



# A999/A999M-23

## Standard Specification for General Requirements for Alloy and Stainless Steel Pipe

This standard is issued under the fixed designation A999/A999M; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

### 1. Scope\*

1.1 This specification<sup>2</sup> covers a group of general requirements that, unless otherwise specified in an individual specification, shall apply to the ASTM product specifications noted below.

1.2 In the case of conflict between a requirement of a product specification and a requirement of this specification, the product specification shall prevail. In the case of conflict between a requirement of the product specification or a requirement of this specification and a more stringent requirement of the purchase order, the purchase order shall prevail.

Title of Specification	ASTM Designation <sup>3</sup>
Seamless, Welded, and Heavily Cold Worked Austenitic Stainless Steel Pipes	A312/A312M
Seamless and Welded Steel Pipe for Low-Temperature Service and Other Applications with Required Notch Toughness	A333/A333M
Seamless Ferritic Alloy-Steel Pipe for High Temperature Service	A335/A335M
Electric-Fusion-Welded Austenitic Chromium-Nickel Stainless Steel Pipe for High-Temperature Service and General Applications	A358/A358M
Carbon and Ferritic Alloy Steel Forged and Bored Pipe for High-Temperature Service	A369/A369M
Seamless Austenitic Steel Pipe for High-Temperature Service	A376/A376M
Welded Large Diameter Austenitic Steel Pipe for Corrosive or High-Temperature Service	A409/A409M
Centrifugally Cast Ferritic Alloy Steel Pipe for High-Temperature Service	A426/A426M
Centrifugally Cast Austenitic Steel Pipe for High-Temperature Service	A451/A451M
Centrifugally Cast Iron-Chromium-Nickel High-Alloy Tubing for Pressure Application at High Temperatures	A608/A608M
Welded, Unannealed Austenitic Stainless Steel Tubular Products	A778/A778M
Seamless and Welded Ferritic/Austenitic Stainless Steel Pipe	A790/A790M

<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 999 in Section II of that Code.

<sup>3</sup> These designations refer to the latest issue of the respective specifications. See *Annual Book of ASTM Standards*, Vol 01.01.

Single- or Double-Welded Austenitic Stainless Steel Pipe	A813/A813M
Cold-Worked Welded Austenitic Stainless Steel Pipe	A814/A814M
Centrifugally Cast Ferritic/Austenitic Stainless Steel Pipe for Corrosive Environments	A872/A872M
Ferritic/Austenitic (Duplex) Stainless Steel Pipe Electric Fusion Welded with Addition of Filler Metal	A928/A928M
Spray-Formed Seamless Austenitic Stainless Steel Pipes	A943/A943M
Spray-Formed Seamless Ferritic/Austenitic Stainless Steel Pipe	A949/A949M
Austenitic Chromium-Nickel-Silicon Alloy Steel Seamless and Welded Pipe	A954

1.3 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 apply unless the “M” designation (SI) of the product specification is specified in the order.

NOTE 1—The dimensionless designator NPS (nominal pipe size) is used in this standard for such traditional terms as “nominal diameter,” “size,” “nominal bore,” and “nominal size.”

1.4 The following precautionary statement pertains only to the test method portion, Section 21, of this specification: *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

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.*

### 2. Referenced Documents

#### 2.1 ASTM Standards:<sup>4</sup>

- A312/A312M Specification for Seamless, Welded, and Heavily Cold Worked Austenitic Stainless Steel Pipes
- A333/A333M Specification for Seamless and Welded Steel

<sup>4</sup> For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard’s Document Summary page on the ASTM website.

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



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Pipe for Low-Temperature Service and Other Applications with Required Notch Toughness

A335/A335M Specification for Seamless Ferritic Alloy-Steel Pipe for High-Temperature Service

A358/A358M Specification for Electric-Fusion-Welded Austenitic Chromium-Nickel Stainless Steel Pipe for High-Temperature Service and General Applications

A369/A369M Specification for Carbon and Ferritic Alloy Steel Forged and Bored Pipe for High-Temperature Service

A370 Test Methods and Definitions for Mechanical Testing of Steel Products

A376/A376M Specification for Seamless Austenitic Steel Pipe for High-Temperature Service

A409/A409M Specification for Welded Large Diameter Austenitic Steel Pipe for Corrosive or High-Temperature Service

A426/A426M Specification for Centrifugally Cast Ferritic Alloy Steel Pipe for High-Temperature Service

A451/A451M Specification for Centrifugally Cast Austenitic Steel Pipe for High-Temperature Service

A608/A608M Specification for Centrifugally Cast Iron-Chromium-Nickel High-Alloy Tubing for Pressure Application at High Temperatures

A700 Guide for Packaging, Marking, and Loading Methods for Steel Products for Shipment

A751 Test Methods and Practices for Chemical Analysis of Steel Products

A778/A778M Specification for Welded, Unannealed Austenitic Stainless Steel Tubular Products

A790/A790M Specification for Seamless and Welded Ferritic/Austenitic Stainless Steel Pipe

A813/A813M Specification for Single- or Double-Welded Austenitic Stainless Steel Pipe

A814/A814M Specification for Cold-Worked Welded Austenitic Stainless Steel Pipe

A872/A872M Specification for Centrifugally Cast Ferritic/Austenitic Stainless Steel Pipe for Corrosive Environments

A928/A928M Specification for Ferritic/Austenitic (Duplex) Stainless Steel Pipe Electric Fusion Welded with Addition of Filler Metal

A941 Terminology Relating to Steel, Stainless Steel, Related Alloys, and Ferroalloys

A943/A943M Specification for Spray-Formed Seamless Austenitic Stainless Steel Pipes

A949/A949M Specification for Spray-Formed Seamless Ferritic/Austenitic Stainless Steel Pipe

A954 Specification for Austenitic Chromium-Nickel-Silicon Alloy Steel Seamless and Welded Pipe (Withdrawn 2005)<sup>5</sup>

A994 Guide for Editorial Procedures and Form of Product Specifications for Steel, Stainless Steel, and Related Alloys

