



Designation: A790/A790M – 23

## 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.

1.5 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

<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.

Current edition approved May 1, 2023. Published May 2023. Originally approved in 1981. Last previous edition approved in 2022 as A790/A790M – 22. DOI: 10.1520/A0790\_A0790M-23.

<sup>2</sup> For ASME Boiler and Pressure Vessel Code applications see related Specification SA-790 in Section II of that Code.

### 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

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

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

<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>.

<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>.

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



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 water or by other means |
| S31500          |                   | 1800–1900<br>[980–1040]  | Rapid cooling in water or by other means |
| S31803          |                   | 1870–2010<br>[1020–1100] | Rapid cooling in water or by other means |
| S32003          |                   | 1850–2050<br>[1010–1120] | Rapid cooling in water or by other means |
| S32101          |                   | 1870 [1020]              | Rapid cooling in water or by other means |
| S32202          |                   | 1870–1975<br>[1020–1080] | Rapid cooling in water or by other means |
| S32205          | 2205              | 1870–2010<br>[1020–1100] | Rapid cooling in water or by other means |
| S32304          | 2304              | 1700–1920<br>[925–1050]  | Rapid cooling in water or by other means |
| S32506          |                   | 1870–2050<br>[1020–1120] | Rapid cooling in water or by other means |
| S32520          |                   | 1975–2050<br>[1080–1120] | Rapid cooling in water or by other means |
| S32550          | 255               | 1900 [1040] min          | Rapid cooling in water or by other means |
| S32707          |                   | 1975–2050<br>[1080–1120] | Rapid cooling in water or by other means |
| S32750          | 2507              | 1880–2060<br>[1025–1125] | Rapid cooling in water or by other means |
| S32760          |                   | 1960–2085<br>[1070–1140] | Rapid cooling in water or by other means |
| S32808          |                   | 1920–2100<br>[1050–1150] | Rapid cooling in water or by other means |
| S32900          | 329               | 1700–1750<br>[925–955]   | Rapid cooling in water or by other means |
| S32906          |                   | 1870–2100<br>[1020–1150] | Rapid cooling in water or by other means |
| 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>[1050–1125] | Rapid cooling in water or by other means |
| S39277          |                   | 1975–2155<br>[1080–1180] | Rapid cooling in water or by other means |
| S81921          |                   | 1760–2010<br>[960–1100]  | Rapid cooling in water or by other means |
| S82011          |                   | 1850–2050<br>[1010–1120] | Rapid cooling in water or by other means |
| S82121          |                   | 1830–2010<br>[1000–1100] | Rapid cooling in water or by other means |
| S82441          |                   | 1870 [1020]              | Rapid cooling in water or by other means |
| S83071          | ...               | 1830–2100<br>[1000–1150] | Rapid cooling in water or by other means |

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

## 2.5 AWS Standard:<sup>7</sup>

### 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),

<sup>7</sup> Available from American Welding Society (AWS), 550 NW LeJeune Rd., Miami, FL 33126, <http://www.aws.org>.



- 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.

## 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.

## 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.

## 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



## A790/A790M – 23

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>          |                   | 0.030 | 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 | ...            |
| S83071                       | ...               | 0.030 | 0.50–1.50 | 0.030 | 0.020 | 0.50      | 6.0–8.0   | 29.0–31.0 | 3.0–4.0   | 0.28–0.40 | 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 + 0.5 %W) + 16 × % N ≥ 41.

