- A 563 Specification for Carbons and Alloy Steel Nuts
- A 706/A 706M Specification for Low-Alloy Steel Deformed and Plain Bars for Concrete Reinforcement
- A 751 Test Methods, Practices, and Terminology for Chemical Analysis of Steel Products
- B 695 Specification for Coatings of Zinc Mechanically Deposited on Iron and Steel
- D 3951 Practice for Commercial Packaging
- F 606 Test Methods for Determining the Mechanical Properties of Externally and Internally Threaded Fasteners, Washers, Direct Tension Indicators, and Rivets
- F 1470 Guide for Fastener Sampling for Specified Mechanical Properties and Performance Inspection
- F 1554 Specification for Anchor Bolts, Steel, 36, 55, and 105-ksi Yield Strength
- F 1789 Terminology for F16 Mechanical Fasteners
- F 2329 Specification for Zinc Coating, Hot-Dip, Requirements for Application to Carbon and Alloy Steel Bolts, Screws, Washers, Nuts, and Special Threaded Fasteners

### 2.2 ASME Standards:

- B 1.1 Unified Screw Threads
- B 18.2.1 Square and Hex Bolts and Screws
- B 18.24 Part Identifying Number (PIN) Code System

## 3. Ordering Information

**3.1** Orders for externally threaded fasteners (including nuts and accessories) under this specification shall include the following:



**3.1.1** ASTM designation and year of issue,

**3.1.2** Name of product, bolts or studs; and bolt head style, that is, hex or heavy hex,

**3.1.3** Grade, that is, A, or B. If no grade is specified, Grade A is furnished.

**3.1.4** Quantities (number of pieces by size including nuts),

**3.1.5** Fastener size and length,

**3.1.6** *Washers* — Quantity and size (separate from bolts),

**3.1.7** *Zinc Coating* — Specify the zinc-coating process required, for example, hot-dip, mechanically deposited, or no preference (see 4.5).

**3.1.8** *Other Finishes* — Specify other protective finish, if required.

**3.1.9** Specify if inspection at point of manufacture is required,

**3.1.10** Specify if certified test report is required (see 8.2), and

**3.1.11** Specify additional testing (8.3) or special requirements.

**3.1.12** For establishment of a part identifying system, see ASME B18.24.

#### **4. Materials and Manufacture**

**4.1** Steel for bolts and studs shall be made by the openhearth, basic-oxygen, or electric-furnace process.

**4.2** Bolts shall be produced by hot or cold forging of the heads or machining from bar stock.

**4.3** *Heat Treatment:*

**4.3.1** Cold headed fasteners with head configurations other than hex shall be stress relief annealed.

**4.3.2** Stress relieving of hex head fasteners shall be at the manufacturer's option.

**4.4** Bolt and stud threads shall be rolled or cut.

**4.5** *Zinc Coatings, Hot-Dip and Mechanically Deposited:*

**4.5.1** When zinc-coated fasteners are required, the purchaser shall specify the zinc-coating process, for example hot dip, mechanically deposited, or no preference.

**4.5.2** When hot-dip is specified, the fasteners shall be zinc-coated by the hot-dip process in accordance with the requirements of Specification F 2329.

**4.5.3** When mechanically deposited is specified, the fasteners shall be zinc-coated by the mechanical-deposition process in accordance with the requirements of Class 55 of Specification B 695.

**4.5.4** When no preference is specified, the supplier may furnish either a hot-dip zinc coating in accordance with Specification F 2329, or a mechanically deposited zinc coating in accordance with Specification B 695, Class 55. Threaded components (bolts and nuts) shall be coated by the same zinc-coating process and the supplier's option is limited to one process per item with no mixed processes in a lot.

#### **5. Chemical Composition**

**5.1** Grade A and B bolts and studs shall have a heat analysis conforming to the requirements specified in Table 1 based on the steel producer's heat analysis.

**5.2** The purchaser shall have the option of conducting product analyses on finished bolts in each lot, which shall conform to the product analysis specified in Table 1.

**5.3** In case of conflict or for referee purposes, the product analysis shall take precedence.

**5.4** Bolts and studs are customarily furnished from stock, in which case individual heats of steel cannot be identified.

**5.5** Application of heats of steel to which bismuth, selenium, tellurium, or lead has been intentionally added shall not be permitted for Grade B bolts and studs.

**5.6** Chemical analyses shall be performed in accordance with Test Methods, Practices, and Terminology A 751.

#### **6. Mechanical Properties**

**6.1** Grades A and B bolts and studs shall conform to the hardness specified in Table 2.

**6.2** Grade A and B bolts and studs 1½ in. in diameter or less, other than those excepted in 6.4, shall be tested full size and shall conform to the requirements for tensile strength specified in Table 3.

**6.3** Grade A and B bolts and studs larger than 1½ in. in diameter, other than those excepted in 6.4, shall preferably be tested full size and when equipment of sufficient capacity is available and shall conform to the requirements for tensile strength specified in Table 3. When equipment of sufficient capacity for full-size bolt testing is not available, or when the length of the bolt makes full-size testing impractical, machined specimens shall be tested and shall conform to the requirements specified in Table 4.

**6.4** Grades A and B bolts and studs less than three diameters in length or bolts with drilled or undersize heads are not subject to tensile tests.

**6.5** In the event that bolts are tested by both full size and by machine test specimen methods, the full-size test



shall govern if a controversy between the two methods exists.

**6.6** For bolts and studs on which both hardness and tension tests are performed, acceptance based on tensile requirements shall take precedence in the event that there is controversy over low readings of hardness tests.

## 7. Dimensions

**7.1** Unless otherwise specified, threads shall be the Coarse Thread Series as specified in the latest issue of ASME B1.1, and shall have a Class 2A tolerance.

**7.2** Unless otherwise specified, Grade A bolts shall be hex bolts with dimensions as given in the latest issue of ASME B18.2.1. Unless otherwise specified, Grade B bolts shall be heavy hex bolts with dimensions as given in the latest issue of ASME B18.2.1.

**7.3** Unless otherwise specified, bolts and studs to be used with nuts or tapped holes which have been tapped oversize, in accordance with Specification A 563, shall have Class 2A threads before hot-dip or mechanically deposited zinc coating. After zinc coating the maximum limit of pitch and major diameter shall not exceed the Class 2A maximum limit by more than the following amounts:

Diameter, in.	Oversize Limit, in (mm) <sup>A</sup>
1/4	0.016
5/16, 3/8	0.017
7/16, 1/2	0.018
9/16 to 3/4, incl	0.020
7/8	0.022
1.0 to 1 1/4, incl	0.024
1 3/8, 1 1/2	0.027
1 3/4 to 4.0, incl	0.050

<sup>A</sup> These values are the same as the overtapping required for zinc-coated nuts in Specification A 563.

**7.4** The gaging limit for bolts and studs shall be verified during manufacture or use by assembly of a nut tapped as nearly as practical to the amount oversize shown above. In case of dispute, a calibrated thread ring gage of that same size (Class X tolerance, gage tolerance plus) shall be used. Assembly of the gage, or the nut described above, must be possible with hand effort following application of light machine oil to prevent galling and damage to the gage. These inspections, when performed to resolve disputes, shall be performed at the frequency and quality described in Table 5.

## 8. Number of Tests and Retests

**8.1** The requirements of this specification shall be met in continuous mass production for stock, and the manufacturer shall make sample inspections to ensure that the product conforms to the specified requirements. Additional tests

of individual shipments of material are not ordinarily contemplated. Individual heats of steel are not identified in the finished product.

**8.2** When specified in the order, the manufacturer shall furnish a test report certified to be the last completed set of mechanical tests for each stock size in each shipment.

**8.3** When additional tests are specified on the purchase order, a lot, for purposes of selecting test samples, shall consist of all material offered for inspection at one time that has the following common characteristics:

**8.3.1** One type of item,

**8.3.2** One nominal size, and

**8.3.3** One nominal length of bolts and studs.

**8.4** From each lot, the number of tests for each requirement shall be as follows:

Number of Pieces in Lot	Number of Samples
800 and under	1
801 to 8 000	2
8 001 to 22 000	3
Over 22 000	5

**8.5** If any machined test specimen shows defective machining it shall be discarded and another specimen substituted.

**8.6** Should any sample fail to meet the requirements of a specified test, double the number of samples from the same lot shall be tested, in which case all of the additional samples shall meet the specification.

## 9. Test Methods

**9.1** Grades A and B bolts and studs shall be tested in accordance with Test Methods F 606.

**9.2** Standard square and hex head bolts only shall be tested by the wedge tension method except as noted in 6.4. Fracture shall be in the body or threads of the bolt without any fracture at the junction of the head and body. Other headed bolts shall be tested by the axial tension method.

**9.3** Speed of testing as determined with a free running crosshead shall be a maximum of 1 in./min for the tensile strength tests of bolts.

## 10. Inspection

**10.1** If the inspection described in 10.2 is required by the purchaser it shall be specified in the inquiry, order, or contract.

**10.2** The inspector representing the purchaser shall have free entry to all parts of the manufacturer's works that concern the manufacture of the material ordered. The



manufacturer shall afford the inspector all reasonable facilities to satisfy him that the material is being furnished in accordance with this specification. All tests and inspections required by the specification that are requested by the purchaser's representative shall be made before shipment, and shall be conducted as not to interfere unnecessarily with the operation of the works.

## 11. Responsibility

**11.1** The party responsible for the fastener shall be the organization that supplies the fastener to the purchaser.

## 12. Rejection and Rehearing

**12.1** Disposition of nonconforming lots shall be in accordance with Guide F 1470, specifically sections on disposition of nonconforming lots, suppliers option, and purchasers option.

## 13. Product Marking

### 13.1 *Grades A and B Bolts and Studs:*

**13.1.1** Bolt heads and one end of studs shall be marked with a unique identifier by the manufacturer to identify the manufacturer. Additional marking required by the manufacturer for his own use shall be at the option of the manufacturer.

**13.1.2** In addition to the requirements of 13.1, all bolt heads, one end of studs  $\frac{3}{8}$  in. and larger, and whenever feasible studs less than  $\frac{3}{8}$  in. shall be marked with a grade marking as follows:

<u>Grade</u>	<u>Marking</u>
A	307A
B	307B

**13.1.3** All markings shall be located on the top of the bolt head or stud end and shall be raised or depressed at the option of the manufacturer.