A1058 Test Methods for Mechanical Testing of Steel Products—Metric

D3951 Practice for Commercial Packaging

E29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications

E213 Practice for Ultrasonic Testing of Metal Pipe and Tubing

E273 Practice for Ultrasonic Testing of the Weld Zone of Welded Pipe and Tubing

E309 Practice for Eddy Current Examination of Steel Tubular Products Using Magnetic Saturation

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

E570 Practice for Flux Leakage Examination of Ferromagnetic Steel Tubular Products

### 2.2 ANSI Standards:

B36.10 Welded and Seamless Wrought Steel Pipe<sup>6</sup>

B36.19 Stainless Steel Pipe<sup>6</sup>

### 2.3 Military Standards:

MIL-STD-163 Steel Mill Products, Preparation for Shipment and Storage<sup>7</sup>

MIL-STD-271 Nondestructive Testing Requirements for Metals<sup>7</sup>

MIL-STD-792 Identification Marking Requirements for Special Purpose Equipment<sup>7</sup>

### 2.4 Federal Standard:

Fed. Std. No. 183 Continuous Identification Marking of Iron and Steel Products<sup>7</sup>

### 2.5 Steel Structures Painting Council:

SSPC-SP6 Surface Preparation Specification No. 6 Commercial Blast Cleaning<sup>8</sup>

### 2.6 ASNT Standards:

SNT-TC-1A Recommended Practice for Personnel Qualification and Certification in Nondestructive Testing<sup>9</sup>

## 3. Materials and Manufacture

3.1 The steel shall be made by a suitable steelmaking process.

3.2 If secondary melting, such as electroslag remelting or vacuum remelting, is used, the heat shall be defined as all of the ingots remelted from a single primary heat.

3.3 If steels of different grades are sequentially strand cast, the resultant transition material shall be removed using an established procedure that positively separates the grades.

3.4 If a specific type of melting is required by the purchaser, it shall be specified in the purchase order.

## 4. Terminology

### 4.1 Definitions:

<sup>6</sup> Portions of these standards appear in *ASTM Book of Standards*, Vol 01.01. Full text of these standards is available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, <http://www.ansi.org>.

<sup>7</sup> Available from Standardization Documents Order Desk, DODSSP, Bldg. 4, Section D, 700 Robbins Ave., Philadelphia, PA 19111-5098, <http://dodssp.daps.dla.mil>.

<sup>8</sup> Available from Steel Structures Painting Council, 4400 Fifth Ave., Pittsburgh, PA 15213.

<sup>9</sup> Available from American Society for Nondestructive Testing (ASNT), P.O. Box 28518, 1711 Arlington Ln., Columbus, OH 43228-0518, <http://www.asnt.org>.

<sup>5</sup> The last approved version of this historical standard is referenced on [www.astm.org](http://www.astm.org).



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4.1.1 The definitions in Terminology A941, except as modified in this specification or in its referenced product specifications, are applicable to this specification.

### 5. Ordering Information

5.1 It is the responsibility of the purchaser to specify all requirements that are necessary for products ordered under the applicable product specification and this general requirements specification. Such requirements to be considered include, but are not limited to, the following:

- 5.1.1 ASTM product specification and year-date,
- 5.1.2 Name of product (for example, stainless steel pipe),
- 5.1.3 Quantity (feet, metres, or number of pieces),
- 5.1.4 Method of manufacture, where applicable (seamless or welded),
- 5.1.5 Specific type of melting, if required (see 3.4),
- 5.1.6 Grade or UNS number,
- 5.1.7 Size (NPS and outside diameter and schedule number, average (nominal) wall thickness (see 9.1), or minimum wall thickness (see 9.1.1), or minimum inside diameter (see 10.1)),
- 5.1.8 Length (specific or random),
- 5.1.9 End finish,
- 5.1.10 Optional requirements,
- 5.1.11 Specification designation and year of issue, and
- 5.1.12 Special requirements or any supplementary requirements, or both.

### 6. Chemical Composition

6.1 *Chemical Analysis*—Samples for chemical analysis and method of analysis shall be in accordance with Test Methods, Practices, and Terminology A751.

6.2 *Heat Analysis*—An analysis of each heat of steel shall be made by the steel manufacturer to determine the percentages of the specified elements. If secondary melting processes are employed, the heat analysis shall be obtained from one remelted ingot or the product of one remelted ingot of each primary melt. The chemical composition thus determined, or that determined from a product analysis made by the tubular product manufacturer shall conform to the requirements specified.

6.2.1 For steels ordered under product specifications referencing this specification of general requirements, the steel shall not contain an unspecified element, other than nitrogen for stainless steels, for the ordered grade to the extent that the steel conforms to the requirements of another grade for which that element is a specified element having a required minimum content. For this requirement, a grade is defined as an alloy described individually and identified by its own UNS designation in a table of chemical requirements within any specification listed within the scope as being covered by this specification.

6.3 *Product Analysis*—Product analysis requirements and options, if any, shall be as contained in the applicable product specification.

### 7. Mechanical Properties

7.1 *Method of Mechanical Tests*—The specimens and mechanical tests required shall be in accordance with Test

Methods and Definitions A370, especially Annex A2 thereof, or Test Methods A1058.

7.1.1 Unless otherwise specified in the ordering requirements, Test Methods A1058 shall apply when the metric version of the product specification is specified.

7.2 Specimens shall be tested at room temperature.

7.3 Small or subsize specimens as described in Test Methods and Definitions A370 or Test Methods A1058 may be used only when there is insufficient material to prepare one of the standard specimens. When using small or subsize specimens, the largest one possible shall be used.

### 8. Tensile Requirements

8.1 The material shall conform to the requirements as to tensile properties in the applicable product specification.

8.2 The yield strength, if specified, shall be determined corresponding to a permanent offset of 0.2 % of the gauge length or to a total extension of 0.5 % of the gauge length under load.

8.3 If the percentage of elongation of any test specimen is less than that specified and any part of the fracture is more than  $\frac{3}{4}$  in. [19.0 mm] from the center of the gauge length, as indicated by scribe marks on the specimen before testing, a retest shall be allowed.

