



GNEE has over 18 years of experience manufacturing **ASTM A312 seamless and welded** stainless steel pipes, providing globally trusted piping solutions. We are committed to quality, stability, and customer satisfaction. Please feel free to email us at [info@gneestainless.com](mailto:info@gneestainless.com). We'd love to serve you.

## Standard Specification for Seamless and Welded Austenitic Stainless Steel Pipes<sup>1</sup>

This standard is issued under the fixed designation A 312/A 312M; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

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

### 1. Scope

1.1 This specification<sup>2</sup> 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°F [–250°C] without qualification by impact tests. Other AISI stainless steel grades are usually accepted for service temperatures as low as –325°F [–200°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°F [–45°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<sup>3</sup>
- A 370 Test Methods and Definitions for Mechanical Testing of Steel Products<sup>3</sup>
- A 450/A 450M Specification for General Requirements for Carbon, Ferritic Alloy, and Austenitic Alloy Steel Tubes<sup>4</sup>
- A 941 Terminology Relating to Steel, Stainless Steel, Related Alloys, and Ferroalloys<sup>4</sup>
- A 999/A 999M Specification for General Requirements for Alloy and Stainless Steel Pipe<sup>4</sup>
- E 112 Test Methods for Determining the Average Grain Size<sup>5</sup>
- E 381 Method of Macroetch Testing Steel Bars, Billets, Blooms, and Forgings<sup>5</sup>
- E 527 Practice for Numbering Metals and Alloys (UNS)<sup>4</sup>

#### 2.2 ANSI Standards:<sup>6</sup>

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

#### 2.3 ASME Standard:

<sup>1</sup> This specification is under the jurisdiction of ASTM Committee A01 on Steel, Stainless Steel, and Related Alloys and is the direct responsibility of Subcommittee A01.10 on Stainless and Alloy Steel Tubular Products.

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<sup>2</sup> For ASME Boiler and Pressure Vessel Code applications see related Specification SA-312 in Section II of that Code.

<sup>3</sup> Annual Book of ASTM Standards, Vol 01.03.

<sup>4</sup> Annual Book of ASTM Standards, Vol 01.01.

<sup>5</sup> Annual Book of ASTM Standards, Vol 03.01.

<sup>6</sup> Available from American National Standards Institute, 11 West 42nd St., 13th Floor, New York, NY 10036.



ASME Boiler and Pressure Vessel Code: Section VIII<sup>7</sup>

2.4 *AWS Standard:*

A5.9 Corrosion-Resisting Chromium and Chromium-Nickel Steel Welding Rods and Electrodes<sup>8</sup>

2.5 *Other Standard:*

SAE J1086 Practice for Numbering Metals and Alloys (UNS)<sup>9</sup>

2.6 *Other Standard:*

SNT-TC-1A Personnel Qualification and Certification in Nondestructive Testing<sup>10</sup>

### 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.

<sup>7</sup> Available from American Society for Mechanical Engineers, Three Park Avenue, New York, NY 10016-5990.

<sup>8</sup> Available from the American Welding Society, 550 N.W. LeJeune Rd., Miami, FL 33135.

<sup>9</sup> Available from Society of Automotive Engineers, 400 Commonwealth Drive, Warrendale, PA 15096.

<sup>10</sup> Society for Nondestructive Testing, 1711 Arlingate Plaza, PO Box 28518, Columbus, OH, 43228-0518.

### 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 *Heat Treatment:*

5.2.1 All pipe shall be furnished in the heat-treated condition in accordance with the requirements of Table 2. The heat-treatment procedure, except for “H” grades, S30815, S31272, S31254, S32654, N08367, N08904, and N08926 shall consist of heating the pipe to a minimum temperature of 1900°F [1040°C] and quenching in water or rapidly cooling by other means.

