Designation: A999/A999M – 13

StandardSpecification for General Requirements for Alloy and Stainless Steel Pipe[1]

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[2] 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[3]
Seamless and Welded Austenitic Stainless Steel Pipes	A312/A312M
Seamless and Welded Steel Pipe for Low-Temperature Service	A333/A333M
Seamless Ferritic Alloy-Steel Pipe for High Temperature Service	A335/A335M
Electric-Fusion-Welded Austenitic Chromium-Nickel Alloy Steel Pipe for High-Temperature Service	A358/A358M
Carbon and Ferritic Alloy Steel Forged and Bored Pipe for High-Temperature Service	A369/A369M
Seamless Austenitic Steel Pipe for Use With High Temperature Central-Station 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
Seamless and Welded Ferritic/Austenitic Stainless Steel Pipe	A790/A790M
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 Pipe	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 22, 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 and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[4]

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

A333/A333M Specification for Seamless and Welded Steel Pipe for Low-Temperature Service

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

[1] 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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[2] For ASME Boiler and Pressure Vessel Code applications see related Specification SA 999 in Section II of that Code.

[3] These designations refer to the latest issue of the respective specifications. See *Annual Book of ASTM Standards*, Vol 01.01.

[4] 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**

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 Practices for Packaging, Marking, and Loading Methods for Steel Products for Shipment
A751 Test Methods, Practices, and Terminology for Chemical Analysis of Steel Products
A778 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)[5]
A994 Guide for Editorial Procedures and Form of Product Specifications for Steel, Stainless Steel, and Related Alloys
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[6]
B36.19 Stainless Steel Pipe[6]

2.3 *Military Standards:*
MIL-STD-163 Steel Mill Products, Preparation for Shipment and Storage[7]
MIL-STD-271 Nondestructive Testing Requirements for Metals[7]
MIL-STD-792 Identification Marking Requirements for Special Purpose Equipment[7]

2.4 *Federal Standard:*
Fed. Std. No. 183 Continuous Identification Marking of Iron and Steel Products[7]

2.5 *Steel Structures Painting Council:*
SSPC-SP6 Surface Preparation Specification No. 6 Commercial Blast Cleaning[8]

2.6 *ASNT Standards:*
SNT-TC-1A Recommended Practice for Personnel Qualification and Certification in Nondestructive Testing[9]

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*:

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] The last approved version of this historical standard is referenced on www.astm.org.

[6] 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.

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

[8] Available from Steel Structures Painting Council, 4400 Fifth Ave., Pittsburgh, PA 15213.

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

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 and 10.1), or minimum wall thickness (see 9.2 and 10.1.1), or minimum inside diameter (see 11.1)),
5.1.8 Length (specific or random),
5.1.9 End finish,
5.1.10 Optional requirements,
5.1.11 Certification (see Section 25),
5.1.12 Specification designation and year of issue, and
5.1.13 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.

7.2 Specimens shall be tested at room temperature.

7.3 Small or subsize specimens as described in Test Methods and Definitions A370 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 gage length or to a total extension of 0.5 % of the gage 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 ¾ in. [19.0 mm] from the center of the gage length, as indicated by scribe marks on the specimen before testing, a retest shall be allowed.

9. Permissible Variation in Mass for Seamless Pipe

9.1 Except as allowed by 9.2, the mass of any length of seamless pipe in sizes NPS 12 and smaller shall not vary more than 10 % over or more than 3.5 % under that specified. For pipe in sizes larger than NPS 12, the mass of any length of pipe shall not vary more than 10 % over or more than 5 % under that specified. Unless otherwise specified, the mass of lengths of pipe in sizes NPS 4 and smaller shall be determined separately or in convenient lots; the mass of lengths of pipe in sizes larger than NPS 4 shall be determined separately.

9.2 *Minimum Wall*—If the wall thickness of the pipe is specified as minimum wall in the purchase order, the mass of any length of seamless pipe shall not vary more than 16 % over that calculated in accordance with 14.3. Unless otherwise specified, the mass of pipe in sizes NPS 4 and smaller shall be determined separately or in convenient lots; the mass of pipe in sizes larger than NPS 4 shall be determined separately.

9.3 The specified mass of pipe shall be determined by multiplying its specified or calculated mass per unit length (see 14.3) by its measured length.

10. Permissible Variations in Wall Thickness

10.1 *Seamless and Welded*—Except as required by 10.1.1, the minimum wall thickness at any point shall not be more than 12.5 % under the nominal wall thickness specified. The minimum wall thickness on inspection is shown in Table X1.1.

10.1.1 *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.

10.2 *Forged and Bored*—The wall thickness shall not vary over that specified by more than ⅛ in. [3.2 mm]. There shall be no variation under the specified wall thickness.

10.3 *Cast*—The wall thickness shall not vary over that specified by more than 1/16 in. [1.6 mm]. There shall be no variation under the specified wall thickness.

11. Permissible Variations in Inside Diameter

11.1 *Forged and Bored, and Cast*—The inside diameter shall not vary under that specified by more than 1/16 in. [1.6 mm]. There shall be no variation over the specified inside diameter.