### 9. Permissible Variations in Wall Thickness

9.1 *Seamless and Welded*—See Table 1 for permitted variations in wall thickness except as required by 9.1.1. The minimum wall thickness on inspection is shown in Table X1.1.

9.1.1 *Minimum Wall*—If the wall thickness of the pipe is specified as minimum wall in the purchase order, there shall be no variation under the specified wall thickness. See Table 2 for permitted variations in minimum wall thickness.

9.2 *Forged and Bored*—The wall thickness shall not vary over that specified by more than  $\frac{1}{8}$  in. [3.2 mm]. There shall be no variation under the specified wall thickness.

9.3 *Cast*—The wall thickness shall not vary over that specified by more than  $\frac{1}{16}$  in. [1.6 mm]. There shall be no variation under the specified wall thickness.

TABLE 1 Permitted Variations in Wall Thickness

NPS [DN] Designator	Tolerance % from Nominal	
	Over	Under
$\frac{1}{8}$ [DN 6] to 2- $\frac{1}{2}$ [DN 65] incl., all t/D ratios	20.0	12.5
3 [DN 80] to 18 [DN 450] incl., t/D up to 5% incl.	22.5	12.5
3 [DN 80] to 18 [DN 450] incl., t/D > 5% incl.	15.0	12.5
20 [DN 500] and larger, welded, all t/D ratios	17.5	12.5
20 [DN 500] and larger, seamless, t/D up to 5 % incl.	22.5	12.5
20 [DN 500] and larger, seamless, t/D > 5%	15.0	12.5



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**TABLE 2 Permitted Variations in Wall Thickness for Minimum Wall**

NPS [DN] Designator	Tolerance % from Specified Minimum	
	Over	Under
½ [DN 6] to 2-½ [DN 65] incl., all t/D ratios	32.5	0
3 [DN 80] to 18 [DN 450] incl., t/D up to 5% incl.	35.0	0
3 [DN 80] to 18 [DN 450] incl., t/D > 5% incl.	27.5	0
20 [DN 500] and larger, welded, all t/D ratios	30.0	0
20 [DN 500] and larger, seamless, t/D up to 5 % incl.	35.0	0
20 [DN 500] and larger, seamless, t/D > 5%	27.5	0

### 10. Permissible Variations in Inside Diameter

10.1 *Forged and Bored, and Cast*—The inside diameter shall not vary under that specified by more than ¼ in. [1.6 mm]. There shall be no variation over the specified inside diameter.

### 11. Permissible Variation in Outside Diameter

11.1 Variations in outside diameter, unless otherwise agreed upon, shall not exceed the limits given in Table 3. The tolerances for outside diameter include ovality, except as provided for in 11.2 and 11.2.1. (See Note 2.)

11.2 For thin-wall pipe, defined as pipe having a wall thickness of 3 % or less of the specified outside diameter, the diameter tolerance of Table 3 is applicable only to the mean of the extreme (maximum and minimum) outside diameter readings in any one cross-section.

11.2.1 For thin-wall pipe, the difference in extreme outside readings (ovality) in any one cross-section shall not exceed 1.5 % of the specified outside diameter.

NOTE 2—Thin-wall pipe usually develops significant ovality (out-of-roundness) during final annealing, straightening, or both. The diameter tolerances given in Table 3 are usually not sufficient to provide for additional ovality expected in thin-wall pipe.

### 12. Permissible Variations in Length

12.1 *Seamless and Welded (No Filler Metal Added)*—If specific cut lengths of 24 ft [7.3 m] or less are ordered, no length of pipe shall be under the length specified or more than ¼ in. [6 mm] over that specified.

12.1.1 Permissible variations in length for lengths greater than 24 ft [7.3 m] shall be subject to agreement between the manufacturer and purchaser.

12.2 *Forged and Bored, Cast, and Cast Cold-Wrought*—If specific cut lengths are ordered, no length of pipe shall be under the length specified or more than ⅛ in. [3 mm] over that specified.

12.3 For pipe ordered to random lengths, the lengths and variations shall be agreed upon between the manufacturer and purchaser.

12.4 No girth welds are permitted unless agreed upon by the manufacturer and purchaser.

### 13. Other Sizes

13.1 A system of standard pipe sizes has been approved by the American National Standards Institute as ANSI B36.10 and B36.19. The standard sizes do not prohibit the production and use of other sizes of pipe produced to the various product specifications referenced in 1.1.

### 14. Ends

14.1 Unless otherwise specified, the pipe shall be furnished with plain ends. All burrs at the ends of the pipe shall be removed.

### 15. Straightness

15.1 The finished pipe shall be reasonably straight.

15.2 For metal-arc welded pipe, the maximum deviation from a 10-ft [3.0-m] straightedge placed so that both ends are in contact with the pipe shall be ⅛ in. [3.2 mm]. For metal-arc welded pipe with lengths shorter than 10 ft [3.0 m], this maximum deviation shall be prorated with respect to the ratio of the actual length to 10 ft [3.0 m].

### 16. Repair by Welding

16.1 Repair by welding of defects in seamless pipe (including centrifugally cast pipe and forged and bored pipe) and of plate defects in welded pipe and, if specifically stated by the applicable product specification, weld seam defects in welded pipe shall be permitted subject to the approval of the purchaser and with the further understanding that the composition of the deposited filler metal shall be suitable for the composition being welded. Defects shall be thoroughly chipped or ground out before welding and each repaired length shall be reheat treated or stress relieved as required by the applicable product specification. Each length of repaired pipe shall be nondestructively tested as required by the applicable product specification.