## 14. Packaging and Package Marking

### 14.1 *Packaging:*

**14.1.1** Unless otherwise specified, packaging shall be in accordance with Practice D 3951.

**14.1.2** When special packaging requirements are required, they shall be defined at the time of the inquiry and order.

### 14.2 *Package Marking:*

**14.2.1** Each shipping unit shall include or be plainly marked with the following information:

**14.2.1.1** ASTM designation and grade,

**14.2.1.2** Size,

**14.2.1.3** Name and brand or trademark of the manufacturer,

**14.2.1.4** Number of pieces,

**14.2.1.5** Purchase order number,

**14.2.1.6** Country of origin.

## 15. Keywords

**15.1** bolts; carbon steel; steel; studs



TABLE 1  
CHEMICAL REQUIREMENTS FOR GRADES A  
AND B BOLTS AND STUDS

	Heat Analysis	Product Analysis
Carbon, max.	0.29	0.33
Manganese, max.	1.20	1.25
Phosphorus, max.	0.04	0.041
Sulfur, max.		
Grade A	0.15	<sup>A</sup>
Grade B	0.05	0.051

NOTE:

<sup>A</sup> Resulturized steel is not subject to rejection based on product analysis for sulfur

TABLE 2  
HARDNESS REQUIREMENTS FOR BOLTS AND STUDS

Grade	Length, in.	Hardness <sup>A</sup>			
		Brinell		Rockwell B	
		Min.	Max.	Min.	Max.
A	Less than 3 × dia <sup>B</sup>	121	241	69	100
	3 × dia and longer	...	241	...	100
B	Less than 3 × dia <sup>B</sup>	121	212	69	95
	3 × dia and longer	...	212	...	95

NOTES:

<sup>A</sup> As measured anywhere on the surface or through the cross section.

<sup>B</sup> Also bolts with drilled or undersize heads. These sizes and bolts with modified heads shall meet the minimum and maximum hardness as hardness is the only requirement.



TABLE 3  
TENSILE REQUIREMENTS FOR FULL-SIZE BOLTS AND STUDS

Bolt Size, in.	Threads Per Inch	Stress Area, <sup>A</sup> in. <sup>2</sup>	Tensile Strength, lbf <sup>B</sup>		
			Grade A, min. <sup>C</sup>	Grade B	
				min. <sup>D</sup>	max. <sup>D</sup>
1/4	20	0.0318	1,900	1,900	3,180
5/16	18	0.0524	3,100	3,100	5,240
3/8	16	0.0775	4,650	4,650	7,750
7/16	14	0.1063	6,350	6,350	10,630
1/2	13	0.1419	8,500	8,500	14,190
9/16	12	0.182	11,000	11,000	18,200
5/8	11	0.226	13,550	13,550	22,600
3/4	10	0.334	20,050	20,050	33,400
7/8	9	0.462	27,700	27,700	46,200
1	8	0.606	36,350	36,350	60,600
1 1/8	7	0.763	45,800	45,800	76,300
1 1/4	7	0.969	58,150	58,150	96,900
1 3/8	6	1.155	69,300	69,300	115,500
1 1/2	6	1.405	84,300	84,300	140,500
1 3/4	5	1.90	114,000	114,000	190,000
2	4 1/2	2.50	150,000	150,000	250,000
2 1/4	4 1/2	3.25	195,000	195,000	325,000
2 1/2	4	4.00	240,000	240,000	400,000
2 3/4	4	4.93	295,800	295,800	493,000
3	4	5.97	358,200	358,200	597,000
3 1/4	4	7.10	426,000	426,000	710,000
3 1/2	4	8.33	499,800	499,800	833,000
3 3/4	4	9.66	579,600	579,600	966,000
4	4	11.08	664,800	664,800	1,108,000

## NOTES:

<sup>A</sup> Area calculated from the equation:

$$A_s = 0.7854 [D - (0.9743/n)]^2$$

where:

$A_s$  = stress area,  
 $D$  = nominal diameter of bolt, and  
 $n$  = threads per inch.

<sup>B</sup> 1 lbf = 4.448 N.<sup>C</sup> Based on 60 ksi (414 MPa).<sup>D</sup> Based on 60–100 ksi (414–690 MPa).



TABLE 4  
TENSILE REQUIREMENTS FOR MACHINED SPECIMENS

	Grade A	Grade B
Tensile strength, ksi	60 min.	60–100
Yield point, min. ksi	...	...
Elongation in 2 in. min., %	18	18

TABLE 5  
SAMPLE SIZES AND ACCEPTANCE NUMBERS FOR  
INSPECTION OF HOT-DIP OR MECHANICALLY  
DEPOSITED ZINC-COATED THREADS

Lot Size	Sample Size <sup>4</sup>	Acceptance Number
2 to 90	13	1
91 to 150	20	2
151 to 280	32	3
281 to 500	50	5
501 to 1,200	80	7
1,201 to 3,200	125	10
3,201 to 10,000	200	14
10,001 and over	315	21

NOTE:

<sup>4</sup> Inspect all bolts in the lot if the lot size is less than the sample size.



## SUPPLEMENTARY REQUIREMENTS

The following supplementary requirement shall apply only when specified in the purchase order or contract.

### S1. Bolts Suitable for Welding

**S1.1** The material described in this section is intended for welding. This supplemental section, by additional chemical composition restrictions and by a carbon equivalent formula, provides assurance of weldability by chemical composition control.

**S1.2** Welding technique is of fundamental importance when bolts produced to this supplementary section are welded. It is presupposed that suitable welding procedures for the steel being welded and the intended service will be selected.

**S1.3** All of the requirements of this supplemental section apply in addition to all of the chemical, mechanical, and other requirements of the base specification, Specification A 307 for Grade B.

**S1.4** Because of the embrittling effects of welding temperatures on cold-forged steel, this supplemental section is limited to hot-forged bolts, or, if not forged, then to bolts produced from hot-rolled bars without forging or threaded bars, bars studs, or stud bolts produced from hot-rolled bars without forging. Cold-forged bolts, or cold-drawn threaded bars, if they are given a thermal treatment by heating to a temperature of not less than 1500°F (815°C) and air-cooled are also suitable.

#### S1.5 Chemical Requirements:

**S1.5.1 Heat Chemical Analysis** — Material conforming to the following additional analysis limitations shall be used to manufacture the product described in this supplementary requirement.

Carbon	0.30%, max
Manganese	1.00%, max
Phosphorus	0.04%, max
Sulfur	0.05%, max
Silicon	0.50%, max

**S1.5.2 Carbon Equivalent** (*Source* — Specification A 706/A 706M) — In addition to the heat chemical analysis requirements in S1.5.1, the heat analysis shall be such as to provide a carbon equivalent (CE) not exceeding 0.55 when calculated as follows:

$$CE = \%C + \frac{\%Mn}{6} + \frac{\%Cu}{40} + \frac{\%Ni}{20} + \frac{\%Cr}{10} - \frac{\%Mo}{50} - \frac{\%V}{10}$$

**S1.6 Analysis Reports** — If requested on the order or contract, the chemical composition of each heat of steel used and the calculated carbon equivalent for each heat shall be reported to the purchaser.

**S1.7 Product (Check) Verification Analysis** — Chemical analyses when made by the purchaser or a representative on bolts from each heat of steel, shall not exceed the values specified in S1.5.2 by more than the following amounts:

	%
Carbon	+0.03
Manganese	+0.06
Phosphorus	+0.008
Sulfur	+0.008
Silicon	+0.05

### S2. Permanent Manufacturer's Identification

**S2.1** Replaced by Specification F 1554.

### S3. Permanent Grade Identification

**S3.1** Replaced by Specification F 1554.



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# **SPECIFICATION FOR COLD-DRAWN, STRESS-RELIEVED CARBON STEEL BARS SUBJECT TO MECHANICAL PROPERTY REQUIREMENTS**



**SA-311/SA-311M**

(Identical with ASTM Specification A311/A311M-04(R10) except for deletion of 5.1.11, revision of Note A to Table 1 and an editorial change to 5.1.9. Certification has been made mandatory in 11.1.)



# SPECIFICATION FOR COLD-DRAWN, STRESS-RELIEVED CARBON STEEL BARS SUBJECT TO MECHANICAL PROPERTY REQUIREMENTS



SA-311/SA-311M

[Identical to ASTM Specification A 311/A 311M-04(R10) except for deletion of 5.1.11, revision of Note A to Table 1 and an editorial change to 5.1.9. Certification has been made mandatory in 11.1.]

## 1. Scope

**1.1** This specification covers two classes, nine grades, and four conditions of stress-relieved cold-drawn carbon steel bars produced to mechanical property requirements. One class, B, is cold drawn with higher than normal (heavy) drafts to provide higher strength levels, and four grades provide improved machinability.

**1.2** Supplementary Requirements, S1 through S6, of an optional nature are provided.

**1.3** The values stated in inch-pound units or SI units are to be regarded as the 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 29/A 29M Specification for Steel Bars, Carbon and Alloy, Hot-Wrought and Cold-Finished, General Requirements for
- A 108 Specification for Steel Bar, Carbon and Alloy, Cold-Finished
- A 370 Test Methods and Definitions for Mechanical Testing of Steel Products
- E 527 Practice for Numbering Metals and Alloys (UNS)

## 3. Terminology

### 3.1 Definitions:

**3.1.1 stress relieving** — heating to a suitable temperature, holding long enough to reduce residual stresses, and

then cooling slowly enough to minimize the development of new residual stresses.

### 3.2 Definitions of Terms Specific to This Standard:

**3.2.1 heavy draft** — Using higher than normal drafts (approximately 10% through 35% reduction), followed by stress relieving, produces higher tensile and yield strengths provided an appropriate composition is used; for example, medium carbon with normal or higher manganese content.