### 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.



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 |
| ...       | S20400                       | 0.030                       | 7.0-9.0   | 0.045              | 0.030  | 1.00      | 15.0-17.0 | 1.50-3.00              | ...        | ...                   | ...       | ...           |
| TP XM-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 | ...           |
| TP XM-10  | S21900                       | 0.08                        | 8.0-10.0  | 0.045              | 0.030  | 1.00      | 19.0-21.5 | 5.5-7.5                | ...        | ...                   | ...       | ...           |
| TP XM-11  | S21904                       | 0.04                        | 8.0-10.0  | 0.045              | 0.030  | 1.00      | 19.0-21.5 | 5.5-7.5                | ...        | ...                   | ...       | ...           |
| TP XM-29  | S24000                       | 0.08                        | 11.5-14.5 | 0.060              | 0.030  | 1.00      | 17.0-19.0 | 2.3-3.7                | ...        | ...                   | ...       | ...           |
| TP 304    | S30400                       | 0.08                        | 2.00      | 0.045              | 0.030  | 1.00      | 18.0-20.0 | 8.0-11.0               | ...        | ...                   | ...       | ...           |
| TP 304L   | S30403                       | 0.035 <sup>D</sup>          | 2.00      | 0.045              | 0.030  | 1.00      | 18.0-20.0 | 8.0-13.0               | ...        | ...                   | ...       | ...           |
| TP 304H   | 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               | ...        | ...                   | ...       | ...           |
| TP 304N   | S30451                       | 0.08                        | 2.00      | 0.045              | 0.030  | 1.00      | 18.0-20.0 | 8.0-18.0               | ...        | ...                   | ...       | ...           |
| TP 304LN  | S30453                       | 0.035                       | 2.00      | 0.045              | 0.030  | 1.00      | 18.0-20.0 | 8.0-12.0               | ...        | ...                   | ...       | ...           |
| ...       | S30600                       | 0.018                       | 2.00      | 0.02               | 0.02   | 3.7-4.3   | 17.0-18.5 | 14.0-15.5              | 0.20       | ...                   | ...       | ...           |
| ...       | S30615                       | 0.16-0.24                   | 2.00      | 0.030              | 0.03   | 3.2-4.0   | 17.0-19.5 | 13.5-16.0              | ...        | ...                   | ...       | ...           |
| ...       | S30815                       | 0.05-0.10                   | 0.80      | 0.040              | 0.030  | 1.40-2.00 | 20.0-22.0 | 10.0-12.0              | ...        | ...                   | ...       | ...           |
| TP 309S   | S30908                       | 0.08                        | 2.00      | 0.045              | 0.030  | 1.00      | 22.0-24.0 | 12.0-15.0              | 0.75       | ...                   | ...       | ...           |
| TP 309H   | S30909                       | 0.04-0.10                   | 2.00      | 0.045              | 0.030  | 1.00      | 22.0-24.0 | 12.0-15.0              | ...        | ...                   | ...       | ...           |
| TP 309Cb  | S30940                       | 0.08                        | 2.00      | 0.045              | 0.030  | 1.00      | 22.0-24.0 | 12.0-16.0              | 0.75       | ...                   | ...       | ...           |
| TP 309HCb | S30941                       | 0.04-0.10                   | 2.00      | 0.045              | 0.030  | 1.00      | 22.0-24.0 | 12.0-16.0              | 0.75       | ...                   | ...       | ...           |
| TP 310S   | S31002                       | 0.015                       | 2.00      | 0.020              | 0.015  | 0.15      | 19.0-22.0 | 24.0-26.0              | 0.10       | ...                   | ...       | ...           |
| TP 310H   | S31008                       | 0.08                        | 2.00      | 0.045              | 0.030  | 1.00      | 24.0-26.0 | 19.0-22.0              | 0.75       | ...                   | ...       | ...           |
| TP 310Cb  | S31009                       | 0.04-0.10                   | 2.00      | 0.045              | 0.030  | 1.00      | 24.0-26.0 | 19.0-22.0              | ...        | ...                   | ...       | ...           |
| TP 310Cb  | S31040                       | 0.08                        | 2.00      | 0.045              | 0.030  | 1.00      | 24.0-26.0 | 19.0-22.0              | 0.75       | ...                   | ...       | ...           |
| TP 310HCb | S31041                       | 0.04-0.10                   | 2.00      | 0.045              | 0.030  | 1.00      | 24.0-26.0 | 19.0-22.0              | 0.75       | ...                   | ...       | ...           |
| ...       | S31050                       | 0.025                       | 2.00      | 0.020              | 0.015  | 0.4       | 24.0-26.0 | 20.5-23.5              | 1.6-2.6    | ...                   | ...       | ...           |
| ...       | S31254                       | 0.020                       | 1.00      | 0.030              | 0.010  | 0.80      | 19.5-20.5 | 17.5-18.5              | 6.0-6.5    | ...                   | ...       | ...           |
| ...       | 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             | ...       | ...           |
| TP 316    | S31600                       | 0.08                        | 2.00      | 0.045              | 0.030  | 1.00      | 16.0-18.0 | 11.0-14.0 <sup>E</sup> | 2.00-3.00  | ...                   | ...       | ...           |
| TP 316L   | 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  | ...                   | ...       | ...           |
| TP 316H   | S31609                       | 0.04-0.10                   | 2.00      | 0.045              | 0.030  | 1.00      | 16.0-18.0 | 11.0-14.0 <sup>E</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)<br>min, 0.70 | ...       | ...           |
| TP 316N   | S31651                       | 0.08                        | 2.00      | 0.045              | 0.030  | 1.00      | 16.0-18.0 | 11.0-14.0 <sup>E</sup> | 2.00-3.00  | ...                   | ...       | ...           |
| TP 316LN  | S31653                       | 0.035                       | 2.00      | 0.045              | 0.030  | 1.00      | 16.0-18.0 | 11.0-14.0 <sup>E</sup> | 2.00-3.00  | ...                   | ...       | ...           |
| TP 317    | S31700                       | 0.08                        | 2.00      | 0.045              | 0.030  | 1.00      | 18.0-20.0 | 11.0-14.0              | 3.0-4.0    | ...                   | ...       | ...           |
| TP 317L   | 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    | ...                   | ...       | ...           |
| ...       | 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    | ...                   | ...       | ...           |
| TP 321    | S32100                       | 0.08                        | 2.00      | 0.045              | 0.030  | 1.00      | 17.0-19.0 | 9.0-12.0               | ...        | ...                   | ...       | ...           |
| TP 321H   | S32109                       | 0.04-0.10                   | 2.00      | 0.045              | 0.030  | 1.00      | 17.0-19.0 | 9.0-12.0               | ...        | ...                   | ...       | ...           |