**TABLE 3 Permissible Variations in Outside Diameter**

NPS Designator	Permissible Variations in Outside Diameter		DN Designator	Permissible Variations in Outside Diameter	
	Over in.	Under in.		Over [mm]	Under [mm]
½ –1½, incl	¼ (0.015)	½ (0.031)	[6–40], incl	[0.4]	[0.8]
Over 1½ to 4, incl	½ (0.031)	½ (0.031)	Over [40 to 100]	[0.8]	[0.8]
Over 4 to 8, incl	⅙ (0.062)	½ (0.031)	Over [100 to 200]	[1.6]	[0.8]
Over 8 to 18, incl	⅙ (0.093)	½ (0.031)	Over [200 to 450]	[2.4]	[0.8]
Over 18 to 26, incl	⅙ (0.125)	½ (0.031)	Over [450 to 650]	[3.2]	[0.8]
Over 26 to 34, incl	⅙ (0.156)	½ (0.031)	Over [650 to 850]	[4.0]	[0.8]
Over 34 to 48, incl	⅙ (0.187)	½ (0.031)	Over [850 to 1200]	[4.8]	[0.8]



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16.2 Repair welding shall be performed using procedures and welders or welding operators that have been qualified in accordance with the ASME Boiler and Pressure Vessel Code, Section IX.

### 17. Retests

17.1 If the results of the qualification tests of any lot do not conform to the requirements specified in the applicable product specification, retests are permitted on additional lengths of pipe of double the original number from the same lot, each of which shall conform to the requirements specified. Only one retest of any lot is permitted. Nonconformance of the retest is cause for the rejection of the lot.

17.2 Any individual length of pipe that meets the test requirements is acceptable. It is permitted to retest individual lengths that do not conform to the test requirements, provided that the reason for nonconformance is established and the nonconforming portion is removed.

### 18. Retreatment

18.1 If individual lengths of pipe selected to represent any lot fail to conform to the test requirements, the lot represented may be reheat treated and resubmitted for test. The manufacturer may reheat treat the pipe, but not more than twice, except with the approval of the purchaser.

### 19. Test Specimens

19.1 Test specimens shall be taken from the ends of finished pipe prior to any forming operations, or being cut to length.

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

19.3 If any test specimen shows flaws or defective machining, the specimen may be discarded and another substituted.

### 20. Flattening Test Requirements

20.1 *Seamless and Centrifugally Cast Pipe*—A section of pipe not less than 2½ in. [60 mm] in length shall be flattened cold between parallel plates in two steps. During the first step, which is a test for ductility, no cracks or breaks on the inside, outside, or end surfaces, except as allowed by 20.3.4, shall occur before the distance between the plates is less than the value of  $H$  calculated as follows:

$$H \geq 1.1 e / t \sim e / t / D \quad (1)$$

where:

$H$  = distance between flattening plates, in. [mm],

$t$  = specified wall thickness, in. [mm],

$D$  = specified outside diameter, outside diameter corresponding to specified ANSI pipe size, or outside diameter calculated by adding  $2t$  (as defined above) to the specified inside diameter in. [mm], and

$e$  = deformation per unit length (constant for a given grade of steel, 0.07 for medium carbon steel (maximum specified carbon 0.19 % or greater), 0.08 for ferritic alloy steel, 0.09 for austenitic steel, 0.09 for duplex (ferritic/austenitic) stainless steel, and 0.09 for low-carbon steel (maximum specified carbon 0.18 % or less)).

During the second step, which is a test for soundness, the flattening shall be continued until the specimen breaks or the opposite walls of the specimen meet.

20.2 *Welded Pipe*—A section of welded pipe not less than 4 in. [100 mm] in length shall be flattened cold between parallel plates in two steps. The weld shall be placed at 90° from the direction of the applied force (at the point of maximum bending). During the first step, which is a test for ductility, no cracks or breaks on the inside or outside surfaces, except as provided for in 20.3.4, shall occur before the distance between the plates is less than the value of  $H$  calculated by Eq 1. During the second step, which is a test for soundness, the flattening shall be continued until the specimen breaks or the opposite walls of the specimen meet.

#### 20.3 *Seamless, Centrifugally Cast, and Welded Pipe:*

20.3.1 Evidence of laminated or defective material or weld that is revealed at any time during the entire flattening test shall be cause for rejection.

20.3.2 Surface imperfections not evident in the test specimen before flattening, but revealed during the first step of the flattening test, shall be judged in accordance with the finish requirements.

20.3.3 Superficial ruptures resulting from surface imperfections shall not be a cause for rejection.

20.3.4 When low  $D$ -to- $t$  ratio tubular products are tested, because the strain imposed due to geometry is unreasonably high on the inside surface at the six and twelve o'clock locations, cracks at these locations shall not be cause for rejection if the  $D$ -to- $t$  ratio is less than 10.

### 21. Nondestructive Test Requirements

21.1 If required by the applicable product specification or the purchase order, the pipe shall be tested by the hydrostatic test (see 21.2) or by the nondestructive electric test (see 21.3).

#### 21.2 *Hydrostatic Test:*

21.2.1 Except as allowed by 21.2.2 and 21.2.3, each length of pipe shall be tested by the manufacturer to a hydrostatic pressure that will produce in the pipe wall a stress not less than 60 % of the specified minimum yield strength for ferritic alloy steel and stainless steel pipe, or 50 % of the specified minimum yield strength for austenitic alloy and stainless steel pipe and for ferritic/austenitic stainless steel pipe. The test pressure or stress shall be determined using the following equation:

$$P \geq 2St/D \quad \text{or} \quad S \geq PD/2t \quad (2)$$



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where:

- $P$  = hydrostatic test pressure in psi [MPa],  
 $S$  = pipe wall stress in psi or [MPa],  
 $t$  = specified wall thickness, nominal wall thickness according to specified ANSI schedule number, or 1.143 times the specified minimum wall thickness, in. [mm], and  
 $D$  = specified outside diameter, outside diameter corresponding to specified ANSI pipe size, or outside diameter calculated by adding  $2t$  (as defined above) to the specified inside diameter, in. [mm].

21.2.1.1 The hydrostatic test pressure determined by Eq 2 shall be rounded to the nearest 50 psi [0.5 MPa] for pressures below 1000 psi [7 MPa], and to the nearest 100 psi [1 MPa] for pressures 1000 psi [7 MPa] and above. The hydrostatic test may be performed prior to cutting to final length, or prior to upsetting, swaging, expanding, bending, or other forming operations.