12. Permissible Variation in Outside Diameter

12.1 Variations in outside diameter, unless otherwise agreed upon, shall not exceed the limits given in Table 1. The

TABLE 1 Permissible Variations in Outside Diameter

NPS Designator	Permissible Variations in Outside Diameter			
	Over		Under	
	in.	mm	in.	mm
⅛-1½, incl	1/64 (0.015)	0.4	1/32 (0.031)	0.8
Over 1½ to 4, incl	1/32 (0.031)	0.8	1/32 (0.031)	0.8
Over 4 to 8, incl	1/16 (0.062)	1.6	1/32 (0.031)	0.8
Over 8 to 18, incl	3/32 (0.093)	2.4	1/32 (0.031)	0.8
Over 18 to 26, incl	⅛ (0.125)	3.2	1/32 (0.031)	0.8
Over 26 to 34, incl	5/32 (0.156)	4.0	1/32 (0.031)	0.8
Over 34 to 48, incl	3/16 (0.187)	4.8	1/32 (0.031)	0.8

tolerances for outside diameter include ovality, except as provided for in 12.2 and 12.2.1. (See Note 2.)

12.2 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 1 is applicable only to the mean of the extreme (maximum and minimum) outside diameter readings in any one cross-section.

12.2.1 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 1 are usually not sufficient to provide for additional ovality expected in thin-wall pipe.

13. Permissible Variations in Length

13.1 *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.

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

13.2 *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.

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

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

14. Mass per Unit Length

14.1 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. (See Note 3.)

14.2 For nonstandard sizes of pipe, the calculated mass per unit length shall be determined using the following equation:

$$M = C(D - t)t \quad (1)$$

where:

C = 10.69 [0.02466],

M = mass per unit length, lb_m/ft [kg/m],

D = specified or calculated (from specified inside diameter and wall thickness) outside diameter, in. [mm], and

t = specified wall thickness, in. (to 3 decimal places) [mm to 2 decimal places].

14.3 When minimum wall thickness is specified in the purchase order, the calculated mass per unit length shall be determined using Eq 1, obtaining from Table X1.1 the nominal wall thickness, t, corresponding to that minimum wall.

NOTE 3—The mass per unit length values given in the American National Standards and the calculated masses per unit length determined using Eq 1 are based upon carbon steel pipe. The mass per unit length of pipe made of ferritic stainless steels may be up to about 5 % less, and that made of austenitic stainless steel up to about 2 % greater, than the values given.

15. Ends

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

16. Straightness

16.1 The finished pipe shall be reasonably straight.

16.2 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].

17. Repair by Welding

17.1 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.

17.2 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.

18. Retests

18.1 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.

18.2 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.

19. Retreatment

19.1 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.

20. Test Specimens

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

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

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

21. Flattening Test Requirements

21.1 *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 21.3.4, shall occur before the distance between the plates is less than the value of H calculated as follows:

$$H = (1+e)t/(e+t/D) \quad (2)$$

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.

21.2 *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 21.3.4, shall occur before the distance between the plates is less than the value of H calculated by Eq 2. 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.

21.3 *Seamless, Centrifugally Cast, and Welded Pipe:*

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

21.3.2 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.

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

21.3.4 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.

22. Nondestructive Test Requirements

22.1 If required by the applicable product specification or the purchase order, the pipe shall be tested by the hydrostatic test (see 22.2) or by the nondestructive electric test (see 22.3).

22.2 *Hydrostatic Test:*

22.2.1 Except as allowed by 22.2.2 and 22.2.3, 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:

$$P = 2St/D \quad or \quad S = PD/2t \quad (3)$$

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].

22.2.1.1 The hydrostatic test pressure determined by Eq 3 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.

22.2.2 Regardless of pipe-wall stress-level determined by Eq 3, the minimum hydrostatic test pressure required to satisfy these requirements need not exceed 2500 psi [17.0 MPa] for outside diameters (see D in 22.2) 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 22.2.3.

22.2.3 With concurrence of the manufacturer, a minimum hydrostatic test pressure in excess of the requirements of 22.1 or22.2, or both, may be stated in the purchase order.

22.2.4 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.

22.2.5 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.

22.3 *Nondestructive Electric Test:*

22.3.1 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.

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

22.3.2.1 The reference discontinuities defined in 22.3.8.2-22.3.8.7 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.

22.3.2.2 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.

22.3.2.3 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).

22.3.2.4 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.

22.3.2.5 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.

22.3.3 *Time of Examination:*

22.3.3.1 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.

22.3.4 *Surface Condition:*

22.3.4.1 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.

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

22.3.5 *Extent of Examination:*

22.3.5.1 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 22.3.5.2.

22.3.5.2 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.

22.3.6 *Operator Qualifications:*

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

22.3.7 *Test Conditions:*

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

22.3.7.2 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

22.3.7.3 *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.

22.3.7.4 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.

22.3.8 *Reference Standards:*

22.3.8.1 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.

22.3.8.2 *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.

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

22.3.8.4 *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