## 4. Classification

**4.1** The bars are furnished in the following classes and grades, and in the conditions shown in 6.4.

**4.1.1 Class A** — Normal-draft cold-drawn and stress-relieved rounds, squares, hexagons, and flats in the following grades:

Grades	UNS Designations
1018	G10180
1035	G10350
1045	G10450
1050	G10500
1541	G15410
1117	G11170
1137	G11370
1141	G11410
1144	G11440

**4.1.2 Class B** — Heavy-draft cold-drawn and stress-relieved rounds and hexagons in the following grades:

Grades	UNS Designations
1045	G10450
1050	G10500
1541	G15410
1141	G11410
1144	G11440



## 5. Ordering Information

**5.1** Orders for material under this specification should include the following information as required to adequately describe the desired material:

**5.1.1** Quantity (weight [mass] or number of pieces),

**5.1.2** Name of material (carbon steel bars, cold drawn, stress relieved),

**5.1.3** Condition 8.3,

**5.1.4** Cross-sectional shape,

**5.1.5** Size,

**5.1.6** Length,

**5.1.7** Class and grade,

**5.1.8** Report of heat analysis, tensile properties Section 11,

**5.1.9** Specification designation A 311 or A 311M,

**5.1.10** Application,

**5.1.11** DELETED

**5.1.12** Supplementary requirements, if any, and

**5.1.13** Additional requirements, if any.

NOTE 1 — A typical ordering description is as follows: 10000 lb carbon steel bars, cold drawn, stress relieved turned and polished, round 2.0 in. (50.8 mm) Diameter, 10 to 12 ft (3048 to 3658 mm) long, Class B, Grade 1050, (UNS G10500), fine grain, test reports required, ASTM A 311/A 311M dated \_\_\_\_\_, hydraulic cylinder piston rods. [5000 kg carbon steel bars, cold drawn, stress relieved turned and polished round 50 mm diameter, 3050 to 3650 mm long, Class B, Grade 1050 (UNS G10500), fine grain, test reports required, ASTM A 311M dated \_\_\_\_\_, hydraulic cylinder piston rods.]

## 6. Materials and Manufacture

**6.1** *Melting Practice* — The steel shall be made by one or more of the following primary processes: open-hearth, basic-oxygen, or electric-furnace. The primary melting may incorporate separate degassing or refining and may be followed by secondary melting using electroslag remelting or vacuum arc remelting. Where secondary melting is employed, the heat shall be defined as all of the ingots remelted from a single primary heat.

### 6.2 Cold Working:

**6.2.1** Class A bars shall be cold drawn using normal drafting practices.

**6.2.2** Class B bars shall be cold drawn using heavy (higher than normal) drafting practices.

**6.3** *Thermal Treatment* — After cold drawing, the bars shall be stress relieved at a temperature of not less than 550°F [288°C] to meet the mechanical requirements specified in Table 2.

**6.4** *Condition* — The bars shall be furnished in the following cold finish conditions, as specified:

**6.4.1** Cold drawn, stress relieved;

**6.4.2** Cold drawn, stress relieved, turned, and polished;

**6.4.3** Cold drawn, stress relieved, turned, ground, and polished; and

**6.4.4** Cold drawn, stress relieved, ground, and polished.

NOTE 2 — When turned bars are specified, turning may be performed prior to cold-drawing.

## 7. Chemical Composition

**7.1** *Composition* — The cast or heat analysis shall conform to the chemical composition requirements specified in Table 1 for the grade ordered.

## 8. Mechanical Properties

**8.1** *Requirements* — The bars shall conform to the requirements listed in Table 2.

**8.2** *Number of Tests* — At least one tension test shall be made on each lot. A lot shall consist of bars of the same size from the same heat which have been stress relieved in the same stationary furnace charge. For continuous type of treatment, a lot shall consist of 25 tons [25 Mg] or less of the same size of each heat, treated in the same cycle.

**8.3** *Specimens* — Tension test specimens shall be taken longitudinally in accordance with and from the locations specified in Test Methods and Definitions A 370.

**8.4** *Test Methods* — Tension tests shall be made in accordance with Test Methods and Definitions A 370. The yield strength shall be determined at 0.2% offset or at 0.005 in./in. [0.005 mm/mm] of gage length, total extension under load.

## 9. Workmanship, Finish, and Appearance

**9.1** *Surface Finish* — Unless otherwise specified, the bars shall have a commercial bright smooth surface finish consistent with the cold finishing operations specified in 6.4.

**9.2** Bars that are thermal treated after cold finishing may have a discolored or oxidized surface.

**9.3** *Oiling* — The bars shall be given a surface coating of oil or other rust inhibitor to protect against rust during shipment.



**9.4 Workmanship** — The bars shall be free of pipe, cracks, and flakes. Within the limits of good manufacturing and inspection practices, the bars shall be free of injurious seams, laps, segregation, or other imperfections that, due to their nature, degree, or extent, will interfere with the use of the material in machining or fabrication of suitable parts.

## 10. General Requirements

**10.1** Material furnished under this specification shall conform to the requirements of the current edition of Specification A 29/A 29M and/or Specification A 108 unless otherwise stated.

## 11. Certification and Test Reports

**11.1** A manufacturer's certification that the material was manufactured and tested in accordance with this specification together with a report of the heat analysis and tension test results shall be furnished at the time of shipment. The report shall include the name of the manufacturer, ASTM designation and year date and revision letter, if any, class and grade, heat number, size, and grain size (if requested).

## 12. Keywords

**12.1** carbon steel bars; cold finished steel bars; steel bars

TABLE 1  
CHEMICAL REQUIREMENTS  
(CAST OR HEAT ANALYSIS)<sup>4</sup>

UNS Designation	Grade	Carbon, %	Manganese, %	Phosphorus, max %	Sulfur, %
G10180	1018	0.15–0.20	0.60–0.90	0.040	0.050 max
G10350	1035	0.32–0.38	0.60–0.90	0.040	0.050 max
G10450	1045	0.43–0.50	0.60–0.90	0.040	0.050 max
G10500	1050	0.48–0.55	0.60–0.90	0.040	0.050 max
G15410	1541	0.36–0.44	1.35–1.65	0.040	0.050 max
G11170	1117	0.14–0.20	1.00–1.30	0.040	0.08–0.13
G11370	1137	0.32–0.39	1.35–1.65	0.040	0.08–0.13
G11410	1141	0.37–0.45	1.35–1.65	0.040	0.08–0.13
G11440	1144	0.40–0.48	1.35–1.65	0.040	0.24–0.33

<sup>4</sup> The intentional addition of Bi, Se, Te, and Pb is not permitted.

TABLE 2  
MECHANICAL REQUIREMENTS

UNS No.	Grade Designation	Diameter, Thickness, or Distance Between Parallel Faces, in. [mm]	Tensile Strength, min., ksi [MPa]	Yield Strength, min., ksi [MPa]	Elongation in 2 in. [50 mm], min., %	Reduction of Area, min., %
Class A — Normal Draft Cold Drawn and Stress Relieved Annealed						
G10180	1018	Up to $\frac{7}{8}$ [20], incl	70 [485]	60 [415]	18	40
		Over $\frac{7}{8}$ [20] to $1\frac{1}{4}$ [30], incl	65 [450]	55 [380]	16	40
		Over $1\frac{1}{4}$ [30] to 2 [50], incl	60 [415]	50 [345]	15	35
		Over 2 [50] to 3 [75], incl	55 [380]	45 [310]	15	35
G10350	1035	Up to $\frac{7}{8}$ [20], incl	85 [590]	75 [520]	13	35
		Over $\frac{7}{8}$ [20] to $1\frac{1}{4}$ [30], incl	80 [550]	70 [485]	12	35
		Over $1\frac{1}{4}$ [30] to 2 [50], incl	75 [520]	65 [450]	12	35
		Over 2 [50] to 3 [75], incl	70 [485]	60 [415]	10	30
G10450	1045	Up to $\frac{7}{8}$ [20], incl	95 [655]	85 [585]	12	35
		Over $\frac{7}{8}$ [20] to $1\frac{1}{4}$ [30], incl	90 [620]	80 [550]	11	30
		Over $1\frac{1}{4}$ [30] to 2 [50], incl	85 [585]	75 [520]	10	30
		Over 2 [50] to 3 [75], incl	80 [550]	70 [485]	10	30
G10500 and G15410	1050 and G1541	Up to $\frac{7}{8}$ [20], incl	100 [690]	90 [620]	11	35
		Over $\frac{7}{8}$ [20] to $1\frac{1}{4}$ [30], incl	95 [655]	85 [585]	11	30
		Over $1\frac{1}{4}$ [30] to 2 [50], incl	90 [620]	80 [550]	10	30
		Over 2 [50] to 3 [75], incl	85 [585]	75 [520]	10	30
G11170	1117	Up to $\frac{7}{8}$ [20], incl	75 [520]	65 [450]	15	40
		Over $\frac{7}{8}$ [20] to $1\frac{1}{4}$ [30], incl	70 [485]	60 [415]	15	40
		Over $1\frac{1}{4}$ [30] to 2 [50], incl	65 [450]	55 [380]	13	35
		Over 2 [50] to 3 [75], incl	60 [415]	50 [345]	12	30
G11370 and G11410	1137 and 1141	Up to $\frac{7}{8}$ [20], incl	95 [655]	90 [620]	11	35
		Over $\frac{7}{8}$ [20] to $1\frac{1}{4}$ [30], incl	90 [620]	85 [585]	11	30
		Over $1\frac{1}{4}$ [30] to 2 [50], incl	85 [585]	80 [550]	10	30
		Over 2 [50] to 3 [70], incl	80 [550]	75 [520]	10	30
G11440	1144	Up to $\frac{7}{8}$ [20], incl	105 [725]	95 [655]	10	30
		Over $\frac{7}{8}$ [20] to $1\frac{1}{4}$ [30], incl	100 [690]	90 [620]	10	30
		Over $1\frac{1}{4}$ [30] to 2 [50], incl	95 [655]	85 [585]	10	25
		Over 2 [50] to 3 [70], incl	90 [620]	80 [550]	10	20
		Over 3 [70] to $4\frac{1}{2}$ [115], incl	85 [585]	75 [520]	10	20
Class B — Heavy Draft Cold Drawn and Stress Relieved Annealed						
UNS No.	Grade Designation	In. [mm], Round or Hexagon <sup>A</sup>	Tensile Strength, min., ksi [MPa]	Yield Strength, min., ksi [MPa]	Elongation in 2 in. [50 mm], min., %	Reduction of Area, min., %
G10450	1045	Up to $\frac{7}{8}$ [20], incl	115 [795]	100 [690]	10	25
		Over $\frac{7}{8}$ [20] to $1\frac{1}{4}$ [30], incl	115 [795]	100 [690]	10	25
		Over $1\frac{1}{4}$ [30] to 2 [50], incl	115 [795]	100 [690]	10	25
		Over 2 [50] to 3 [75], incl	115 [795]	100 [690]	9	25
		Over 3 [75] to 4 [102], incl	105 [725]	90 [620]	7	20
G10500 and G11440	1050 and 1144	Up to $\frac{7}{8}$ [20], incl	115 [795]	100 [690]	8	25
G15410	1541	Over $\frac{7}{8}$ [20] to $1\frac{1}{4}$ [30], incl	115 [795]	100 [690]	8	25
G11410	1141	Over $1\frac{1}{4}$ [30] to 2 [50], incl	115 [795]	100 [690]	8	25
		Over 2 [50] to 3 [75], incl	115 [795]	100 [690]	8	20
		Over 3 [75] to $4\frac{1}{2}$ [115], incl	115 [795]	100 [690]	7	20

<sup>A</sup> Maximum size for hexagons is  $1\frac{1}{2}$  in. [40 mm].