21.2.2 Regardless of pipe-wall stress-level determined by Eq 2, the minimum hydrostatic test pressure required to satisfy these requirements need not exceed 2500 psi [17.0 MPa] for outside diameters (see  $D$  in 21.2) of 3.5 in. [88.9 mm] or less, or 2800 psi [19.0 MPa] for outside diameters over 3.5 in. [88.9 mm]. This does not prohibit testing at higher pressures at the option of the manufacturer or as allowed by 21.2.3.

21.2.3 With concurrence of the manufacturer, a minimum hydrostatic test pressure in excess of the requirements of 21.1 or 21.2, or both, may be stated in the purchase order.

21.2.4 The test pressure shall be held for a minimum of 5 s. For welded pipe, the test pressure shall be held for a time sufficient to permit the entire length of the welded seam to be inspected.

21.2.5 The hydrostatic test may not be capable of testing the end portion of the pipe. The length of pipe that cannot be tested shall be determined by the manufacturer and, if specified in the purchase order, reported to the purchaser.

### 21.3 Nondestructive Electric Test:

21.3.1 Each pipe shall be examined with a nondestructive test in accordance with Practices E213, E309, E426, or E570. Unless specifically called out by the purchaser, the selection of the nondestructive electric test shall be at the option of the manufacturer. Upon agreement between the purchaser and the manufacturer, Practice E273 shall be employed in addition to one of the full periphery tests. 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.

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

21.3.2.1 The reference discontinuities defined in 21.3.8.2 – 21.3.8.7 are convenient standards for the standardization of nondestructive testing equipment. The dimensions of such reference discontinuities should not be construed as the minimum size imperfection detectable by such equipment.

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

21.3.2.3 The eddy-current testing (ET) referenced in this specification, (see Practices E426 and E309), has the capability of detecting significant imperfections, especially of the short abrupt type. The sensitivity of this test decreases with wall thickness over 0.250 in. (6.4 mm).

21.3.2.4 The flux leakage examination referred to in this specification is capable of detecting the presence and location of significant longitudinally or transversely oriented imperfections; however, sensitivity of the test to various types of imperfections is affected by the calibration, and different techniques should be employed to detect differently oriented imperfections.

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

### 21.3.3 Time of Examination:

21.3.3.1 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.

### 21.3.4 Surface Condition:

21.3.4.1 All surfaces shall be free of scale, dirt, grease, paint, and 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.

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

### 21.3.5 Extent of Examination:

21.3.5.1 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 allowed by 21.3.5.2.

21.3.5.2 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.

### 21.3.6 Operator Qualifications:

21.3.6.1 The test unit operator shall be qualified in accordance with SNT-TC-1A, or an equivalent recognized and documented standard.

### 21.3.7 Test Conditions:

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

21.3.7.2 The eddy-current coil frequency used shall not exceed the following:

- On specified walls up to 0.050 in. [1.3 mm] - 100 kHz
- On specified walls up to 0.150 in. [3.8 mm] - 50 kHz
- On specified walls equal to or greater than 0.150 in. [3.8 mm] - 10 kHz

21.3.7.3 *Ultrasonic*—For examination by the ultrasonic method, the nominal transducer frequency shall be 2.00 MHz or more and the nominal transducer size shall be 1.5 in. [38 mm] or less.



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21.3.7.4 If the equipment contains a reject notice filter setting, this shall remain off during calibration and testing unless linearity can be demonstrated at the setting.

### 21.3.8 Reference Standards:

21.3.8.1 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 conditions as the pipe to be examined.

21.3.8.2 *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 12.5 % of the specified wall thickness of the pipe or 0.004 in. [0.1 mm], whichever is the greater. The width of the notch shall not exceed twice the depth. Notches shall be placed on both the OD and ID surfaces.

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

21.3.8.4 *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. Alternatively, the manufacturer of welded pipe is permitted 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 not exceed the following:

NPS Designator	Hole Diameter
½	0.039 in. [1.0 mm]
above ½ to 1 ¼	0.055 in. [1.4 mm]
above 1 ¼ to 2	0.071 in. [1.8 mm]
above 2 to 5	0.087 in. [2.2 mm]
above 5	0.106 in. [2.7 mm]

21.3.8.5 *Transverse Tangential Notch*—Using a round tool or a 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. Such a notch shall have a depth not exceeding 12.5 % of the specified wall thickness of the pipe or 0.004 in. [0.10 mm], whichever is the greater.

21.3.8.6 *Longitudinal Notch*—A notch of 0.031 in. [0.8 mm] or less in width shall be machined in a radial plane parallel to the pipe axis on the outside surface of the pipe, to have a depth not exceeding 12.5 % of the specified wall thickness of the pipe or 0.004 in. [0.10 mm], whichever is the greater.

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

### 21.3.9 Standardization Procedure:

21.3.9.1 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 and may be required upon agreement between the purchaser and the manufacturer.

21.3.9.2 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.

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

21.3.9.4 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, etc., shall not be considered noise. The rejection amplitude shall be adjusted to be at least 50 % of full scale of the readout display.

21.3.9.5 If upon any standardization, the rejection amplitude has decreased by at least 29 % (3 dB) of peak height from the last standardization, the pipe tested since the last calibration shall be rejected or retested for acceptance after the test apparatus settings have been changed, or the transducer(s), coil(s), or sensor(s) have been adjusted, and the test apparatus has been restandardized.

### 21.3.10 Evaluation of Imperfections:

21.3.10.1 Pipes producing a signal equal to or greater than the lowest signal produced by the reference discontinuities shall be identified and separated from the acceptable pipes. The area producing the signal may be reexamined.

21.3.10.2 Such pipes shall be rejected if the test signals were produced by imperfections that cannot be identified or were produced by cracks or crack-like imperfections. Such pipes may be repaired if such repair is permitted by the applicable product specification. To be accepted, a repaired pipe shall pass the same nondestructive test by which it was rejected, and it shall meet the minimum wall thickness requirements of the applicable product specification.