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

**A790/A790M – 23****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                  |                   |                                  |                                |                                      |               |     |
| t ≤ 0.187 in. [5.00 mm] |                   | 100 [690]                        | 70 [485]                       | 25                                   | 290           | 30  |
| t > 0.187 in. [5.00 mm] |                   | 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                                   | 310           | 32  |
| S32808                  |                   |                                  |                                |                                      |               |     |
| t < 0.40 in. [10 mm]    |                   | 116 [800]                        | 80 [550]                       | 15                                   | 310           | 32  |
| t ≥ 0.40 in. [10 mm]    |                   | 101 [700]                        | 72 [500]                       | 15                                   | 310           | 32  |
| S32900                  | 329               | 90 [620]                         | 70 [485]                       | 20                                   | 271           | 28  |
| S32906                  |                   |                                  |                                |                                      |               |     |
| t < 0.40 in. [10 mm]    |                   | 116 [800]                        | 94 [650]                       | 25                                   | 300           | 32  |
| t ≥ 0.40 in. [10 mm]    |                   | 109 [750]                        | 80 [550]                       | 25                                   | 300           | 32  |
| S32950                  |                   | 100 [690]                        | 70 [480]                       | 20                                   | 290           | 30  |
| S33207                  |                   |                                  |                                |                                      |               |     |
| t < 0.157 in. [4 mm]    |                   | 138 [950]                        | 112 [770]                      | 15                                   | 336           | 36  |
| t ≥ 0.157 in. [4 mm]    |                   | 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 < 0.187 in. [5.00 mm] |                   | 101 [700]                        | 75 [515]                       | 30                                   | 293           | 31  |
| t ≥ 0.187 in. [5.00 mm] |                   | 95 [655]                         | 65 [450]                       | 30                                   | 293           | 31  |
| S82121                  | ...               | 94 [650]                         | 65 [450]                       | 25                                   | 286           | 30  |
| S82441                  |                   |                                  |                                |                                      |               |     |
| t < 0.4 in. [10 mm]     |                   | 107 [740]                        | 78 [540]                       | 25                                   | 290           | ... |
| t ≥ 0.4 in. [10 mm]     |                   | 99 [680]                         | 70 [480]                       | 25                                   | 290           | ... |
| S83071                  | ...               | 120 [830]                        | 98 [680]                       | 25                                   | 300           | 32  |

<sup>A</sup> Common name, not a trademark, widely used, not associated with any one producer. 329 is an AISI number.<sup>B</sup> Prior to A790/A790M – 04, the tensile strength value for UNS 32760 was 109–130 ksi [750–895 MPa].

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, 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**. For welded pipe with a specified wall thickness  $\geq \frac{3}{8}$  in. [9.52 mm], two side bend tests may be made instead of the face bend test. 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.

#### **14.8 Test Conditions:**

14.8.1 For eddy-current testing, the excitation coil frequency shall be chosen to ensure adequate penetration yet provide good signal-to-noise ratio.

14.8.2 The maximum eddy-current coil frequency used shall be as follows:

- On specified walls up to 0.050 in.—100 KHz max
- On specified walls up to 0.150 in.—50 KHz max
- On specified walls over 0.150 in.—10 KHz max

14.8.3 *Ultrasonic*—For examination by the ultrasonic method, the minimum nominal transducer frequency shall be 2.00 MHz and the maximum nominal transducer size shall be 1.5 in. If the equipment contains a reject notice filter setting, this shall remain off during calibration and testing unless linearity can be demonstrated at that setting.

14.9 *Reference Standards*—Reference standards of convenient length shall be prepared from a length of pipe of the same grade, size (NPS, or outside diameter and schedule or wall thickness), surface finish and heat treatment condition as the pipe to be examined.

14.9.1 *For Ultrasonic Testing*, the reference ID and OD notches shall be any one of the three common notch shapes shown in Practice **E213**, at the option of the manufacturer. The depth of each notch shall not exceed  $12 \frac{1}{2}$  % of the specified nominal wall thickness of the pipe or 0.004 in., whichever is greater. The width of the notch shall not exceed twice the depth. Notches shall be placed on both the OD and ID surfaces.

14.9.2 *For Eddy-Current Testing*, the reference standard shall contain, at the option of the manufacturer, any one of the following discontinuities:

14.9.2.1 *Drilled Hole*—The reference standard shall contain three or more holes equally spaced circumferentially around

the pipe and longitudinally separated by a sufficient distance to allow distinct identification of the signal from each hole. The holes shall be drilled radially and completely through the pipe wall, with care being taken to avoid distortion of the pipe while drilling. One hole shall be drilled in the weld, if visible. Alternately, the producer of welded pipe may choose to drill one hole in the weld and run the calibration standard through the test coils three times with the weld turned at 120° on each pass. The hole diameter shall vary with NPS as follows:

| NPS Designator | Hole Diameter      |
|----------------|--------------------|
| above ½ to 1¼  | 0.039 in. [1 mm]   |
| above 1¼ to 2  | 0.055 in. [1.4 mm] |
| above 2 to 5   | 0.071 in. [1.8 mm] |
| above 5        | 0.087 in. [2.2 mm] |
|                | 0.106 in. [2.7 mm] |

**14.9.2.2 Transverse Tangential Notch**—Using a round tool or file with a ¼-in. [6.4-mm] diameter, a notch shall be filed or milled tangential to the surface and transverse to the longitudinal axis of the pipe. Said notch shall have a depth not exceeding 12 ½ % of the specified nominal wall thickness of the pipe or 0.004 in. [0.102 mm], whichever is greater.