## SUPPLEMENTARY REQUIREMENTS

One or more of the following supplementary requirements shall apply only when specified by the purchaser in the inquiry or order. Details of these requirements shall be agreed upon between the manufacturer and the purchaser.

### **S1. Special Surface**

**S1.1** When inspection standards more restrictive than visual inspection are required, special surface may be specified.

### **S2. Restricted Cast or Heat Analysis**

**S2.1** When required, the purchaser may specify restrictive cast or heat analysis limits on one or more elements. The degree of restriction and the number of elements so restricted are both subject to agreement between the manufacturer and the purchaser.

### **S3. Restricted Decarburization**

**S3.1** The purchaser may specify a maximum affected depth of decarburization when required for special applications, subject to agreement between the manufacturer and the purchaser.

### **S4. Nonmetallic Inclusion Requirements (Microscopical)**

**S4.1** When nonmetallic inclusion requirements are specified, the samples for testing shall be taken on a longitudinal direction midway between the center and the surface of the material. The area of the sample to be examined

should be agreed upon between the purchaser and the manufacturer, and the test specimen should be hardened by heating and quenched before being polished to avoid pits. The rating of the inclusion count should also be agreed upon and be based upon examination at a magnification of 100 diameters. Resulfurized steels are not subject to inclusion ratings.

### **S5. Restricted Incidental Elements**

**S5.1** The purchaser may specify limiting maximum requirements for copper, nickel, chromium, or molybdenum subject to agreement between the manufacturer and the purchaser.

### **S6. Grain Size**

**S6.1** The steel shall conform to either the coarse austenitic grain size (except as stated in S6.2), or the fine austenitic grain size requirement of Specification A 29/A 29M.

**S6.2** Certain elements, or combinations of elements, such as manganese, sulfur, and lead tend to produce grain refinement and it is technically inappropriate to ensure coarse grain size as measured by the McQuaid-Ehn test on high manganese, high sulfur, and leaded steels such as 1144, 1151, and 11L41.

## **SPECIFICATION FOR SEAMLESS AND WELDED AUSTENITIC STAINLESS STEEL PIPES**



**SA-312/SA-312M**

(Identical with ASTM Specification A312/A312M-01a except for the deletion of 5.2, revision to 6.2 to add "H" Grade heat treatment requirements and editorial differences in 7.1 and Table 1 and an editorial correction to the Cr and Ni percent chemical composition for UNS S31002 in Table 1.)



# SPECIFICATION FOR SEAMLESS AND WELDED AUSTENITIC STAINLESS STEEL PIPES



SA-312/SA-312M

(Identical with ASTM Specification A 312/A 312M-01a except for the deletion of 5.2, revision to 6.2 to add “H” Grade heat treatment requirements and editorial differences in 7.1 and Table 1 and an editorial correction to the Cr and Ni percent chemical composition for UNS S31002 in Table 1.)

## 1. Scope

**1.1** This specification covers seamless, straight-seam welded, and heavily cold worked welded austenitic stainless steel pipe intended for high-temperature and general corrosive service.

NOTE 1— When the impact test criterion for a low-temperature service would be 15 ft-lbf [20 J] energy absorption or 15 mils [0.38 mm] lateral expansion, some of the austenitic stainless steel grades covered by this specification are accepted by certain pressure vessel or piping codes without the necessity of making the actual test. For example, Grades TP304, TP304L, and TP347 are accepted by the ASME Pressure Vessel Code, Section VIII Division 1, and by the Chemical Plant and Refinery Piping Code, ANSI B31.3, for service at temperatures as low as  $-425^{\circ}\text{F}$  [ $-250^{\circ}\text{C}$ ] without qualification by impact tests. Other AISI stainless steel grades are usually accepted for service temperatures as low as  $-325^{\circ}\text{F}$  [ $-200^{\circ}\text{C}$ ] without impact testing. Impact testing may, under certain circumstances, be required. For example, materials with chromium or nickel content outside the AISI ranges, and for material with carbon content exceeding 0.10%, are required to be impact tested under the rules of ASME Section VIII Division 1 when service temperatures are lower than  $-50^{\circ}\text{F}$  [ $-45^{\circ}\text{C}$ ].

**1.2** Grades TP304H, TP309H, TP309HCb, TP310H, TP310HCb, TP316H, TP321H, TP347H, and TP348H are modifications of Grades TP304, TP309Cb, TP309S, TP310Cb, TP310S, TP316, TP321, TP347, and TP348, and are intended for high-temperature service.

**1.3** Optional supplementary requirements are provided for pipe where a greater degree of testing is desired. These supplementary requirements call for additional tests to be made and, when desired, one or more of these may be specified in the order.

**1.4** Table X1.1 lists the standardized dimensions of welded and seamless stainless steel pipe as shown in ANSI B36.19. These dimensions are also applicable to heavily cold worked pipe. Pipe having other dimensions may be furnished provided such pipe complies with all other requirements of this specification.

**1.5** Grades TP321 and TP321H have lower strength requirements for pipe manufactured by the seamless process in nominal wall thicknesses greater than  $\frac{3}{8}$  in. [9.5 mm].

**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. The inch-pound units shall apply unless the “M” designation of this specification is specified in the order.

NOTE 2— The dimensionless designator NPS (nominal pipe size) has been substituted in this standard for such traditional terms as “nominal diameter,” “size,” and “nominal size.”

## 2. Referenced Documents

### 2.1 ASTM Standards:

- A 262 Practices for Detecting Susceptibility to Intergranular Attack in Austenitic Stainless Steels
- A 370 Test Methods and Definitions for Mechanical Testing of Steel Products
- A 450/A 450M Specification for General Requirements for Carbon, Ferritic Alloy, and Austenitic Alloy Steel Tubes
- A 941 Terminology Relating to Steel, Stainless Steel, Related Alloys, and Ferroalloys
- A 999/A 999M Specification for General Requirements for Alloy and Stainless Steel Pipe
- E 112 Test Methods for Determining the Average Grain Size



E 381 Method of Macroetch Testing Steel Bars, Billets, Blooms, and Forgings  
E 527 Practice for Numbering Metals and Alloys (UNS)

**2.2 ANSI Standards:**

B1.20.1 Pipe Threads, General Purpose  
B36.10 Welded and Seamless Wrought Steel Pipe  
B36.19 Stainless Steel Pipe

**2.3 ASME Standard:**

ASME Boiler and Pressure Vessel Code: Section VIII

**2.4 AWS Standard:**

A5.9 Corrosion-Resisting Chromium and Chromium-Nickel Steel Welding Rods and Electrodes

**2.5 Other Standard:**

SAE J1086 Practice for Numbering Metals and Alloys (UNS)

**2.6 Other Standard:**

SNT-TC-1A Personnel Qualification and Certification in Nondestructive Testing

### 3. Terminology

**3.1 Definitions:**

**3.1.1** The definitions in Specification A 999/A 999M and Terminology A 941 are applicable to this specification.

### 4. Ordering Information

**4.1** Orders for material to this specification should include the following, as required, to describe the desired material adequately:

**4.1.1** Quantity (feet, centimetres, or number of lengths),

**4.1.2** Name of material (austenitic steel pipe),

**4.1.3** Process (seamless (SML) or welded (WLD) or heavily cold worked (HCW),

**4.1.4** Grade (Table 1),

**4.1.5** Size (NPS or outside diameter and schedule number or average wall thickness),

**4.1.6** Length (specific or random) (Section 13),

**4.1.7** End finish (Section on Ends of Specification A 999/A 999M),

**4.1.8** Optional requirements (product analysis, see Section 8; hydrostatic or nondestructive electric test, see Section 12),

**4.1.9** Test report required (Certification Section of Specification A 999/A 999M),

**4.1.10** Specification number, and

**4.1.11** Special requirements or any supplementary requirements selected, or both.

### 5. General Requirements

**5.1** Material furnished under this specification shall conform to the applicable requirements of the current edition of Specification A 999/A 999M unless otherwise provided herein.

#### 5.2 DELETED

### 6. Materials and Manufacture

#### 6.1 Manufacture:

**6.1.1** The pipe shall be manufactured by one of the following processes:

**6.1.2** *Seamless (SML) pipe* shall be made by a process that does not involve welding at any stage of production.

**6.1.3** *Welded (WLD) pipe* shall be made using an automatic welding process with no addition of filler metal during the welding process.

**6.1.4** *Heavily cold-worked (HCW) pipe* shall be made by applying cold working of not less than 35% reduction in thickness of both wall and weld to a welded pipe prior to the final anneal. No filler shall be used in making the weld. Prior to cold working, the weld shall be 100% radiographically inspected in accordance with the requirements of ASME Boiler and Pressure Vessel Code, Section VIII, Division 1, latest revision, Paragraph UW-51.

**6.1.5** Welded pipe and HCW pipe of NPS 14 and smaller shall have a single longitudinal weld. Welded pipe and HCW pipe of a size larger than NPS 14 shall have a single longitudinal weld or shall be produced by forming and welding two longitudinal sections of flat stock when approved by the purchaser. All weld tests, examinations, inspections, or treatments shall be performed on each weld seam.

**6.1.6** At the option of the manufacturer, pipe shall be either hot finished or cold finished.

**6.1.7** The pipe shall be free of scale and contaminating exogenous iron particles. Pickling, blasting, or surface finishing is not mandatory when pipe is bright annealed. The purchaser is permitted to require that a passivating treatment be applied to the finished pipe.