21.3.10.3 If the test signals were produced by visual imperfections such as scratches, surface roughness, dings, straightener marks, cutting chips, steel die stamps, stop marks, or pipe reducer ripple, the pipe is permitted to be accepted based upon visual examination provided that the depth of the imperfection is less than 0.004 in. [0.1 mm] or 12.5 % of the specified wall thickness, whichever is the greater.

21.3.10.4 Rejected pipe may be reconditioned and retested, provided that the wall thickness is not decreased to less than that required by the applicable 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.

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

## 22. Inspection

22.1 The inspector representing the purchaser shall have entry at all times work on the contract of the purchaser is being performed, to all parts of the manufacturer's facilities that concern the manufacture of the product ordered. The manufacturer shall afford the inspector all reasonable facilities to be satisfied that the product is being furnished in accordance with



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this specification. All required tests and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be conducted so as not to interfere unnecessarily with the manufacturer's operations.

### 23. Rejection

23.1 Each length of pipe received from the manufacturer may be inspected by the purchaser and, if it does not meet the requirements of the specification based upon the inspection and test method as outlined in the applicable product specification, the length may be rejected and the manufacturer shall be notified. Disposition of rejected pipe shall be a matter of agreement between the manufacturer and the purchaser.

23.2 Pipe that fails in any of the forming operations or in the process of installation and is found to be defective shall be set aside and the manufacturer shall be notified for mutual evaluation of the suitability of the pipe. Disposition of such pipe shall be matter for agreement.

### 24. Certification

24.1 The manufacturer or supplier shall furnish to the purchaser a certificate of compliance stating that the product was manufactured, sampled, tested, and inspected in accordance with the specification, including year-date, the supplementary requirements, and any other requirements designated in the purchase order or contract, and has been found to meet such requirements. A signature or notarization is not required; however, the document shall be dated and shall clearly identify the organization submitting it.

24.1.1 Notwithstanding the absence of a signature or notarization, the certifying organization is responsible for the contents of the document.

24.2 In addition to the certificate of compliance, the manufacturer or supplier shall furnish to the purchaser a test report that includes the following information and test results, as applicable:

24.2.1 Heat number,

24.2.2 Heat analysis,

24.2.3 Product analysis if specified or required,

24.2.4 Tensile properties,

24.2.5 Width in the gauge length, if longitudinal strip tension test specimens were used,

24.2.6 Bend test acceptable,

24.2.7 Flattening test acceptable,

24.2.8 Hydrostatic test pressure,

24.2.9 Nondestructive electric test method,

24.2.10 Impact test results, and

24.2.11 Other test results or information required to be reported by the applicable product specification.

24.3 Test results or information required to be reported by supplementary requirements, or other requirements designated in the purchase order or contract shall be reported but may be reported in a separate document.

24.4 The test report shall include a statement of explanation for the letter added to the specification number marked on the tubes (see 25.5) if all of the requirements of the specification have not been completed. The purchaser must certify that all

requirements of the specification have been completed before the removal of the letter (that is, X, Y, or Z).

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

### 25. Product Marking

25.1 Each length of pipe shall be legibly marked with the manufacturer's name or brand, the specification number (year of issue not required) and grade. Marking shall begin approximately 12 in. [300 mm] from the end of each length of pipe. For pipe less than NPS 2 and pipe under 3 ft [1 m] in length, the required information may be marked on a tag securely attached to the bundle or box in which the pipes are shipped.

25.2 When pipe marked as specified is rejected, the ASTM designation shall be canceled.

25.3 For austenitic steel pipe, the marking paint or ink shall not contain detrimental amounts of harmful metals, or metal salts, such as zinc, lead, or copper, which cause corrosive attack on heating.

25.4 Pipes that have been weld repaired in accordance with 16.1 shall be marked WR.

25.5 When it is specified that certain requirements of a specification adopted by the ASME Boiler and Pressure Vessel Committee are to be completed by the purchaser upon receipt of the material, the manufacturer shall indicate that all requirements of the specification have not been completed by a letter such as X, Y, or Z, immediately following the specification number. This letter may be removed after completion of all requirements in accordance with the specification. An explanation of specification requirements to be completed is provided in 24.1.

### 26. Packaging, Marking, and Loading

26.1 If specified in the purchase order, packaging, marking, and loading for shipment shall be in accordance with the procedures of Practices A700.

### 27. Government Procurement

27.1 If specified in the contract or purchase order, the following requirements shall be considered in the inquiry, contract, or order for agencies of the U.S. Government where scale-free pipe is required. Such requirements shall take precedence if there is a conflict between these requirements and those of the applicable product specification.

27.2 Pipe shall be ordered to nominal pipe size (NPS) and schedule. Nominal pipe shall be as specified in ANSI B36.10 or B36.19.



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**27.3 Responsibility for Inspection**—Unless otherwise specified in the contract or purchase order, the manufacturer is responsible for the performance of all inspection and test requirements specified. The absence of any inspection requirements in the specification shall not relieve the contractor of the responsibility for ensuring that all products or supplies submitted to the government for acceptance comply with all requirements of the contract or purchase order. Sampling inspection, as part of the manufacturing operations, is an acceptable practice to ascertain conformance to requirements; however, this does not authorize submission of known defective material, either indicated or actual, nor does it commit the government to accept the material. Except as otherwise specified in the contract or purchase order, the manufacturer may use its own or any other suitable facilities for the performance of the inspection and test requirements unless disapproved by the purchaser at the time the order is placed. The purchaser shall have the right to perform any of the inspections and tests set forth if such inspections and tests are deemed necessary to ensure that the products conform to the prescribed requirements.

**27.4 Sampling for Flattening and Flaring Test and for Visual and Dimensional Examination**—Minimum sampling for flattening and flaring tests and visual and dimensional examination shall be as follows:

Lot Size (Pieces per Lot)	Sample Size Entire Lot
2 to 8	8
9 to 90	8
91 to 150	12
151 to 280	19
281 to 500	21
501 to 1200	27
1201 to 3200	35
3201 to 10 000	38
10 001 to 35 000	46

In all cases, the acceptance number is zero and the rejection number is one. Rejected lots may be screened and resubmitted for visual and dimensional examination. All defective items shall be replaced with acceptable items prior to lot acceptance.

