



Designation: **A790/A790M—13 A790/A790M – 13a**

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

This standard is issued under the fixed designation A790/A790M; 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 ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

## 1. Scope\*

1.1 This specification<sup>2</sup> covers seamless and straight-seam welded ferritic/austenitic steel pipe intended for general corrosive service, with particular emphasis on resistance to stress corrosion cracking. These steels are susceptible to embrittlement if used for prolonged periods at elevated temperatures.

1.2 Optional supplementary requirements are provided for pipe when 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.

1.3 **Appendix X1** of this specification lists the dimensions of welded and seamless stainless steel pipe as shown in ANSI B36.19. Pipe having other dimensions may be furnished provided such pipe complies with all other requirements of this specification.

1.4 The values stated in either SI units or inch-pound units are to be regarded separately as standard. Within the text, the SI units are shown in brackets. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in non-conformance with the standard. The inch-pound units shall apply unless the *M* designation of this specification is specified in the order.

NOTE 1—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:<sup>3</sup>

[A370 Test Methods and Definitions for Mechanical Testing of Steel Products](#)

[A923 Test Methods for Detecting Detrimental Intermetallic Phase in Duplex Austenitic/Ferritic Stainless Steels](#)

[A941 Terminology Relating to Steel, Stainless Steel, Related Alloys, and Ferroalloys](#)

[A999/A999M Specification for General Requirements for Alloy and Stainless Steel Pipe](#)

[E213 Practice for Ultrasonic Testing of Metal Pipe and Tubing](#)

[E309 Practice for Eddy-Current Examination of Steel Tubular Products Using Magnetic Saturation](#)

[E381 Method of Macroetch Testing Steel Bars, Billets, Blooms, and Forgings](#)

[E426 Practice for Electromagnetic \(Eddy-Current\) Examination of Seamless and Welded Tubular Products, Titanium, Austenitic Stainless Steel and Similar Alloys](#)

[E527 Practice for Numbering Metals and Alloys in the Unified Numbering System \(UNS\)](#)

### 2.2 ANSI Standards:<sup>4</sup>

[B1.20.1 Pipe Threads, General Purpose](#)

[B36.10 Welded and Seamless Wrought Steel Pipe](#)

[B36.19 Stainless Steel Pipe](#)

### 2.3 SAE Standard:<sup>5</sup>

[SAE J 1086](#)

<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-790 in Section II of that Code.

<sup>3</sup> For referenced ASTM standards, visit the ASTM website, [www.astm.org](http://www.astm.org), or contact ASTM Customer Service at [service@astm.org](mailto:service@astm.org). For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

<sup>4</sup> Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, <http://www.ansi.org>.

<sup>5</sup> Available from Society of Automotive Engineers (SAE), 400 Commonwealth Dr., Warrendale, PA 15096-0001, <http://www.sae.org>.

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

2.4 *Other Standard:*<sup>6</sup>

[SNT-TC-1A Personal Qualification and Certification in Nondestructive Testing](#)

2.5 *AWS Standard*

[A5.9 Corrosion-Resisting Chromium and Chromium-Nickel Steel Welding Rods and Electrodes](#)

### 3. Terminology

3.1 *Definitions*—For definitions of terms used in this specification refer to Terminology [A941](#).

### 4. Ordering Information

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

4.1.1 Quantity (feet, [metres], or number of lengths),

4.1.2 Name of material (ferritic/austenitic steel pipe),

4.1.3 Process (seamless or welded),

4.1.4 Grade (see [Table 1](#)),

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

4.1.6 Length (specific or random) (see [Section 11](#)),

4.1.7 End finish (section on ends of Specification [A999/A999M](#)),

4.1.8 Optional requirements (product analysis, [Section 9](#); hydrostatic test or nondestructive electric test, [Section 14](#)),

4.1.9 Test report required (section on certification of Specification [A999/A999M](#)),

4.1.10 Specification designation, and

4.1.11 Special requirements and any supplementary requirements selected.

### 5. General Requirements

5.1 Material furnished under this specification shall conform to the applicable requirements of the current edition of Specification [A999/A999M](#) unless otherwise provided herein.

### 6. Materials and Manufacture

6.1 *Manufacture:*

6.1.1 The pipe shall be made by the seamless or an automatic welding process, with no addition of filler metal in the welding operation.

6.1.2 At the manufacturer's option, pipe may be either hot-finished or cold-finished.

6.1.3 The pipe shall be pickled free of scale. When bright annealing is used, pickling is not necessary.

6.2 *Discard*—A sufficient discard shall be made from each ingot to secure freedom from injurious piping and undue segregation.