**14.9.2.3 Longitudinal Notch**—A notch 0.031 in. or less in width shall be machined in a radial plane parallel to the tube axis on the outside surface of the pipe to have a depth not exceeding 12 ½ % of the specified wall thickness of the pipe or 0.004 in., whichever is greater. The length of the notch shall be compatible with the testing method.

More or smaller reference discontinuities, or both, may be used by agreement between the purchaser and the manufacturer.

#### 14.10 Standardization Procedure:

**14.10.1** The test apparatus shall be standardized at the beginning and end of each series of pipes of the same size (NPS or diameter and schedule or wall thickness, grade, and heat treatment condition), and at intervals not exceeding 4 h. More frequent standardization may be performed at the manufacturer's option or may be required upon agreement between the purchaser and the manufacturer.

**14.10.2** The test apparatus shall also be standardized after any change in test system settings, change of operator, equipment repair, or interruption due to power loss, process shutdown, or when a problem is suspected.

**14.10.3** The reference standard shall be passed through the test apparatus at the same speed and test system settings as the pipe to be tested.

**14.10.4** The signal-to-noise ratio for the reference standard shall be 2½ to 1 or greater. Extraneous signals caused by identifiable causes such as dings, scratches, dents, straightener marks, and so forth shall not be considered noise. The rejection amplitude shall be adjusted to be at least 50 % of full scale of the readout display.

**14.10.5** If upon any standardization, the rejection amplitude has decreased by 29 % (3 dB) of peak height from the last standardization, the pipe since the last calibration shall be rejected. The test system settings may be changed or the transducer(s), coil(s), or sensor(s) adjusted and the unit restandardized. But all pipe tested since the last acceptable standardization must be retested for acceptance.

#### 14.11 Evaluation of Imperfections:

**14.11.1** Pipes producing a signal equal to or greater than the lowest signal produced by the reference standard(s) shall be identified and separated from the acceptable pipes. The area producing the signal may be reexamined.

**14.11.2** Such pipes shall be rejected if the test signal was produced by imperfections that cannot be identified or was produced by cracks or crack-like imperfections. These pipes may be repaired per Sections 12 and 13. To be accepted, a repaired pipe must pass the same non-destructive test by which it was rejected, and it must meet the minimum wall thickness requirements of this specification.

**14.11.3** If the test signals were produced by visual imperfections such as: (1) scratches, (2) surface roughness, (3) dings, (4) straightener marks, (5) cutting chips, (6) steel die stamps, (7) stop marks, or (8) pipe reducer ripple. The pipe may be accepted based on visual examination, provided the imperfection is less than 0.004 in. [0.1 mm] or 12 ½ % of the specified wall thickness (whichever is greater).

**14.11.4** Rejected pipe may be reconditioned and retested providing the wall thickness is not decreased to less than that required by this or the product specification. The outside diameter at the point of grinding may be reduced by the amount so removed. To be accepted, retested pipe shall meet the test requirement.

**14.11.5** If the imperfection is explored to the extent that it can be identified as non-rejectable, the pipe may be accepted without further test providing the imperfection does not encroach on the minimum wall thickness.

### 15. Repair by Welding

**15.1** For welded pipe of size NPS 6 or larger with a specified wall thickness of 0.188 in. [4.8 mm] or more, 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 A999/A999M.

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

**15.3** Except as allowed by 15.3.1, 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 pipe being repaired as given in Table 4.

**15.3.1** Subject to approval by the purchaser, it shall be permissible for weld repairs to be made with the gas tungsten-arc welding process using a filler metal more highly alloyed than the base metal, if needed for corrosion resistance or other properties.

**15.4** Pipes that have had weld seam repairs with filler metal shall be identified with the symbol "WR" and shall be so stated

**TABLE 4 Pipe and Filler Metal Specification**

| Pipe<br>UNS Designation | Filler Metal   |                 |
|-------------------------|----------------|-----------------|
|                         | AWS A5.9 Class | UNS Designation |
| S31803                  | ER2209         | S39209          |
| S32205                  | ER2209         | S39209          |
| S31200                  | ER2553         | S39553          |
| S82441                  | ER2209         | S39209          |



and identified on the certificate of tests. If filler metal other than that listed in **Table 4** is used, the filler metal shall be identified on the certificate of tests.