**27.5 Sampling for Chemical Analysis**—One sample for chemical analysis shall be selected from each two pipes chosen from each lot. A lot shall be all material poured from one heat.

**27.6 Sampling for Tension and Bend Test**—One sample shall be taken from each lot. A lot shall consist of all pipe of the same outside diameter and wall thickness manufactured during an 8-h shift from the same heat of steel, and heat treated under the same conditions of temperature and time in a single charge in a batch-type furnace, or heat treated under the same condition in a continuous furnace, and presented for inspection at the same time.

**27.7 Hydrostatic and Ultrasonic Tests**—Each pipe shall be tested by the ultrasonic (if specified) and hydrostatic tests.

**27.8** Pipe shall be free from heavy oxide or scale. The internal surface of hot finished ferritic steel pipe shall be pickled or blast cleaned to a free of scale condition equivalent to the CSa2 visual standard in SSPC-SP6. Cleaning shall be

performed in accordance with a written procedure that has been shown to be effective. This procedure shall be available for audit.

**27.9** In addition to the marking required by this specification, each length of pipe NPS ¼ or larger shall be marked, in accordance with FED-STD-183 and MIL-STD-792, with the nominal pipe size, schedule number, length, and heat number or lot identification number.

**27.10** Pipe shall be straight to within the tolerance given in Table 4.

**27.11** If specified, each pipe shall be ultrasonically examined in accordance with MIL-STD-271, except that the notch depth in the reference standard shall be 5 % of the wall thickness or 0.005 in. [0.1 mm], whichever is the greater. Any pipe that produces an indication equal to or greater than 100 % of the indication from the reference discontinuity shall be rejected.

**27.12** The pipe shall be free from repair welds, welded joints, laps, laminations, seams, visible cracks, tears, grooves, slivers, pits, and other imperfections detrimental to the pipe as determined by visual and ultrasonic examination, or alternate tests, as specified.

**27.13** Pipe shall be uniform in quality and condition and have a finish conforming to the best practice for standard quality pipe. Surface imperfections such as handling marks, straightening marks, light mandrel and die marks, shallow pits, and scale pattern will not be considered defects if the imperfections are removable within the tolerances specified for wall thickness or 0.005 in. [0.1 mm], whichever is the greater. The bottom of imperfections shall be visible and the profile shall be rounded and faired-in.

**27.14** No weld repair by the manufacturer is permitted.

**27.15** Preservation shall be level A or commercial, and packing shall be level A, B, or commercial, as specified. Level A preservation and level A or B packing shall be in accordance with MIL-STD-163 and commercial preservation and packing shall be in accordance with Practices A700 or Practice D3951.

## 28. Keywords

28.1 alloy steel pipe; austenitic stainless steel; duplex stainless steel; ferritic/austenitic stainless steel; seamless steel pipe; stainless steel pipe; steel pipe; welded steel pipe

**TABLE 4 Straightness Tolerances**

Specified OD, in. <sup>A</sup>	Specified Wall Thickness, in. <sup>A</sup>	Maximum Curvature in any 3 ft, in. <sup>A</sup>	Maximum Curvature in Total Length, in. <sup>A</sup>
Up to 5.0, incl.	Over 3 % OD to 0.5, incl.	0.030	0.010 × length, ft
Over 5.0 to 8.0, incl.	Over 4 % OD to 0.75, incl.	0.045	0.015 × length, ft
Over 8.0 to 12.75, incl.	Over 4 % OD to 1.0, incl.	0.060	0.020 × length, ft

<sup>A</sup> 1 in. = 25.4 mm.



**ANNEXES**

**(Mandatory Information)**

**A1. REQUIREMENTS FOR THE INTRODUCTION OF NEW MATERIALS**

A1.1 New materials may be proposed for inclusion in product specifications referencing this general requirements specification subject to the following conditions:

A1.1.1 Application for the addition of a new grade to a specification shall be made to the chair of the subcommittee that has jurisdiction over that specification.

A1.1.2 The application shall be accompanied by a statement from at least one user indicating that there is a need for the new grade to be included in the applicable product specification.

A1.1.3 The application shall be accompanied by test data as required by the applicable product specification. Test data from

a minimum of three test lots, as defined by the applicable product specification, each from a different heat, shall be furnished.

A1.1.4 The application shall provide recommendations for all requirements appearing in the applicable product specification.

A1.1.5 The application shall state whether the new grade is covered by patent.

**A2. REQUIREMENTS FOR THE INTRODUCTION OF MATERIALS FROM OTHER A01 OR B02.07 SPECIFICATIONS**

A2.1 Wrought materials that are already covered by another A01 or B02.07 specification may be proposed for inclusion in specifications referencing this specification of general requirements subject to the following conditions:

A2.1.1 Application for the addition of a grade that is already covered in another A01 or B02.07 specification shall be made to the chair of the subcommittee that has jurisdiction over that specification.

A2.1.2 The chemical requirements, the specified mechanical properties, and the heat treatment requirements of the grade being added shall be the same as those for the grade in the A01 or B02.07 specification in which the grade is presently covered.

A2.1.3 The application shall provide recommendations for all requirements appearing in the applicable specification.

A2.1.4 The application shall state whether or not the grade is covered by patent.



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**APPENDIX**

**(Nonmandatory Information)**

**X1. MINIMUM WALL THICKNESS ON INSPECTION FOR NOMINAL (AVERAGE) PIPE WALL THICKNESS**

**TABLE X1.1 Minimum Wall Thicknesses on Inspection for Nominal (Average) Pipe Wall Thicknesses**

NOTE 1—The following equation, upon which this table is based, may be applied to calculate minimum wall thickness from nominal (average) wall thickness:

$$t_n \times 0.875 = t_m$$

where:

$t_n$  = nominal (average) wall thickness, in. [mm], and

$t_m$  = minimum wall thicknesses, in. [mm].

The wall thickness in inch-pound units is rounded to three decimal places in accordance with the rounding method of Practice E29. The wall thickness in SI units is rounded to one decimal place in accordance with the rounding method of Practice E29.