6.3 Unless otherwise stated in the order, all pipe shall be furnished in the heat-treated condition as shown in [Table 1](#).

6.3.1 For seamless pipe, as an alternate to final heat treatment in a continuous furnace or batch-type furnace, immediately following hot forming while the temperature of the pipes is not less than the specified minimum solution treatment temperature, pipes shall be individually quenched in water or rapidly cooled by other means, except for UNS S32950, which shall be air cooled.

6.3.2 If the purchaser desires pipe without heat treatment subsequent to welding, the purchase order shall specify the following condition:

6.3.2.1 No final heat treatment of pipe fabricated from plate that has been heat treated as required by [Table 1](#) for the particular grade is required, *provided a sample of that heat of finished pipe or material representative of that heat of pipe as a prolongation of the weld passes the Test Methods [A923 Method B or C](#) (See [Note 2](#)), including base metal, weld metal, and heat affected zone per heat. Each pipe supplied under this requirement shall be stenciled with the suffix "HT-O."*

6.3.2.2 For materials not listed in [Table 3](#) of Test Methods [A923](#), the HT-O provision does not apply.

NOTE 2—The Test Methods [A923](#) test method (B or C) is at the manufacturer's option, unless otherwise specified by the purchaser.

### 7. Chemical Composition

7.1 The steel shall conform to the chemical requirements as prescribed in [Table 2](#).

### 8. Heat Analysis

8.1 An analysis of each heat of steel shall be made by the steel manufacturer to determine the percentages of the elements specified.

<sup>6</sup> Available from American Society for Nondestructive Testing (ASNT), P.O. Box 28518, 1711 Arlington Ln., Columbus, OH 43228-0518, <http://www.asnt.org>.

**TABLE 1 Heat Treatment**

| UNS Designation | Type <sup>A</sup> | Temperature °F [°C]      | Quench   |
|-----------------|-------------------|--------------------------|--|
| S31200          |                   | 1920–2010<br>[1050–1100] | Rapid cooling in water                             |
| S31260          |                   | 1870–2010<br>[1020–1100] | Rapid cooling in air or water                      |
| S31500          |                   | 1800–1900<br>[980–1040]  | Rapid cooling in air or water                      |
| S31803          |                   | 1870–2010<br>[1020–1100] | Rapid cooling in air or water                      |
| S32003          |                   | 1850–2050<br>[1010–1120] | Rapid cooling in air or water                      |
| S32101          |                   | 1870 [1020]              | Quenched in water or rapidly cooled by other means |
| S32202          |                   | 1870–1975<br>[1020–1080] | Rapid cooling in air or water                      |
| S32205          | 2205              | 1870–2010<br>[1020–1100] | Rapid cooling in air or water                      |
| S32304          | 2304              | 1700–1920<br>[925–1050]  | Rapid cooling in air or water                      |
| S32506          |                   | 1870–2050<br>[1020–1120] | Rapid cooling in air or water                      |
| S32520          |                   | 1975–2050<br>[1080–1120] | Rapid cooling in air or water                      |
| S32550          | 255               | 1900 [1040] min          | Rapid cooling in air or water                      |
| S32707          |                   | 1975–2050<br>[1080–1120] | Rapid cooling in air or water                      |
| S32750          | 2507              | 1880–2060<br>[1025–1125] | Rapid cooling in air or water                      |
| S32760          |                   | 1960–2085<br>[1070–1140] | Rapid cooling in air or water                      |
| S32808          |                   | 1920–2100<br>[1050–1150] | Rapid cooling in air or water                      |
| S32900          | 329               | 1700–1750<br>[925–955]   | Rapid cooling in air or water                      |
| S32906          |                   | 1870–2100<br>[1020–1150] | Rapid cooling in air or water                      |
| S32950          |                   | 1820–1880<br>[990–1025]  | Air cool   |
| S33207          |                   | 1905–2085<br>[1040–1140] | Rapid cooling in water or by other means           |
| S39274          |                   | 1920–2060<br>[1025–1125] | Rapid cooling in air or water                      |
| S39277          |                   | 1975–2155<br>[1080–1180] | Rapid cooling in air or water                      |
| S81921          |                   | 1760–2010<br>[960–1100]  | Rapid cooling in air or water                      |
| S82011          |                   | 1850–2050<br>[1010–1120] | Rapid cooling in air or water                      |
| S82121          |                   | 1830 [1000]              | Rapid cooling in air or water                      |
| S82441          |                   | 1870 [1020]              | Rapid cooling in air or water                      |

<sup>A</sup>Common name, not a trademark, widely used, not associated with any one producer. 329 is na AISI number.