15.5 Weld repairs shall be completed prior to any heat treatment.

## **16. Product Marking**

16.1 In addition to the marking prescribed in Specification **A999/A999M**, the marking shall include the manufacturer's

private identifying mark and whether the pipe is seamless or welded. If specified in the purchase order, the marking for pipe larger than NPS 4 shall include the weight.

## **17. Keywords**

17.1 duplex stainless steel; ferritic/austenitic stainless steel; seamless steel pipe; stainless steel pipe; steel pipe; welded steel pipe

# **SUPPLEMENTARY REQUIREMENTS**

## **FOR PIPE REQUIRING SPECIAL CONSIDERATION**

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 over NPS 5 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 over NPS 8.

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 **A999/A999M** shall be made on a specimen from one end or both ends of each pipe. Crops 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 **A999/A999M** 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 **E381**. 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.



# A790/A790M – 23

## APPENDIX

(Nonmandatory Information)

**X1. Table X1.1 IS BASED ON TABLE 1 OF THE AMERICAN NATIONAL STANDARD FOR STAINLESS STEEL PIPE (ANSI B36.19-1965)**

**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                 |
| ⅛                 | 0.405            | 10.29  | ...                      | ...  | 0.049 <sup>B</sup>        | 1.24 | 0.068              | 1.73              | 0.095              | 2.41               |
| ¼                 | 0.540            | 13.72  | ...                      | ...  | 0.065 <sup>B</sup>        | 1.65 | 0.088              | 2.24              | 0.119              | 3.02               |
| ⅜                 | 0.675            | 17.15  | ...                      | ...  | 0.065 <sup>B</sup>        | 1.65 | 0.091              | 2.31              | 0.126              | 3.20               |
| ½                 | 0.840            | 21.34  | 0.065 <sup>B</sup>       | 1.65 | 0.083 <sup>B</sup>        | 2.11 | 0.109              | 2.77              | 0.147              | 3.73               |
| ¾                 | 1.050            | 26.67  | 0.065 <sup>B</sup>       | 1.65 | 0.083 <sup>B</sup>        | 2.11 | 0.113              | 2.87              | 0.154              | 3.91               |
| 1.0               | 1.315            | 33.40  | 0.065 <sup>B</sup>       | 1.65 | 0.109 <sup>B</sup>        | 2.77 | 0.133              | 3.38              | 0.179              | 4.55               |
| 1¼                | 1.660            | 42.16  | 0.065 <sup>B</sup>       | 1.65 | 0.109 <sup>B</sup>        | 2.77 | 0.140              | 3.56              | 0.191              | 4.85               |
| 1½                | 1.900            | 48.26  | 0.065 <sup>B</sup>       | 1.65 | 0.109 <sup>B</sup>        | 2.77 | 0.145              | 3.68              | 0.200              | 5.08               |
| 2                 | 2.375            | 60.33  | 0.065 <sup>B</sup>       | 1.65 | 0.109 <sup>B</sup>        | 2.77 | 0.154              | 3.91              | 0.218              | 5.54               |
| 2½                | 2.875            | 73.03  | 0.083                    | 2.11 | 0.120 <sup>B</sup>        | 3.05 | 0.203              | 5.16              | 0.276              | 7.01               |
| 3                 | 3.500            | 88.90  | 0.083                    | 2.11 | 0.120 <sup>B</sup>        | 3.05 | 0.216              | 5.49              | 0.300              | 7.62               |
| 3½                | 4.000            | 101.60 | 0.083                    | 2.11 | 0.120 <sup>B</sup>        | 3.05 | 0.226              | 5.74              | 0.318              | 8.08               |
| 4                 | 4.500            | 114.30 | 0.083                    | 2.11 | 0.120 <sup>B</sup>        | 3.05 | 0.237              | 6.02              | 0.337              | 8.56               |
| 5                 | 5.563            | 141.30 | 0.109 <sup>B</sup>       | 2.77 | 0.134 <sup>B</sup>        | 3.40 | 0.258              | 6.55              | 0.375              | 9.52               |
| 6                 | 6.625            | 168.28 | 0.109                    | 2.77 | 0.134 <sup>B</sup>        | 3.40 | 0.280              | 7.11              | 0.432              | 10.97              |
| 8                 | 8.625            | 219.08 | 0.109 <sup>B</sup>       | 2.77 | 0.148 <sup>B</sup>        | 3.76 | 0.322              | 8.18              | 0.500              | 12.70              |
| 10                | 10.750           | 273.05 | 0.134 <sup>B</sup>       | 3.40 | 0.165 <sup>B</sup>        | 4.19 | 0.365              | 9.27              | 0.500 <sup>B</sup> | 12.70 <sup>B</sup> |
| 12                | 12.750           | 323.85 | 0.156 <sup>B</sup>       | 3.96 | 0.180 <sup>B</sup>        | 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 <sup>B</sup>       | 3.96 | 0.188                     | 4.78 | ...                | ...               | ...                | ...                |
| 16                | 16.000           | 406.40 | 0.165 <sup>B</sup>       | 4.19 | 0.188                     | 4.78 | ...                | ...               | ...                | ...                |
| 18                | 18.000           | 457.20 | 0.165 <sup>B</sup>       | 4.19 | 0.188                     | 4.78 | ...                | ...               | ...                | ...                |
| 20                | 20.000           | 508.00 | 0.188 <sup>B</sup>       | 4.78 | 0.218 <sup>B</sup>        | 5.54 | ...                | ...               | ...                | ...                |
| 22                | 22.000           | 558.80 | 0.188 <sup>B</sup>       | 4.78 | 0.218 <sup>B</sup>        | 5.54 | ...                | ...               | ...                | ...                |
| 24                | 24.000           | 609.60 | 0.218 <sup>B</sup>       | 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).