TABLE 1 Continued

| 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  | ...        | ...       | ...                      | ...           | ...                   | ...      | ...       | ...       | ...   | ...       |
| TP347H  | S34709                       | 0.04–0.10                   | 2.00      | 0.045      | 0.030  | 1.00      | 17.0–19.0 | 9.0–13.0  | ...        | ...       | ...                      | ...           | ...                   | ...      | ...       | ...       | ...   | ...       |
| 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  | ...        | ...       | ...                      | 0.10          | ...                   | ...      | ...       | ...       | ...   | ...       |
| TP348H  | S34809                       | 0.04–0.10                   | 2.00      | 0.045      | 0.030  | 1.00      | 17.0–19.0 | 9.0–13.0  | ...        | ...       | ...                      | 0.10          | ...                   | ...      | ...       | ...       | ...   | ...       |
| .....   | S35045                       | 0.06–0.10                   | 1.50      | ...        | 0.015  | 1.00      | 25.0–29.0 | 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      | 20.0–22.0 | 23.5–25.5 | 6.0–7.0    | ...       | ...                      | ...           | 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.



6.2 *Heat Treatment*—All pipe shall be furnished in the heat-treated condition in accordance with the requirements of Table 2. Alternatively, for seamless pipe, immediately following hot forming while the temperature of the pipes is not less than the specified minimum solution treatment temperature, pipes may be individually quenched in water or rapidly cooled by other means.