**6.2 Heat Treatment**— All pipe shall be furnished in the heat-treated condition in accordance with the requirements of Table 2. Other than for Grades S33228, S30815, S31272 and the “H” grades, seamless pipe immediately following hot forming may be individually quenched in water or rapidly cooled by other means, provided that the temperature of the pipes after hot forming is not less than the minimum specified solution treatment temperature. For H Grades, as well as Grades S33228, S30815, and S31272, the pipes shall be reheated to the specified solution treatment temperature for the required time before quenching.



### 6.3 Grain Size:

**6.3.1** The grain size of Grade UNS S32615, as determined in accordance with Test Methods E 112, shall be No. 3 or finer.

**6.3.2** The grain size of grades TP309H, TP309HCb, TP310H and TP310HCb, as determined in accordance with Test Methods E 112, shall be No. 6 or coarser.

**6.3.3** The grain size of grades 304H, 316H, 321H, 347H, and 348H, as determined in accordance with Test Methods E 112, shall be No. 7 or coarser.

## 7. Chemical Composition

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

## 8. Product Analysis

**8.1** At the request of the purchaser, an analysis of one billet or one length of flat-rolled stock from each heat, or two pipes from each lot shall be made by the manufacturer. A lot of pipe shall consist of the following number of lengths of the same size and wall thickness from any one heat of steel:

NPS Designator	Lengths of Pipe in Lot
Under 2	400 or fraction thereof
2 to 5	200 or fraction thereof
6 and over	100 or fraction thereof

**8.2** The results of these analyses shall be reported to the purchaser or the purchaser's representative, and shall conform to the requirements specified in Section 7.

**8.3** If the analysis of one of the tests specified in 8.1 does not conform to the requirements specified in Section 7, an analysis of each billet or pipe from the same heat or lot may be made, and all billets or pipe conforming to the requirements shall be accepted.

## 9. Permitted Variations in Wall Thickness

**9.1** In addition to the implicit limitation of wall thickness for seamless pipe imposed by the limitation on weight in Specification A 999/A 999M, the wall thickness for seamless and welded pipe at any point shall be within the tolerances specified in Table 3, except that for welded pipe the weld area shall not be limited by the 'Over' tolerance. The wall thickness and outside diameter for inspection for compliance with this requirement for pipe ordered by NPS and schedule number is shown in Table X1.1.

## 10. Tensile Requirements

**10.1** The tensile properties of the material shall conform to the requirements prescribed in Table 4.

## 11. Mechanical Tests, Grain Size Determinations, and Weld Decay Tests Required

**11.1 Transverse or Longitudinal Tension Test** — One tension test shall be made on a specimen for lots of not more than 100 pipes. Tension tests shall be made on specimens from two tubes for lots of more than 100 pipes.

NOTE 3 — The term "lot," for mechanical tests, applies to all pipe of the same diameter and wall thickness (or schedule) which are produced from the same heat of steel and subjected to the same finishing treatment: (1) in a continuous heat-treatment furnace, (2) in a batch-type heat-treatment furnace, equipped with recording pyrometers and automatically controlled within a 50°F [30°C] range, or (3) by direct quenching after hot forming, the larger of: (a) Each 200 ft [60 m] or fraction thereof or, (b) That pipe heat treated in the same batch furnace charge.

**11.2 Flattening Test** — For material heat treated in a batch-type furnace, flattening tests shall be made on 5% of the pipe from each heat-treated lot. For material heat treated by the continuous process, or by direct quenching after hot forming this test shall be made on a sufficient number of pipe to constitute 5% of the lot, but in no case less than two lengths of pipe.

**11.2.1** For welded pipe a transverse-guided face bend test of the weld may be conducted instead of a flattening test in accordance with the method outlined in the steel tubular product supplement of Test Methods and Definitions A 370. The ductility of the weld shall be considered acceptable when there is no evidence of cracks in the weld or between the weld and the base metal after bending. Test specimens from 5% of the lot shall be taken from the pipe or test plates of the same material as the pipe, the test plates being attached to the end of the cylinder and welded as a prolongation of the pipe longitudinal seam.

**11.3 Grain Size** — Grain size determinations on Grades TP309H, TP309HCb, TP310H, TP310HCb, and UNS S32615 shall be made on the same number of tubes as prescribed for the flattening test.

**11.4** HCW pipe shall be capable of passing the weld decay tests listed in Supplementary S9 with a weld metal to base metal loss ratio of 0.90 to 1.1. The test is not required to be performed unless S9 is specified in the purchase order.

## 12. Hydrostatic or Nondestructive Electric Test

**12.1** Each pipe shall be subjected to the nondestructive electric test or the hydrostatic test. The type of test to be used shall be at the option of the manufacturer, unless otherwise specified in the purchase order.

**12.2** The hydrostatic test shall be in accordance with Specification A 999/A 999M, unless specifically exempted under the provisions of 12.3.

**12.3** For pipe whose dimensions equal or exceed NPS 10, the purchaser, with the agreement of the manufacturer,



may waive the hydrostatic test requirement when in lieu of such test the purchaser performs a system test. Each length of pipe furnished without the completed manufacturer's hydrostatic test shall include with the mandatory markings the letters "NH."

#### **12.4 Nondestructive Electric Test:**

Nondestructive electric tests shall be in accordance with Specification A 999/A 999M.

### **13. Lengths**

**13.1** Pipe lengths shall be in accordance with the following regular practice:

**13.1.1** Unless otherwise agreed upon, all sizes from NPS  $\frac{1}{8}$  to and including NPS 8 are available in a length up to 24 ft (Note 4) with the permissible range of 15 to 24 ft (Note 4). Short lengths are acceptable and the number and minimum length shall be agreed upon between the manufacturer and the purchaser.

NOTE 4 — This value(s) applies when the inch-pound designation of this specification is the basis of purchase. When the "M" designation of this specification is the basis of purchase, the corresponding metric value(s) shall be agreed upon between the manufacturer and the purchaser.

**13.1.2** If definite cut lengths are desired, the lengths required shall be specified in the order. No pipe shall be under the specified length and not more than  $\frac{1}{4}$  in. [6 mm] over that specified.

**13.1.3** No jointers are permitted unless otherwise specified.

### **14. Workmanship, Finish, and Appearance**

**14.1** The finished pipes shall be reasonably straight and shall have a workmanlike finish. Imperfections may be removed by grinding, provided the wall thicknesses are not decreased to less than that permitted in Section 9 of Specification A 999/A 999M.

### **15. Repair by Welding**

**15.1** For welded pipe whose diameter equals or exceeds NPS 6, and whose nominal wall thickness equals or exceeds 0.200, weld repairs made with the addition of compatible filler metal may be made to the weld seam with the same procedures specified for plate defects in the section on Repair by Welding of Specification A 999/A 999M.

**15.2** Weld repairs of the weld seam shall not exceed 20% of the seam length.

**15.3** Weld repairs shall be made only with the gas tungsten-arc welding process using the same classification of bare filler rod qualified to the most current AWS Specification A5.9 as the grade of stainless steel pipe being

repaired and as shown in Table 5. Alternatively, subject to approval by the purchaser, weld repairs shall be made only with the gas tungsten-arc welding process using a filler metal more highly alloyed than the base metal when needed for corrosion resistance or other properties.

**15.4** Pipes that have had weld seam repairs with filler metal shall be uniquely identified and shall be so stated and identified on the certificate of tests. When filler metal other than that listed in Table 5 is used, the filler metal shall be identified on the certificate of tests.

### **16. Certification**

**16.1** In addition to the information required by Specification A 999/A 999M, the certification shall state whether or not the material was hydrostatically tested. If the material was nondestructively tested, the certification shall so state and shall show which standard practice was followed and what reference discontinuities were used.

### **17. Marking**

**17.1** In addition to the marking specified in Specification A 999/A 999M, the marking shall include the NPS (nominal pipe size) or outside diameter and schedule number or average wall thickness, heat number, and NH when hydrotesting is not performed and ET when eddy-current testing is performed or UT when ultrasonic testing is performed. The marking shall also include the manufacturer's private identifying mark, the marking requirement of 12.3, if applicable, and whether seamless (SML), welded (WLD), or heavily cold-worked (HCW). For Grades TP304H, TP316H, TP321H, TP347H, TP348H, and S30815, the marking shall also include the heat number and heat-treatment lot identification. If specified in the purchase order, the marking for pipe larger than NPS 4 shall include the weight.

### **18. Government Procurement**

#### **18.1 Scale Free Pipe for Government Procurement:**

**18.1.1** When specified in the contract or order, the following requirements shall be considered in the inquiry, contract or order, for agencies of the U.S. Government where scale free pipe or tube is required. These requirements shall take precedence if there is a conflict between these requirements and the product specifications.

**18.1.2** The requirements of Specification A 999/A 999M for pipe and Specification A 450/A 450M for tubes shall be applicable when pipe or tube is ordered to this specification.