## SUMMARY OF CHANGES

Committee A01 has identified the location of selected changes to this standard since the last issue (A790/A790M – 22) that may impact the use of this standard. (Approved May 1, 2023.)

(1) Revised 13.3.1.

Committee A01 has identified the location of selected changes to this standard since the last issue (A790/A790M – 20) that may impact the use of this standard. (Approved March 1, 2022.)

(1) Revised quench method wording in Table 1 to allow for rapid cooling by other means than just air or water.



## **A790/A790M – 23**

*ASTM International takes no position respecting the validity of any patent rights asserted in connection with any item mentioned in this standard. Users of this standard are expressly advised that determination of the validity of any such patent rights, and the risk of infringement of such rights, are entirely their own responsibility.*

*This standard is subject to revision at any time by the responsible technical committee and must be reviewed every five years and if not revised, either reapproved or withdrawn. Your comments are invited either for revision of this standard or for additional standards and should be addressed to ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee, which you may attend. If you feel that your comments have not received a fair hearing you should make your views known to the ASTM Committee on Standards, at the address shown below.*

*This standard is copyrighted by ASTM International, 100 Barr Harbor Drive, PO Box C700, West Conshohocken, PA 19428-2959, United States. Individual reprints (single or multiple copies) of this standard may be obtained by contacting ASTM at the above address or at 610-832-9585 (phone), 610-832-9555 (fax), or [service@astm.org](mailto:service@astm.org) (e-mail); or through the ASTM website ([www.astm.org](http://www.astm.org)). Permission rights to photocopy the standard may also be secured from the Copyright Clearance Center, 222 Rosewood Drive, Danvers, MA 01923, Tel: (978) 646-2600; <http://www.copyright.com/>*





# INTERNATIONAL STANDARD

**ISO  
2577**

Third edition  
2007-12-15

---

## **Plastics — Thermosetting moulding materials — Determination of shrinkage**

*Plastiques — Matières à mouler thermodurcissables — Détermination  
du retrait*



Reference number  
ISO 2577:2007(E)

**PDF disclaimer**

This PDF file may contain embedded typefaces. In accordance with Adobe's licensing policy, this file may be printed or viewed but shall not be edited unless the typefaces which are embedded are licensed to and installed on the computer performing the editing. In downloading this file, parties accept therein the responsibility of not infringing Adobe's licensing policy. The ISO Central Secretariat accepts no liability in this area.

Adobe is a trademark of Adobe Systems Incorporated.

Details of the software products used to create this PDF file can be found in the General Info relative to the file; the PDF-creation parameters were optimized for printing. Every care has been taken to ensure that the file is suitable for use by ISO member bodies. In the unlikely event that a problem relating to it is found, please inform the Central Secretariat at the address given below.



**COPYRIGHT PROTECTED DOCUMENT**

© ISO 2007

All rights reserved. Unless otherwise specified, no part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from either ISO at the address below or ISO's member body in the country of the requester.