## 9. Product Analysis

9.1 At the request of the purchaser's inspector, 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, incl   | 200 or fraction thereof |
| 6 and over     | 100 or fraction thereof |

9.2 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.

9.3 If the analysis of one of the tests specified in 8.1 or 9.1 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.

**TABLE 2 Chemical Requirements<sup>A</sup>**

| UNS Designation <sup>B</sup> | Type <sup>C</sup> | C     | Mn        | P     | S     | Si        | Ni        | Cr        | Mo        | N         | Cu        | Others         |
|------------------------------|-------------------|-------|-----------|-------|-------|-----------|-----------|-----------|-----------|-----------|-----------|----------------|
| S31200                       |                   | 0.030 | 2.00      | 0.045 | 0.030 | 1.00      | 5.5–6.5   | 24.0–26.0 | 1.20–2.00 | 0.14–0.20 | ...       | ...            |
| S31260                       |                   | 0.030 | 1.00      | 0.030 | 0.030 | 0.75      | 5.5–7.5   | 24.0–26.0 | 2.5–3.5   | 0.10–0.30 | 0.20–0.80 | W<br>0.10–0.50 |
| S31500                       |                   | 0.030 | 1.20–2.00 | 0.030 | 0.030 | 1.40–2.00 | 4.2–5.2   | 18.0–19.0 | 2.50–3.00 | 0.05–0.10 | ...       | ...            |
| S31803                       |                   | 0.030 | 2.00      | 0.030 | 0.020 | 1.00      | 4.5–6.5   | 21.0–23.0 | 2.5–3.5   | 0.08–0.20 | ...       | ...            |
| S32003                       |                   | 0.030 | 2.00      | 0.030 | 0.020 | 1.00      | 3.0–4.0   | 19.5–22.5 | 1.50–2.00 | 0.14–0.20 | ...       | ...            |
| S32101                       |                   | 0.040 | 4.0–6.0   | 0.040 | 0.030 | 1.00      | 1.35–1.70 | 21.0–22.0 | 0.10–0.80 | 0.20–0.25 | 0.10–0.80 | ...            |
| S32202                       |                   | 0.030 | 2.00      | 0.040 | 0.010 | 1.00      | 1.00–2.80 | 21.5–24.0 | 0.45      | 0.18–0.26 | ...       | ...            |
| S32205                       | 2205              | 0.030 | 2.00      | 0.030 | 0.020 | 1.00      | 4.5–6.5   | 22.0–23.0 | 3.0–3.5   | 0.14–0.20 | ...       | ...            |
| S32304                       | 2304              | 0.030 | 2.50      | 0.040 | 0.040 | 1.00      | 3.0–5.5   | 21.5–24.5 | 0.05–0.60 | 0.05–0.20 | 0.05–0.60 | ...            |
| S32506                       |                   | 0.030 | 1.00      | 0.040 | 0.015 | 0.90      | 5.5–7.2   | 24.0–26.0 | 3.0–3.5   | 0.08–0.20 | ...       | W<br>0.05–0.30 |
| S32520                       |                   | 0.030 | 1.5       | 0.035 | 0.020 | 0.80      | 5.5–8.0   | 24.0–26.0 | 3.0–5.0   | 0.20–0.35 | 0.5–3.00  | ...            |
| S32550                       | 255               | 0.04  | 1.50      | 0.040 | 0.030 | 1.00      | 4.5–6.5   | 24.0–27.0 | 2.9–3.9   | 0.10–0.25 | 1.50–2.50 | ...            |
| S32707                       |                   | 0.030 | 1.50      | 0.035 | 0.010 | 0.50      | 5.5–9.5   | 26.0–29.0 | 4.0–5.0   | 0.30–0.50 | 1.0       | Co<br>0.5–2.0  |
| S32750 <sup>D</sup>          | 2507              | 0.030 | 1.20      | 0.035 | 0.020 | 0.80      | 6.0–8.0   | 24.0–26.0 | 3.0–5.0   | 0.24–0.32 | 0.5       | ...            |
| S32760 <sup>E</sup>          |                   | 0.05  | 1.00      | 0.030 | 0.010 | 1.00      | 6.0–8.0   | 24.0–26.0 | 3.0–4.0   | 0.20–0.30 | 0.50–1.00 | W<br>0.50–1.00 |
| S32808                       |                   | 0.030 | 1.10      | 0.030 | 0.010 | 0.50      | 7.0–8.2   | 27.0–27.9 | 0.80–1.20 | 0.30–0.40 | ...       | W<br>2.10–2.50 |
| S32900                       | 329               | 0.08  | 1.00      | 0.040 | 0.030 | 0.75      | 2.5–5.0   | 23.0–28.0 | 1.00–2.00 | ...       | ...       | ...            |
| S32906                       |                   | 0.030 | 0.80–1.50 | 0.030 | 0.030 | 0.80      | 5.8–7.5   | 28.0–30.0 | 1.50–2.60 | 0.30–0.40 | 0.80      | ...            |
| S32950                       |                   | 0.030 | 2.00      | 0.035 | 0.010 | 0.60      | 3.5–5.2   | 26.0–29.0 | 1.00–2.50 | 0.15–0.35 | ...       | ...            |
| S33207                       |                   | 0.030 | 1.50      | 0.035 | 0.010 | 0.80      | 6.0–9.0   | 29.0–33.0 | 3.0–5.0   | 0.40–0.60 | 1.0       | ...            |
| S39274                       |                   | 0.030 | 1.00      | 0.030 | 0.020 | 0.80      | 6.0–8.0   | 24.0–26.0 | 2.5–3.5   | 0.24–0.32 | 0.20–0.80 | W<br>1.50–2.50 |
| S39277                       |                   | 0.025 | 0.80      | 0.025 | 0.002 | 0.80      | 6.5–8.0   | 24.0–26.0 | 3.0–4.0   | 0.23–0.33 | 1.20–2.00 | W<br>0.8–1.2   |
| S81921                       |                   | 0.030 | 2.00–4.00 | 0.040 | 0.030 | 1.00      | 2.00–4.00 | 19.0–22.0 | 1.00–2.00 | 0.14–0.20 | ...       | ...            |
| S82011                       |                   | 0.030 | 2.0–3.0   | 0.040 | 0.020 | 1.00      | 1.00–2.00 | 20.5–23.5 | 0.10–1.00 | 0.15–0.27 | 0.50      | ...            |
| S82121                       | ...               | 0.035 | 1.00–2.50 | 0.040 | 0.010 | 1.00      | 2.00–4.00 | 21.0–23.0 | 0.30–1.30 | 0.15–0.25 | 0.20–1.20 | ...            |
| S82441                       |                   | 0.030 | 2.5–4.0   | 0.035 | 0.005 | 0.70      | 3.0–4.5   | 23.0–25.0 | 1.00–2.00 | 0.20–0.30 | 0.10–0.80 | ...            |