NOTE 2—This table is a master table covering wall thicknesses available in the purchase of different classifications of pipe, but it is not meant to imply that all of the walls listed herein are necessarily obtainable for the applicable product specification.

Nominal (Average) Thickness ( $t_n$ )		Minimum Thickness on Inspection ( $t_m$ )		Nominal (Average) Thickness ( $t_n$ )		Minimum Thickness on Inspection ( $t_m$ )		Nominal (Average) Thickness ( $t_n$ )		Minimum Thickness on Inspection ( $t_m$ )	
in.	[mm]	in.	[mm]	in.	[mm]	in.	[mm]	in.	mm	in.	[mm]
0.068	[1.7]	0.060	[1.5]	0.294	[7.5]	0.257	[6.5]	0.750	[19.0]	0.658	[16.6]
0.068	[2.2]	0.077	[2.0]	0.300	[7.6]	0.262	[6.7]	0.812	[20.6]	0.710	[18.0]
0.091	[2.3]	0.080	[2.0]	0.307	[7.8]	0.269	[6.8]	0.843	[21.4]	0.736	[18.7]
0.095	[2.4]	0.083	[2.1]	0.308	[7.8]	0.270	[6.9]	0.854	[21.7]	0.756	[19.2]
0.113	[2.9]	0.099	[2.5]	0.312	[7.9]	0.273	[6.9]	0.875	[22.2]	0.766	[19.5]
0.119	[3.0]	0.104	[2.6]	0.318	[8.1]	0.278	[7.1]	0.906	[23.0]	0.783	[20.1]
0.125	[3.2]	0.109	[2.8]	0.322	[8.2]	0.282	[7.2]	0.937	[23.8]	0.820	[20.8]
0.126	[3.2]	0.110	[2.8]	0.330	[8.4]	0.289	[7.3]	0.968	[24.6]	0.847	[21.5]
0.133	[3.4]	0.116	[2.9]	0.337	[8.6]	0.295	[7.5]	1.000	[25.4]	0.875	[22.2]
0.140	[3.6]	0.122	[3.1]	0.343	[8.7]	0.300	[7.6]	1.031	[26.2]	0.902	[22.9]
0.145	[3.7]	0.127	[3.2]	0.344	[8.7]	0.301	[7.6]	1.062	[27.0]	0.929	[23.6]
0.147	[3.7]	0.129	[3.3]	0.358	[9.1]	0.313	[8.0]	1.083	[27.8]	0.956	[24.3]
0.154	[3.9]	0.135	[3.4]	0.365	[9.3]	0.319	[8.1]	1.125	[28.6]	0.984	[25.0]
0.156	[4.0]	0.136	[3.5]	0.375	[9.5]	0.328	[8.3]	1.156	[29.4]	1.012	[25.7]
0.179	[4.5]	0.157	[4.0]	0.382	[9.7]	0.334	[8.5]	1.218	[30.9]	1.066	[27.1]
0.187	[4.7]	0.164	[4.2]	0.400	[10.2]	0.350	[8.9]	1.250	[31.8]	1.094	[27.8]
0.188	[4.8]	0.164	[4.2]	0.406	[10.3]	0.355	[9.0]	1.281	[32.5]	1.121	[28.5]
0.191	[4.9]	0.167	[4.2]	0.432	[10.4]	0.378	[9.6]	1.312	[33.3]	1.148	[29.2]
0.200	[5.1]	0.175	[4.4]	0.436	[11.1]	0.382	[9.7]	1.343	[34.1]	1.175	[29.8]
0.203	[5.2]	0.178	[4.5]	0.437	[11.1]	0.382	[9.7]	1.375	[34.9]	1.203	[30.6]
0.216	[5.5]	0.189	[4.8]	0.438	[11.1]	0.383	[9.7]	1.406	[35.7]	1.230	[31.2]
0.218	[5.5]	0.191	[4.9]	0.500	[12.7]	0.438	[11.1]	1.436	[36.5]	1.258	[32.0]
0.219	[5.6]	0.192	[4.9]	0.531	[13.5]	0.465	[11.8]	1.500	[36.1]	1.312	[33.3]
0.226	[5.7]	0.196	[5.0]	0.552	[14.0]	0.483	[12.3]	1.531	[38.9]	1.340	[34.0]
0.237	[6.0]	0.207	[5.2]	0.562	[14.3]	0.492	[12.5]	1.562	[39.7]	1.367	[34.7]
0.250	[6.4]	0.219	[5.6]	0.593	[15.1]	0.519	[13.2]	1.593	[40.5]	1.394	[35.4]
0.258	[6.6]	0.226	[5.7]	0.600	[15.2]	0.525	[13.3]	1.750	[44.5]	1.531	[38.9]
0.276	[7.0]	0.242	[6.1]	0.625	[15.9]	0.547	[13.9]	1.781	[45.2]	1.558	[39.6]
0.277	[7.0]	0.242	[6.1]	0.656	[16.6]	0.573	[14.6]	1.812	[46.0]	1.586	[40.3]
0.279	[7.1]	0.244	[6.2]	0.674	[17.1]	0.590	[15.0]	1.968	[50.0]	1.772	[43.7]
0.280	[7.1]	0.245	[6.2]	0.687	[17.4]	0.601	[15.3]	2.062	[52.4]	1.804	[45.8]
0.281	[7.1]	0.246	[6.2]	0.719	[18.3]	0.629	[16.0]	2.343	[59.5]	2.050	[52.1]

**SUMMARY OF CHANGES**

Committee A01 has identified the location of selected changes to this specification since the last issue (A999/A999M – 18) that may impact the use of this specification. (Approved Sept. 1, 2023.)

- (1) Revised 5.1.7 to match new Section 9 and Section 10.
- (2) Deleted Section 9 and renumbered former Section 10 to 9.
- (3) Revised new Section 9 to use dimensions in place of mass.
- (4) Added Table 1 and Table 2 with DN units.



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(5) Deleted 14.2 and 14.3.

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