ISO copyright office  
Case postale 56 • CH-1211 Geneva 20  
Tel. + 41 22 749 01 11  
Fax + 41 22 749 09 47  
E-mail [copyright@iso.org](mailto:copyright@iso.org)  
Web [www.iso.org](http://www.iso.org)

Published in Switzerland

## Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 2577 was prepared by Technical Committee ISO/TC 61, *Plastics*, Subcommittee SC 12, *Thermosetting materials*.

This third edition cancels and replaces the second edition (ISO 2577:1984), which has been technically revised.

Copyright International Organization for Standardization  
Provided by IHS under license with ISO  
No reproduction or networking permitted without license from IHS

# Plastics — Thermosetting moulding materials — Determination of shrinkage

## 1 Scope

This International Standard specifies a method of determining the moulding shrinkage and the shrinkage after heat treatment of moulded test specimens of thermosetting moulding materials.

These characteristics are useful for the production control of thermosetting material and for checking uniformity of manufacture. Furthermore, knowledge of the initial shrinkage of thermosetting materials is important for the construction of moulds, and knowledge of post-shrinkage for establishing the suitability of the moulding material for the manufacture of moulded pieces with accurate dimensions.

## 2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 295, *Plastics — Compression moulding of test specimens of thermosetting materials*

ISO 10724-1, *Plastics — Injection moulding of test specimens of thermosetting powder moulding compounds (PMCs) — Part 1: General principles and moulding of multipurpose test specimens*

ISO 10724-2, *Plastics — Injection moulding of test specimens of thermosetting powder moulding compounds (PMCs) — Part 2: Small plates*

## 3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

### 3.1

#### **moulding shrinkage**

difference in dimensions between a moulding and the mould cavity in which it was moulded, both the mould and the moulding being at normal temperature when measured

### 3.2

#### **post-shrinkage**

shrinkage of a plastic product after moulding, during post-treatment, storage or use

## 4 Apparatus

**4.1 Mould, press, etc.,** suitable for moulding the test specimens specified in Clause 6. For compression moulding, a positive or a semi-positive mould with single or multiple cavities shall be used. For injection moulding, the type D2 ISO mould, giving 60 mm × 60 mm × 2 mm specimens, as specified in ISO 10724-2:1998, Clause 4, shall be used.

If required, marks may be engraved in the mould near opposite ends of the specimen to facilitate the accurate measurement of the length of the cavity and the specimens.

**NOTE** If multiple cavities are used with a positive mould, resulting variations in test specimen density may be sufficient to produce inconsistent shrinkage.

**4.2 Equipment**, suitable for measuring the lengths of the test specimen and the corresponding cavity of the mould to within 0,02 mm.

**4.3 Oven** (for post-shrinkage only).

## 5 Sampling

A representative sample shall be taken from the moulding material and be kept at room temperature in airtight containers, without any conditioning, until moulded into test specimens.

## 6 Test specimens

**6.1** The test specimens shall be:

- a) for compression moulding — bars of length 120 mm, width 15 mm and thickness 10 mm;
- b) for injection moulding — flat square plates measuring approximately 60 mm × 60 mm × 2 mm.

**6.2** The specimens shall be moulded to shape by compression or injection moulding using a mould with single or multiple cavities.

## 7 Procedure

**7.1** If not already known, measure the lengths of the cavities (or the distances between the engraved marks in the mould) to the nearest 0,02 mm at a temperature of  $23\text{ °C} \pm 2\text{ °C}$ .

Record these measurements for use in the calculation of shrinkage.

From time to time, moulds should be checked for wear, etc. As an alternative to measuring directly the lengths of the cold moulds, the gauge for the moulds may be obtained very precisely by cold-moulding specimens from lead and measuring their lengths.

**7.2** Mould at least two specimens from the sample to be tested, under the conditions given below:

- a) For compression moulding:

Mould the specimens under the conditions of pressure, temperature, time, etc., specified in ISO 295 or in the relevant specification for the material.

- b) For injection moulding:

Mould the specimens under the conditions specified in ISO 10724-2:1998, Clause 5, and ISO 10724-1.

In the case of fibrous materials that are to be injection-moulded as a plate, at least four specimens shall be tested.

**7.3** After removal from the mould, allow the test specimens to cool to room temperature by placing them on a material with low thermal conductivity and under an appropriate load to avoid warping. Store them at a

temperature of  $23\text{ }^{\circ}\text{C} \pm 2\text{ }^{\circ}\text{C}$  and a relative humidity of 45 % to 55 % for between 16 h and 72 h, or for such shorter time as can be shown to give the same test results.