**18.1.3** Pipe and tube shall be one of the following grades as specified herein:



Grade	UNS Designation
TP304	S30400
TP304L	S30403
TP304N	S30451
TP316	S31600
TP316L	S31603
TP316N	S31651
TP317	S31700
TP317L	S31703
TP321	S32100
TP347	S34700

**18.1.4 Part Number:**

*Example:* ASTM A 312/A 312M Pipe 304 NPS 12 SCH 40S SMLS

Specification Number .....	ASTM A 312
Pipe .....	P
Grade .....	304
NPS .....	12
Wall .....	0.375
SMLS OR WELDED .....	SML

**18.1.4.1**

Specification Number .....	ASTM A 312
Tube .....	T
Grade .....	304
Outside Diameter.....	0.250
Wall .....	0.035
SMLS OR WELDED .....	WLD

**18.1.5 Ordering Information** — Orders for material under this specification shall include the following in addition to the requirements of Section 4:

**18.1.5.1** Pipe or tube,

**18.1.5.2** Part number,

**18.1.5.3** Ultrasonic inspection, if required,

**18.1.5.4** If shear wave test is to be conducted in two opposite circumferential directions,

**18.1.5.5** Intergranular corrosion test, and

**18.1.5.6** Level of preservation and packing required.

**19. Keywords**

**19.1** austenitic stainless steel; seamless steel pipe; stainless steel pipe; steel pipe; welded steel pipe

TABLE 1  
CHEMICAL REQUIREMENTS

Grade	UNS Designation <sup>A</sup>	Composition, % <sup>B</sup>																
		Carbon	Manganese	Phosphorus	Sulfur	Silicon	Chromium	Nickel	Molybdenum	Titanium	Columbium	Tantalum, max.	Nitrogen <sup>C</sup>	Vanadium	Copper	Cerium	Boron	Aluminum
...	S20400	0.030	7.0–9.0	0.045	0.030	1.00	15.0–17.0	1.50–3.00	...	...	...	...	0.15–0.30	...	...	...	...	...
TPXM-19	S20910	0.06	4.0–6.0	0.045	0.030	1.00	20.5–23.5	11.5–13.5	1.50–3.00	...	0.10–0.30	...	0.20–0.40	0.10–0.30	...	...	...	...
TPXM-10	S21900	0.08	8.0–10.0	0.045	0.030	1.00	19.0–21.5	5.5–7.5	...	...	...	...	0.15–0.40	...	...	...	...	...
TPXM-11	S21904	0.04	8.0–10.0	0.045	0.030	1.00	19.0–21.5	5.5–7.5	...	...	...	...	0.15–0.40	...	...	...	...	...
TPXM-29	S24000	0.08	11.5–14.5	0.060	0.030	1.00	17.0–19.0	2.3–3.7	...	...	...	...	0.20–0.40	...	...	...	...	...
TP304	S30400	0.08	2.00	0.045	0.030	1.00	18.0–20.0	8.0–11.0	...	...	...	...	...	...	...	...	...	...
TP304L	S30403	0.035 <sup>D</sup>	2.00	0.045	0.030	1.00	18.0–20.0	8.0–13.0	...	...	...	...	...	...	...	...	...	...
TP304H	S30409	0.04–0.10	2.00	0.045	0.030	1.00	18.0–20.0	8.0–11.0	...	...	...	...	...	...	...	...	...	...
...	S30415	0.04–0.06	0.80	0.045	0.030	1.00–2.00	18.0–19.0	9.0–10.0	...	...	...	...	0.12–0.18	...	...	0.03–0.08	...	...
TP304N	S30451	0.08	2.00	0.045	0.030	1.00	18.0–20.0	8.0–11.0	...	...	...	...	0.10–0.16	...	...	...	...	...
TP304LN	S30453	0.035	2.00	0.045	0.030	1.00	18.0–20.0	8.0–12.0	...	...	...	...	0.10–0.16	...	...	...	...	...
...	S30600	0.018	2.00	0.02	0.02	3.7–4.3	17.0–18.5	14.0–15.5	0.20	...	...	...	...	...	0.50 max.	...	...	...
...	S30615	0.16–0.24	2.00	0.030	0.03	3.2–4.0	17.0–19.5	13.5–16.0	13.5–16.0	...	...	...	...	...	...	...	...	0.80–1.50
...	S30815	0.05–0.10	0.80	0.040	0.030	1.40–2.00	20.0–22.0	10.0–12.0	...	...	...	...	0.14–0.20	...	...	0.03–0.08	...	...
TP309S	S30908	0.08	2.00	0.045	0.030	1.00	22.0–24.0	12.0–15.0	0.75	...	...	...	...	...	...	...	...	...
TP309H	S30909	0.04–0.10	2.00	0.045	0.030	1.00	22.0–24.0	12.0–15.0	...	...	...	...	...	...	...	...	...	...
TP309Cb	S30940	0.08	2.00	0.045	0.030	1.00	22.0–24.0	12.0–16.0	0.75	...	10 × C min., 1.10 max.	...	...	...	...	...	...	...
TP309HCb	S30941	0.04–0.10	2.00	0.045	0.030	1.00	22.0–24.0	12.0–16.0	0.75	...	10 × C min., 1.10 max.	...	...	...	...	...	...	...
TP310S	S31002	0.015	2.00	0.020	0.015	0.15	24.0–26.0	19.0–22.0	0.10	...	...	...	0.10	...	...	...	...	...
TP310H	S31008	0.08	2.00	0.045	0.030	1.00	24.0–26.0	19.0–22.0	0.75	...	...	...	...	...	...	...	...	...
TP310Cb	S31009	0.04–0.10	2.00	0.045	0.030	1.00	24.0–26.0	19.0–22.0	...	...	...	...	...	...	...	...	...	...
TP310Cb	S31040	0.08	2.00	0.045	0.030	1.00	24.0–26.0	19.0–22.0	0.75	...	10 × C min., 1.10 max.	...	...	...	...	...	...	...
TP310HCb	S31041	0.04–0.10	2.00	0.045	0.030	1.00	24.0–26.0	19.0–22.0	0.75	...	10 × C min., 1.10 max.	...	...	...	...	...	...	...
...	S31050	0.025	2.00	0.020	0.015	0.4	24.0–26.0	20.5–23.5	1.6–2.6	...	...	...	0.09–0.15	...	...	...	...	...
...	S31254	0.020	1.00	0.030	0.010	0.80	19.5–20.5	17.5–18.5	6.0–6.5	...	...	...	0.18–0.22	...	0.50–1.00	...	...	...
...	S31272	0.08–0.12	1.5–2.00	0.030	0.015	0.25–0.75	14.0–16.0	14.0–16.0	1.00–1.40	0.30–0.60	...	...	...	...	...	...	0.004–0.008	...
TP316	S31600	0.08	2.00	0.045	0.030	1.00	16.0–18.0	11.0–14.0 <sup>F</sup>	2.00–3.00	...	...	...	...	...	...	...	...	...
TP316L	S31603	0.035 <sup>D</sup>	2.00	0.045	0.030	1.00	16.0–18.0	10.0–14.0	2.00–3.00	...	...	...	...	...	...	...	...	...
TP316H	S31609	0.04–0.10	2.00	0.045	0.030	1.00	16.0–18.0	11.0–14.0 <sup>F</sup>	2.00–3.00	...	...	...	...	...	...	...	...	...
...	S31635	0.08	2.00	0.045	0.030	0.75	16.0–18.0	10.0–12.0	2.00–3.00	5 × (C+N) min, 0.70	...	...	0.10	...	...	...	...	...
TP316N	S31651	0.08	2.00	0.045	0.030	1.00	16.0–18.0	11.0–14.0 <sup>F</sup>	2.00–3.00	...	...	...	0.10–0.16	...	...	...	...	...
TP316LN	S31653	0.035	2.00	0.045	0.030	1.00	16.0–18.0	11.0–14.0 <sup>F</sup>	2.00–3.00	...	...	...	0.10–0.16	...	...	...	...	...
TP317	S31700	0.08	2.00	0.045	0.030	1.00	18.0–20.0	11.0–14.0	3.0–4.0	...	...	...	...	...	...	...	...	...
TP317L	S31703	0.035	2.00	0.045	0.030	1.00	18.0–20.0	11.0–15.0	3.0–4.0	...	...	...	...	...	...	...	...	...
...	S31725	0.03	2.00	0.040 <sup>F</sup>	0.030	1.00	18.0–20.0	13.5–17.5	4.0–5.0	...	...	...	0.10	...	0.75	...	...	...
...	S31726	0.03	2.00	0.040 <sup>F</sup>	0.030	1.00	17.0–20.0	14.5–17.5	4.0–5.0	...	...	...	0.10–0.20	...	0.75	...	...	...
TP321	S32100	0.08	2.00	0.045	0.030	1.00	17.0–19.0	9.0–12.0	...	<sup>G</sup>	...	...	0.10	...	...	...	...	...
TP321H	S32109	0.04–0.10	2.00	0.045	0.030	1.00	17.0–19.0	9.0–12.0	...	<sup>H</sup>	...	...	...	...	...	...	...	...



TABLE 1  
CHEMICAL REQUIREMENTS (CONT'D)

Grade	UNS Designation <sup>A</sup>	Composition, % <sup>B</sup>																
		Carbon	Manganese	Phosphorus	Sulfur	Silicon	Chromium	Nickel	Molybdenum	Titanium	Columbium	Tantalum, max.	Nitrogen <sup>C</sup>	Vanadium	Copper	Cerium	Boron	Aluminum
...	S32615	0.07	2.00	0.045	0.030	4.8–6.0	16.5–19.5	19.0–22.0	0.30–1.50	...	...	...	...	...	1.50–2.50	...	...	...
...	S32654	0.020	2.0–4.0	0.030	0.005	0.50	24.0–25.0	21.0–23.0	7.0–8.0	...	...	...	0.45–0.55	...	0.30–0.60	...	...	...
...	S33228	0.04–0.08	1.00	0.020	0.015	0.30	26.0–28.0	31.0–33.0	...	...	0.60–1.00	...	...	...	...	0.05–0.10	...	0.025
...	S34565	0.03	5.0–7.0	0.030	0.010	1.00	23.0–25.0	16.0–18.0	4.0–5.0	...	0.10	...	0.40–0.60	...	...	...	...	...
TP347	S34700	0.08	2.00	0.045	0.030	1.00	17.0–19.0	9.0–13.0	...	...	<sup>I</sup>	...	...	...	...	...	...	...
TP347H	S34709	0.04–0.10	2.00	0.045	0.030	1.00	17.0–19.0	9.0–13.0	...	...	<sup>J</sup>	...	...	...	...	...	...	...
TP347LN	S34751	0.005–0.020	2.00	0.045	0.030	1.00	17.0–19.0	9.0–13.0	...	...	0.20–0.50 <sup>F, K</sup>	...	0.06–0.10	...	...	...	...	...
TP348	S34800	0.08	2.00	0.045	0.030	1.00	17.0–19.0	9.0–13.0	...	...	<sup>J</sup>	0.10	...	...	...	...	...	...
TP348H	S34809	0.04–0.10	2.00	0.045	0.030	1.00	17.0–19.0	9.0–13.0	...	...	<sup>J</sup>	0.10	...	...	...	...	...	...
...	S35045	0.06–0.10	1.50	...	0.015	1.00	25–29.0	32.0–37.0	...	0.15–0.60	...	...	...	...	0.75	...	...	0.15–0.60
...	S35315	0.04–0.08	2.00	0.040	0.030	1.20–2.00	24.0–26.0	34.0–36.0	...	...	...	...	0.12–0.18	...	...	0.03–0.08	...	...
TPXM-15	S38100	0.08	2.00	0.030	0.030	1.50–2.50	17.0–19.0	17.5–18.5	...	...	...	...	...	...	...	...	...	...
...	N08367	0.030	2.00	0.040	0.030	1.00	20.00–22.00	23.5–25.5	6.00–7.00	...	...	...	0.18–0.25	...	0.75	...	...	...
...	N08904	0.020	2.00	0.040	0.030	1.00	19.0–23.0	23.0–28.0	4.0–5.0	...	...	...	0.10	...	1.00–2.00	...	...	...
...	N08926	0.020	2.00	0.030	0.010	0.50	24.0–26.0	19.0–21.0	6.0–7.0	...	...	...	0.15–0.25	...	0.50–1.50	...	...	...