<sup>A</sup>Maximum, unless a range or minimum is indicated. Where ellipses (...) appear in this table, there is no minimum and analysis for the element need not be determined or reported.

<sup>B</sup>New designation established in accordance with Practice E527 and SAE J 1086.

<sup>C</sup>Common name, not a trademark, widely used, not associated with any one producer. 329 is an AISI number.

<sup>D</sup>% Cr + 3.3 × % Mo + 16 × % N ≥ 41.

<sup>E</sup>% Cr + 3.3 × % Mo + 16 × % N ≥ 40.

## 10. Tensile and Hardness Properties

10.1 The material shall conform to the tensile and hardness properties prescribed in **Table 3**.

## 11. Lengths

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

11.1.1 Unless otherwise agreed upon, all sizes from NPS 1/8 to and including NPS 8 are available in a length up to 24 ft (see **Note 3**) with the permissible range of 15 to 24 ft (see **Note 3**). Short lengths are acceptable and the number and minimum length shall be agreed upon between the manufacturer and the purchaser.

**NOTE 3**—This value 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 purchaser.

11.1.2 If definite cut lengths are desired, the lengths required shall be specified in the order. No pipe shall be less than the specified length and no more than 1/4 in. [6 mm] over it.

11.1.3 No jointers are permitted unless otherwise specified.

## 12. Workmanship, Finish, and Appearance

12.1 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 the Permissible Variations in Wall Thickness Section of Specification **A999/A999M**.