**7.4** Before measuring the lengths of the test specimens, place them on a flat surface or against a straight edge in order to determine any warp or distortion. Any test specimen that has a warp exceeding 1 % of its length shall be discarded.

**7.5** For the determination of moulding shrinkage, measure, to the nearest 0,02 mm, the lengths of bar specimens parallel to their major axis between opposite end faces or the distances between the gauge marks, at a temperature of  $23\text{ }^{\circ}\text{C} \pm 2\text{ }^{\circ}\text{C}$ . Measurement of plate specimens shall be made at distance of 20 mm from the corners, making two measurements in the same direction.

**NOTE** In order to measure the effect of orientation on the shrinkage of an injection-moulded specimen, shrinkages in two directions at right-angles (each of which is calculated from an average of two measurements in the same direction) are measured and calculated independently.

**7.6** For the determination of post-shrinkage, place the test specimens, measured as described in 7.5, in an oven maintained at the temperature given below. Support the specimens to avoid deformation and in such a way that they are separated from each other.

The heating temperatures shall be:

80  $^{\circ}\text{C} \pm 2\text{ }^{\circ}\text{C}$  for urea-formaldehyde moulding materials;

110  $^{\circ}\text{C} \pm 3\text{ }^{\circ}\text{C}$  for all other thermosetting moulding materials.

The times of exposure shall be:

48 h  $\pm$  1 h for rapid determination;

168 h  $\pm$  2 h for normal determination.

Post-shrinkage depends strongly on the time of exposure. Therefore the exposure time shall be noted [see 8.2 and Clause 9, item f)] and shall be as specified in the specification for the material.

At the end of the heating period, remove the test specimens from the oven and allow them to cool in a standard atmosphere of  $23\text{ }^{\circ}\text{C} \pm 2\text{ }^{\circ}\text{C}$  and a relative humidity of 45 % to 55 % for at least 3 h.

After the cooling period, measure the test specimens again, at a temperature of  $23\text{ }^{\circ}\text{C} \pm 2\text{ }^{\circ}\text{C}$ , to the nearest 0,02 mm, as specified in 7.5.

## 8 Expression of results

**8.1** The moulding shrinkage (MS) is given, as a percentage, by the equation:

$$\text{MS} = \frac{L_0 - L_1}{L_0} \times 100$$

where

$L_0$  is the length, in millimetres, of the dimension of the mould, determined as in 7.1;

$L_1$  is the length, in millimetres, of the corresponding dimension measured on the test specimen in accordance with 7.5.

**NOTE** When shrinkage is being determined using injection-moulded plates,  $L_0$  and  $L_1$  are each the average of two readings, measured in the same direction, taken 20 mm from the corners of the mould and the test specimen, respectively.

**8.2** Post-shrinkage (PS) is given, as a percentage, by the equation:

$$PS_{48\text{ h}} \text{ or } PS_{168\text{ h}} = \frac{L_1 - L_2}{L_1} \times 100$$

where

$L_1$  is as defined in 8.1;

$L_2$  is the length, in millimetres, of the same dimension of the test specimen, measured after heat treatment for 48 h or 168 h in accordance with 7.6.

**NOTE** When post-shrinkage is being determined using injection-moulded plates,  $L_2$  is the average of two readings, measured in the same direction, taken 20 mm from the corners of the test specimen.

## 9 Test report

The test report shall include the following particulars:

- a) a reference to this International Standard;
- b) the grade and designation of the moulding material;
- c) the type of test specimen used (bar or plate);
- d) the method of moulding the specimens (compression or injection) and the moulding conditions;
- e) the number of test specimens discarded because of excessive warping;
- f) the conditions of heat treatment for the determination of post-shrinkage;
- g) the moulding shrinkage (MS) and the post-shrinkage ( $PS_{48\text{ h}}$  and/or  $PS_{168\text{ h}}$ ), as a percentage, including the individual values, the arithmetic mean and, for injection-moulded plates, the direction of measurement with respect to the direction of injection;
- h) the dates of moulding the test specimens, measurement of moulding shrinkage, post-shrinkage heat treatment, and measurement of post-shrinkage.

www.iso.org/standard/54442.html

www.iso.org

---

## ICS 83.080.10

Price based on 4 pages