<sup>A</sup> New designation established in accordance with Practice E 527 and SAE J1086.

<sup>B</sup> Maximum, unless otherwise indicated.

<sup>C</sup> The method of analysis for nitrogen shall be a matter of agreement between the purchaser and manufacturer.

<sup>D</sup> For small diameter or thin walls or both, where many drawing passes are required, a carbon maximum of 0.040% is necessary in grades TP304L and TP316L. Small outside diameter tubes are defined as those less than 0.500 in. [12.7 mm] in outside diameter and light wall tubes as those less than 0.049 in. [1.20 mm] in average wall thickness (0.044 in. [1.10 mm] in minimum wall thickness).

<sup>E</sup> For welded TP316, TP316N, TP316LN, and TP316H pipe, the nickel range shall be 10.0–14.0%.

<sup>F</sup> For welded pipe, the phosphorus maximum shall be 0.045%.

<sup>G</sup> The titanium content shall be not less than five times the carbon content and not more than 0.70%.

<sup>H</sup> The titanium content shall be not less than four times the carbon content and not more than 0.60%.

<sup>I</sup> The columbium content shall be not less than ten times the carbon content and not more than 1.00%.

<sup>J</sup> The columbium content shall be not less than eight times the carbon content and not more than 1.0%.

<sup>K</sup> Grade S34751 shall have a columbium (niobium) plus tantalum content of not less than 15 times the carbon content.

TABLE 2  
ANNEALING REQUIREMENTS

Grade or UNS Designation <sup>A</sup>	Heat Treating Temperature <sup>B</sup>	Cooling/Testing Requirements
All grades not individually listed below:	1900°F [1040°C]	<i>C</i>
TP321H, TP347H, TP348H		
Cold finished	2000°F [1100°C]	<i>D</i>
Hot finished	1925°F [1050°C]	<i>D</i>
TP304H, TP316H		
Cold finished	1900°F [1040°C]	<i>D</i>
Hot finished	1900°F [1040°C]	<i>D</i>
TP309H, TP309HCb, TP310H, TP310HCb	1900°F [1040°C]	<i>D</i>
S30600	2010–2140°F [1100–1170°C]	<i>D</i>
S30815, S31272	1920°F [1050°C]	<i>D</i>
S31254, S32654	2100°F [1150°C]	<i>D</i>
S33228	2050–2160°F [1120–1180°C]	<i>D</i>
S34565	2050–2140°F [1120–1170°C]	<i>D</i>
S35315	2010°F [1100°C]	<i>D</i>
N08367	2025°F [1110°C]	<i>D</i>
N08904	2000°F [1100°C]	<i>D</i>
N08926	2010°F [1100°C]	<i>D</i>

<sup>A</sup> New designation established in accordance with Practice E 527 and SAE J1086.

<sup>B</sup> Minimum, unless otherwise stated.

<sup>C</sup> Quenched in water or rapidly cooled by other means, at a rate sufficient to prevent reprecipitation of carbides, as demonstrable by the capability of passing Practices A 262, Practice E. The manufacturer is not required to run the test unless it is specified on the purchase order (see Supplementary Requirement S7). Note that Practices A 262 requires the test to be performed on sensitized specimens in the low-carbon and stabilized types and on specimens representative of the as-shipped condition for other types. In the case of low-carbon types containing 3% or more molybdenum, the applicability of the sensitizing treatment prior to testing shall be a matter for negotiation between the seller and the purchaser.

<sup>D</sup> Quenched in water or rapidly cooled by other means.

TABLE 3  
PERMITTED VARIATIONS IN WALL THICKNESS

NPS Designator	Tolerance, % from Nominal	
	Over	Under
1/8 to 2 1/2 incl., all <i>t/D</i> ratios	20.0	12.5
3 to 18 incl., <i>t/D</i> up to 5% incl.	22.5	12.5
3 to 18 incl., <i>t/D</i> > 5%	15.0	12.5
20 and larger, welded, all <i>t/D</i> ratios	17.5	12.5
20 and larger, seamless, <i>t/D</i> up to 5% incl.	22.5	12.5
20 and larger, seamless, <i>t/D</i> > 5%	15.0	12.5

where:

*t* = Nominal Wall Thickness

*D* = Ordered Outside Diameter



TABLE 4  
TENSILE REQUIREMENTS

Grade	UNS Designation	Tensile Strength, Min. ksi [MPa]	Yield Strength, Min. ksi [MPa]
...	S20400	95 [635]	48 [330]
TPXM-19	S20910	100 [690]	55 [380]
TPXM-10	S21900	90 [620]	50 [345]
TPXM-11	S21904	90 [620]	50 [345]
TPXM-29	S24000	100 [690]	55 [380]
TP304	S30400	75 [515]	30 [205]
TP304L	S30403	70 [485]	25 [170]
TP304H	S30409	75 [515]	30 [205]
...	S30415	87 [600]	42 [290]
TP304N	S30451	80 [550]	35 [240]
TP304LN	S30453	75 [515]	30 [205]
...	S30600	78 [540]	35 [240]
...	S30615	90 [620]	40 [275]
...	S30815	87 [600]	45 [310]
TP309S	S30908	75 [515]	30 [205]
TP309H	S30909	75 [515]	30 [205]
TP309Cb	S30940	75 [515]	30 [205]
TP309HCb	S30941	75 [515]	30 [205]
...	S31002	73 [500]	30 [205]
TP310S	S31008	75 [515]	30 [205]
TP310H	S31009	75 [515]	30 [205]
TP310Cb	S31040	75 [515]	30 [205]
TP310HCb	S31041	75 [515]	30 [205]
...	S31050:		
t ≤ 0.25 in.		84 [580]	39 [270]
t > 0.25 in.		78 [540]	37 [255]
...	S31254:		
t ≤ 0.187 in. [5.00 mm]		98 [675]	45 [310]
t > 0.187 in. [5.00 mm]		95 [655]	45 [310]
...	S31272	65 [450]	29 [200]
TP316	S31600	75 [515]	30 [205]
TP316L	S31603	70 [485]	25 [170]
TP316H	S31609	75 [515]	30 [205]
...	S31635	75 [515]	30 [205]
TP316N	S31651	80 [550]	35 [240]
TP316LN	S31653	75 [515]	30 [205]
TP317	S31700	75 [515]	30 [205]
TP317L	S31703	75 [515]	30 [205]
...	S31725	75 [515]	30 [205]
...	S31726	80 [550]	35 [240]
TP321	S32100:		
Welded		75 [515]	30 [205]
Seamless:			
≤ 3/8 in.		75 [515]	30 [205]
> 3/8 in.		70 [485]	25 [170]
TP321H	S32109:		
Welded		75 [515]	30 [205]
Seamless:			
≤ 3/16 in.		75 [515]	30 [205]
> 3/16 in.		70 [480]	25 [170]
...	S32615	80 [550]	32 [220]
...	S32654	109 [750]	62 [430]
...	S33228	73 [500]	27 [185]
...	S34565	115 [795]	60 [415]
TP347	S34700	75 [515]	30 [205]
TP347H	S34709	75 [515]	30 [205]
TP347LN	S34751	75 [515]	30 [205]
TP348	S34800	75 [515]	30 [205]
TP348H	S34809	75 [515]	30 [205]
...	S35045	70 [485]	25 [170]
...	S35315	94 [650]	39 [270]

TABLE 4  
TENSILE REQUIREMENTS (CONT'D)

Grade	UNS Designation	Tensile Strength, Min. ksi [MPa]	Yield Strength, Min. ksi [MPa]
TPXM-15	S38100	75 [515]	30 [205]
...	N08367:		
t ≤ 0.187		100 [690]	45 [310]
t > 0.187		95 [655]	45 [310]
...	N08904	71 [490]	31 [215]
...	N08926	94 [650]	43 [295]
Elongation in 2 in. or 50 mm (or 4D), Min., %:		Longitudinal	Transverse
All Grades except S31050 and S32615		35	25
S32615, S31050		25	...
N08367		30	...

TABLE 5  
PIPE AND FILLER METAL SPECIFICATION

Pipe		Filler Metal	
Grade	UNS Designation	AWS A5.9 Class	UNS Designation
TP304	S30400	ER308	S30800, W30840
TP304L	S30403	ER308L	S30883, W30843
TP304N	S30451	ER308	S30880, W30840
TP304LN	S30453	ER308L	S30883, W30843
TP304H	S30409	ER308	S30880, W30840
TP309Cb	S30940	...	...
TP309S	S30908	...	...
TP310Cb	S31040	...	...
TP310S	S31008	...	...
...	S31272	...	...
TP316	S31600	ER316	S31680, W31640
TP316L	S31603	ER316L	S31683, W31643
TP316N	S31651	ER316	S31680, W31640
TP316LN	S31653	ER316L	S31683, W31643
TP316H	S31609	ER316H	S31680, W31640
TP321	S32100	ER321	S32180, W32140
...	...	ER347	S34780, W34740
TP347	S34700	ER347	S34780, W34740
TP348	S34800	ER347	S34780, W34740
TPXM-19	S22100	ER209	S20980, W32240
TPXM-29	S28300	ER240	S23980, W32440
...	N08367	...	N06625
...	S20400	ER209	S20980, W32240
...	N08926	...	N06625



## SUPPLEMENTARY REQUIREMENTS

One or more of the following supplementary requirements shall apply only when specified in the purchase order. The purchaser may specify a different frequency of test or analysis than is provided in the supplementary requirement. Subject to agreement between the purchaser and manufacturer, retest and retreatment provisions of these supplementary requirements may also be modified.

### S1. Product Analysis

**S1.1** For all pipe NPS 5 and larger in nominal size there shall be one product analysis made of a representative sample from one piece for each ten lengths or fraction thereof from each heat of steel.