**TABLE 3 Tensile and Hardness Requirements**

| UNS Designation                 | Type <sup>A</sup> | Tensile Strength, min, ksi [MPa] | Yield Strength, min, ksi [MPa] | Elongation in 2 in. or 50 mm, min, % | Hardness, max |     |
|---------------------------------|-------------------|----------------------------------|--------------------------------|--------------------------------------|---------------|-----|
|                                 |                   |                                  |                                |                                      | HBW           | HRC |
| S31200                          |                   | 100 [690]                        | 65 [450]                       | 25                                   | 280           | ... |
| S31260                          |                   | 100 [690]                        | 65 [450]                       | 25                                   | ...           | ... |
| S31500                          |                   | 92 [630]                         | 64 [440]                       | 30                                   | 290           | 30  |
| S31803                          |                   | 90 [620]                         | 65 [450]                       | 25                                   | 290           | 30  |
| S32003                          |                   | 95 [655]                         | 65 [450]                       | 25                                   | 290           | 30  |
| S32101                          |                   |                                  |                                |                                      |               |     |
| t ≤ 0.187 in. [5.00 mm]         |                   | 101 [700]                        | 77 [530]                       | 30                                   | 290           | ... |
| t > 0.187 in. [5.00 mm]         |                   | 94 [650]                         | 65 [450]                       | 30                                   | 290           | ... |
| S32202                          |                   | 94 [650]                         | 65 [450]                       | 30                                   | 290           | 30  |
| S32205                          | 2205              | 95 [655]                         | 65 [450]                       | 25                                   | 290           | 30  |
| S32304                          | 2304              | 87 [600]                         | 58 [400]                       | 25                                   | 290           | 30  |
| S32506                          |                   | 90 [620]                         | 65 [450]                       | 18                                   | 302           | 32  |
| S32520                          |                   | 112 [770]                        | 80 [550]                       | 25                                   | 310           | ... |
| S32550                          | 255               | 110 [760]                        | 80 [550]                       | 15                                   | 297           | 31  |
| S32707                          |                   | 133 [920]                        | 101 [700]                      | 25                                   | 318           | 34  |
| S32750                          | 2507              | 116 [800]                        | 80 [550]                       | 15                                   | 300           | 32  |
| S32760 <sup>B</sup>             |                   | 109 [750]                        | 80 [550]                       | 25                                   | 300           | ... |
| S32808                          |                   | 116 [800]                        | 80 [550]                       | 15                                   | 310           | 32  |
| S32900                          | 329               | 90 [620]                         | 70 [485]                       | 20                                   | 271           | 28  |
| S32906                          |                   |                                  |                                |                                      |               |     |
| t below 0.40 in. [10 mm]        |                   | 116 [800]                        | 94 [650]                       | 25                                   | 300           | 32  |
| t 0.40 in. [10 mm] and above    |                   | 109 [750]                        | 80 [550]                       | 25                                   | 300           | 32  |
| S32950                          |                   | 100 [690]                        | 70 [480]                       | 20                                   | 290           | 30  |
| S33207                          |                   |                                  |                                |                                      |               |     |
| t below 0.157 in. [4 mm]        |                   | 138 [950]                        | 112 [770]                      | 15                                   | 336           | 36  |
| t 0.157 in. [4 mm] and above    |                   | 123 [850]                        | 101 [700]                      | 15                                   | 336           | 36  |
| S39274                          |                   | 116 [800]                        | 80 [550]                       | 15                                   | 310           | 32  |
| S39277                          |                   | 120 [825]                        | 90 [620]                       | 25                                   | 290           | 30  |
| S81921                          |                   | 90 [620]                         | 65 [450]                       | 25                                   | 290           | 30  |
| S82011                          |                   |                                  |                                |                                      |               |     |
| t below 0.187 in. [5.00 mm]     |                   | 101 [700]                        | 75 [515]                       | 30                                   | 293           | 31  |
| t 0.187 in. [5.00 mm] and above |                   | 95 [655]                         | 65 [450]                       | 30                                   | 293           | 31  |
| S82121                          | ...               | 94 [650]                         | 65 [450]                       | 25                                   | 286           | 30  |
| S82441 t < 0.4 inches [10 mm]   |                   | 107 [740]                        | 78 [540]                       | 25                                   | 290           | ... |
| S82441 t > 0.4 inches [10mm]    |                   | 99 [680]                         | 70 [480]                       | 25                                   | 290           | ... |

<sup>A</sup>Common name, not a trademark, widely used, not associated with any one producer. 329 is na AISI number.

<sup>B</sup>Prior to A790/A790M – 04, the tensile strength value for UNS 32760 was 109–130 ksi [750–895 MPa].