### 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.

**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]                        | C                            |
| TP321H, TP347H, TP348H                    |                                        |                              |
| Cold finished                             | 2000°F [1100°C]                        | D                            |
| Hot finished                              | 1925°F [1050°C]                        | D                            |
| TP304H, TP316H                            |                                        |                              |
| Cold finished                             | 1900°F [1040°C]                        | D                            |
| Hot finished                              | 1900°F [1040°C]                        | D                            |
| TP309H, TP309HCb, TP310H, TP310HCb        | 1900°F [1040°C]                        | D                            |
| S30600                                    | 2010–2140°F [1100–1170°C]              | D                            |
| S30815, S31272                            | 1920°F [1050°C]                        | D                            |
| S31254, S32654                            | 2100°F [1150°C]                        | D                            |
| S33228                                    | 2050–2160°F [1120–1180°C]              | D                            |
| S34565                                    | 2050–2140°F [1120–1170°C]              | D                            |
| S35315                                    | 2010°F [1100°C]                        | D                            |
| N08367                                    | 2025°F [1110°C]                        | D                            |
| N08904                                    | 2000°F [1100°C]                        | D                            |
| N08926                                    | 2010°F [1100°C]                        | D                            |

<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.

## 7. Chemical Composition

7.1 The steel shall conform to the requirements as to chemical composition prescribed in Table 2.

## 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  
2 to 5  
6 and over

400 or fraction thereof  
200 or fraction thereof  
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

**TABLE 3 Permitted Variations in Wall Thickness**

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

where:

$t$  = Nominal Wall Thickness

$D$  = Ordered Outside Diameter



TABLE 4 Tensile Requirements

| Grade                                         | UNS Designation | Tensile Strength, min<br>ksi [MPa] | Yield Strength, min<br>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]                         |
| 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                                 | ...                              |

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 NPS10, 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 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 ¼ 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.

**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          |

#### 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

## 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 5.3, 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:

$$R = (W_0 - W) / (B_0 - B)$$

where:

$W_0$  = average weld-metal thickness before the test,

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

$B_0$  = 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 number 1 of the American National Standard for stainless steel pipe (ANSI B36.19).

**TABLE X1.1 Dimensions of Welded and Seamless Stainless Steel Pipe**

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

| NPS<br>Designator | Outside Diameter |        | Nominal Wall Thickness   |      |                           |                   |                    |                   |                    |                    |
|-------------------|------------------|--------|--------------------------|------|---------------------------|-------------------|--------------------|-------------------|--------------------|--------------------|
|                   | in.              | mm     | Schedule 5S <sup>A</sup> |      | Schedule 10S <sup>A</sup> |                   | Schedule 40S       |                   | Schedule 80S       |                    |
|                   |                  |        | in.                      | mm   | in.                       | mm                | in.                | mm                | in.                | mm                 |
| ⅜                 | 0.405            | 10.29  | ...                      | ...  | 0.049                     | 1.24              | 0.068              | 1.73              | 0.095              | 2.41               |
| ¼                 | 0.540            | 13.72  | ...                      | ...  | 0.065                     | 1.65              | 0.088              | 2.24              | 0.119              | 3.02               |
| ⅜                 | 0.675            | 17.15  | ...                      | ...  | 0.065                     | 1.65              | 0.091              | 2.31              | 0.126              | 3.20               |
| ½                 | 0.840            | 21.34  | 0.065                    | 1.65 | 0.083                     | 2.11              | 0.109              | 2.77              | 0.147              | 3.73               |
| ¾                 | 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               |
| 1¼                | 1.660            | 42.16  | 0.065                    | 1.65 | 0.109                     | 2.77              | 0.140              | 3.56              | 0.191              | 4.85               |
| 1½                | 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               |
| 2½                | 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               |
| 3½                | 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              | ...                | ...               | ...                | ...                |

<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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