**S1.2** For pipe smaller than NPS 5 there shall be one product analysis made from ten lengths per heat of steel or from 10% of the number of lengths per heat of steel, whichever number is smaller.

**S1.3** Individual lengths failing to conform to the chemical requirements specified in Section 7 shall be rejected.

### S2. Transverse Tension Tests

**S2.1** There shall be one transverse tension test made from one end of 10% of the lengths furnished per heat of steel. This applies only to pipe NPS 8 and larger.

**S2.2** If a specimen from any length fails to conform to the tensile properties specified that length shall be rejected.

### S3. Flattening Test

**S3.1** The flattening test of Specification A 999/A 999M shall be made on a specimen from one end or both ends of each pipe. Crop ends may be used. If this supplementary requirement is specified, the number of tests per pipe shall also be specified. If a specimen from any length fails because of lack of ductility prior to satisfactory completion of the first step of the flattening test requirement, that pipe shall be rejected subject to retreatment in accordance with Specification A 999/A 999M and satisfactory retest. If a specimen from any length of pipe fails because of a lack of soundness that length shall be rejected, unless subsequent retesting indicates that the remaining length is sound.

### S4. Etching Tests

**S4.1** The steel shall be homogeneous as shown by etching tests conducted in accordance with the appropriate portions of Method E 381. Etching tests shall be made on a cross section from one end or both ends of each pipe and shall show sound and reasonably uniform material free

of injurious laminations, cracks, and similar objectionable defects. If this supplementary requirement is specified, the number of tests per pipe required shall also be specified. If a specimen from any length shows objectionable defects, the length shall be rejected, subject to removal of the defective end and subsequent retests indicating the remainder of the length to be sound and reasonably uniform material.

### S5. Radiographic Examination

**S5.1** The entire length of weld in each double welded pipe shall be radiographically examined, using X-radiation, in accordance with Paragraph UW-51 of Section VIII Division 1 of the ASME Boiler and Pressure Vessel Code. In addition to the marking required by Section 13 each pipe shall be marked "RT" after the specification and grade. Requirements of S5 shall be required in the certification.

### S6. Stabilizing Heat Treatment

**S6.1** Subsequent to the solution anneal required in 6.2, Grades TP309HCb, TP310HCb, TP321, TP321H, TP347, TP347H, TP348, and TP348H shall be given a stabilization heat treatment at a temperature lower than that used for the initial solution annealing heat treatment. The temperature of stabilization heat treatment shall be at a temperature as agreed upon between the purchaser and vendor.

### S7. Intergranular Corrosion Test

**S7.1** When specified, material shall pass intergranular corrosion tests conducted by the manufacturer in accordance with Practices A 262, Practice E.

NOTE S7.1 — Practice E requires testing on the sensitized condition for low carbon or stabilized grades, and on the as-shipped condition for other grades.

**S7.2** A stabilization heat treatment in accordance with Supplementary Requirement S6 may be necessary and is permitted in order to meet this requirement for the grades containing titanium or columbium, particularly in their H versions.



**S8. Minimum Wall Pipe**

**S8.1** When specified by the purchaser, pipe shall be furnished on a minimum wall basis. The wall of such pipe shall not fall below the thickness specified. In addition to the marking required by Section 17, the pipe shall be marked S8.

**S9. Weld Decay Test**

**S9.1** When specified in the purchase order, one sample from each lot of pipe shall be subject to testing in a boiling solution of 50% reagent grade hydrochloric acid and 50% water.

**S9.2** The sample, of approximately 2 in. [50 mm] length, shall be prepared from a production length of pipe. Depending on the size of the pipe, it is permitted to section the sample longitudinally to allow it to fit in the Erlenmeyer flask. As a minimum, the tested sample shall include the entire weld and adjacent area and the full length of base metal 180° across from the weld. All burrs and sharp edges shall be removed by light grinding. Dust and grease shall be removed by cleaning with soap and water or other suitable solvents.

**S9.3** The hydrochloric acid solution shall be prepared by slowly adding reagent grade (approximately 37%) hydrochloric acid to an equal volume of distilled water.

**Warning** — Protect eyes and use rubber gloves when handling acid. Mixing and testing shall be performed in a protective enclosure.

**S9.4** The test container shall be a 1-L Erlenmeyer flask equipped with ground-glass joints and an Ahline condenser. The volume of the solution shall be approximately 700 mL.

**S9.5** The thickness of the weld and the base metal 180° from the weld shall be measured near both ends of the sample. These measurements shall be made with a micrometer with an anvil shape suitable for measuring the thickness with an accuracy to at least 0.001 in. [0.025 mm].

**S9.6** The sample sections, both weld and base metal, shall be immersed in the flask containing the solution. Boiling chips shall be added and the solution brought to

a boil. Boiling shall be maintained through the duration of the test. The time of testing shall be that which is required to remove 40 to 60% of the original base metal thickness (usually 2 h or less). If more than 60% of the base metal thickness remains, it is permitted to terminate the test after 24 h.

**S9.7** At the end of the test period, the samples shall be removed from the solution, rinsed with distilled water, and dried.

**S9.8** The thickness measurements as in S9.5 shall be repeated. The anvil shape of the micrometer used shall be suitable for measuring the minimum remaining thickness with an accuracy to at least 0.001 in. [0.025 mm].

**S9.9** The corrosion ratio,  $R$ , shall be calculated as follows:

$$R = (W_o - W) / (B_o - B)$$

where:

$W_o$  = average weld-metal thickness before the test

$W$  = average weld-metal thickness after the test

$B_o$  = average base-metal thickness before the test, and

$B$  = average base-metal thickness after the test

**S9.9.1** The corrosion ratio for HCW pipe shall be as specified in 11.4.

**S9.9.2** The corrosion ratio shall be 1.25 or less, or as further restricted in the purchase order, when the weld decay test is specified for welded (WLD) pipe.

$$R = (W_o - W) / (B_o - B)$$

where:

$W_o$  = average weld-metal thickness before the test

$W$  = average weld-metal thickness after the test

$B_o$  = average base-metal thickness before the test, and

$B$  = average base-metal thickness after the test

**S9.9.1** The corrosion ratio for HCW pipe shall be as specified in 11.4.

**S9.9.2** The corrosion ratio shall be 1.25 or less, or as further restricted in the purchase order, when the weld decay test is specified for welded (WLD) pipe.



## APPENDIX

## (Nonmandatory Information)

**X1. DIMENSIONS OF WELDED AND SEAMLESS STAINLESS STEEL PIPE**

**X1.1** Table X1.1 is based on Table 1 of the American National Standard for stainless steel pipe (ANSI B36.19).

TABLE X1.1  
DIMENSIONS OF WELDED AND SEAMLESS STAINLESS STEEL PIPE

NPS Designator	Outside Diameter		Nominal Wall Thickness							
			Schedule 5S <sup>A</sup>		Schedule 10S <sup>A</sup>		Schedule 40S		Schedule 80S	
	in.	mm	in.	mm	in.	mm	in.	mm	in.	mm
1/8	0.405	10.29	...	...	0.049	1.24	0.068	1.73	0.095	2.41
1/4	0.540	13.72	...	...	0.065	1.65	0.088	2.24	0.119	3.02
3/8	0.675	17.15	...	...	0.065	1.65	0.091	2.31	0.126	3.20
1/2	0.840	21.34	0.065	1.65	0.083	2.11	0.109	2.77	0.147	3.73
3/4	1.050	26.67	0.065	1.65	0.083	2.11	0.113	2.87	0.154	3.91
1.0	1.315	33.40	0.065	1.65	0.109	2.77	0.133	3.38	0.179	4.55
1 1/4	1.660	42.16	0.065	1.65	0.109	2.77	0.140	3.56	0.191	4.85
1 1/2	1.900	48.26	0.065	1.65	0.109	2.77	0.145	3.68	0.200	5.08
2	2.375	60.33	0.065	1.65	0.109	2.77	0.154	3.91	0.218	5.54
2 1/2	2.875	73.03	0.083	2.11	0.120	3.05	0.203	5.16	0.276	7.01
3	3.500	88.90	0.083	2.11	0.120	3.05	0.216	5.49	0.300	7.62
3 1/2	4.000	101.60	0.083	2.11	0.120	3.05	0.226	5.74	0.318	8.08
4	4.500	114.30	0.083	2.11	0.120	3.05	0.237	6.02	0.337	8.56
5	5.563	141.30	0.109	2.77	0.134	3.40	0.258	6.55	0.375	9.52
6	6.625	168.28	0.109	2.77	0.134	3.40	0.280	7.11	0.432	10.97
8	8.625	219.08	0.109	2.77	0.148	3.76	0.322	8.18	0.500	12.70
10	10.750	273.05	0.134	3.40	0.165	4.19	0.365	9.27	0.500 <sup>B</sup>	12.70 <sup>B</sup>
12	12.750	323.85	0.156	3.96	0.180	4.57	0.375 <sup>B</sup>	9.52 <sup>B</sup>	0.500 <sup>B</sup>	12.70 <sup>B</sup>
14	14.000	355.60	0.156	3.96	0.188 <sup>B</sup>	4.78 <sup>B</sup>	...	...	...	...
16	16.000	406.40	0.165	4.19	0.188 <sup>B</sup>	4.78 <sup>B</sup>	...	...	...	...
18	18.000	457.20	0.165	4.19	0.188 <sup>B</sup>	4.78 <sup>B</sup>	...	...	...	...
20	20.000	508.00	0.188	4.78	0.218 <sup>B</sup>	5.54 <sup>B</sup>	...	...	...	...
22	22.000	558.80	0.188	4.78	0.218 <sup>B</sup>	5.54 <sup>B</sup>	...	...	...	...
24	24.000	609.60	0.218	5.54	0.250	6.35	...	...	...	...
30	30.000	762.00	0.250	6.35	0.312	7.92	...	...	...	...

NOTE 1: The decimal thickness listed for the respective pipe sizes represents their nominal or average wall dimensions.

<sup>A</sup> Schedules 5S and 10S wall thicknesses do not permit threading in accordance with the American National Standard for Pipe Threads (ANSI B1.20.1).

<sup>B</sup> These do not conform to the American National Standard for Welded and Seamless Wrought Steel Pipe (ANSI B36.10-1979).



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