### 13. Mechanical Tests Required

13.1 *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 2 pipes for lots of more than 100 pipes.

13.2 *Mechanical Testing Lot Definition*— The term *lot* for mechanical tests applies to all pipe of the same nominal size and wall thickness (or schedule) that is produced from the same heat of steel and subjected to the same finishing treatment as defined as follows:

13.2.1 Where the heat treated condition is obtained, consistent with the requirements of 6.3, in a continuous heat treatment furnace or by directly obtaining the heat treated condition by quenching after hot forming, the lot shall include all pipe of the same size and heat, heat treated in the same furnace at the same temperature, time at heat, and furnace speed or all pipe of the same size and heat, hot formed and quenched in the same production run.

13.2.2 Where final heat treatment is obtained, consistent with the requirements of 6.3, in a batch-type heat-treatment furnace equipped with recording pyrometers and automatically controlled within a 50 °F [30 °C] or smaller range, the lot shall be the larger of (a) each 200 ft [60 m] or fraction thereof or (b) that pipe heat treated in the same batch furnace charge.

13.2.3 Where the final heat treatment is obtained, consistent with the requirements of 6.3, in a batch-type heat-treatment furnace not equipped with recording pyrometers and automatically controlled within a 50 °F [30 °C] or smaller range, the term *lot* for mechanical tests applies to the pipe heat treated in the same batch furnace charge, provided that such pipe is of the same nominal size and wall thickness (or schedule) and is produced from the same heat of steel.

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

13.3.1 For welded pipe with a diameter equal to or exceeding NPS 10, 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 A370. 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 pipes 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.

13.4 *Hardness Test*—Brinell or Rockwell hardness tests shall be made on specimens from two pipes from each lot (see 13.2).

## 14. Hydrostatic or Nondestructive Electric Test

14.1 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.

14.2 The hydrostatic test shall be in accordance with Specification A999/A999M, except that the value for S to be used in the calculation of the hydrostatic test pressure shall be equal to 50 % of the specified minimum yield strength of the pipe.

14.3 *Nondestructive Electric Test*: Nondestructive electric tests shall be in accordance with Practices E213 or E309.

14.3.1 As an alternative to the hydrostatic test, and when specified by the purchaser, each pipe shall be examined with a nondestructive test in accordance with Practices E213 or E309. Unless specifically called out by the purchaser, the selection of the nondestructive electric test will be at the option of the manufacturer. The range of pipe sizes that may be examined by each method shall be subject to the limitations in the scope of the respective practices.

14.3.1.1 The following information is for the benefit of the user of this specification:

14.3.1.2 The reference standards defined in 14.3.1.3-14.3.1.5 are convenient standards for calibration of nondestructive testing equipment. The dimensions of these standards should not be construed as the minimum size imperfection detectable by such equipment.

14.3.1.3 The ultrasonic testing (UT) can be performed to detect both longitudinally and circumferentially oriented defects. It should be recognized that different techniques should be employed to detect differently oriented imperfections. The examination may not detect short, deep, defects.

14.3.1.4 The eddy-current testing (ET) referenced in this specification (see Practice E426) has the capability of detecting significant discontinuities, especially the short abrupt type.

14.3.1.5 A purchaser interested in ascertaining the nature (type, size, location, and orientation) of discontinuities that can be detected in the specific application of these examinations should discuss this with the manufacturer of the tubular product.

14.4 *Time of Examination*—Nondestructive testing for specification acceptance shall be performed after all mechanical processing, heat treatments, and straightening operations. This requirement does not preclude additional testing at earlier stages in the processing.

### 14.5 *Surface Condition*:

14.5.1 All surfaces shall be free of scale, dirt, grease, paint, or other foreign material that could interfere with interpretation of test results. The methods used for cleaning and preparing the surfaces for examination shall not be detrimental to the base metal or the surface finish.

14.5.2 Excessive surface roughness or deep scratches can produce signals that interfere with the test.

### 14.6 *Extent of Examination*:

14.6.1 The relative motion of the pipe and the transducer(s), coil(s), or sensor(s) shall be such that the entire pipe surface is scanned, except as in 14.6.2.

14.6.2 The existence of end effects is recognized and the extent of such effects shall be determined by the manufacturer and, if requested, shall be reported to the purchaser. Other nondestructive tests may be applied to the end areas, subject to agreement between the purchaser and the manufacturer.

14.7 *Operator Qualifications*—The test unit operator shall be certified in accordance with SNT-TC-1A, or an equivalent recognized and documented standard.