Designation: A 450/A 450M – 07

Standard Specification for General Requirements for Carbon and Low Alloy Steel Tubes[1]

This standard is issued under the fixed designation A 450/A 450M; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

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

1. Scope*

1.1 This specification[2] covers a group of requirements which, with the exceptions of 5.3 and Sections 6, 7, 18, 19, 20, 21, 22, 23, and 24, are mandatory requirements to the following ASTM tubular product specifications:[3]

Title of Specification	ASTM Designation[A]
Electric-Resistance-Welded Carbon Steel and Carbon Manganese Steel Boiler Tubes	A 178/A 178M
Seamless Cold-Drawn Low-Carbon Steel Heat-Exchanger and Condenser Tubes	A 179/A 179M
Seamless Carbon Steel Boiler Tubes for High-Pressure Service	A 192/A 192M
Seamless Medium-Carbon Steel Boiler and Superheater Tubes	A 210/A 210M
Electric-Resistance-Welded Carbon Steel Heat-Exchanger and Condenser Tubes	A 214/A 214M
Seamless and Electric-Welded Low-Alloy Steel Tubes	A 423/A 423M
Seamless Cold-Drawn Carbon Steel Feedwater Heater Tubes	A 556/A 556M
Seamless, Cold-Drawn Carbon Steel Tubing for Hydraulic System Service	A 822/A 822M

[A] These designations refer to the latest issue of the respective specifications.

1.2 One or more of Sections 5.3, 6, 7, 18, 19, 20, 21, 21.1, 23, and 24 apply when the product specification or purchase order has a requirement for the test or analysis described by these sections.

1.3 In case of conflict between a requirement of the product specification and a requirement of this general requirement specification only the requirement of the product specification need be satisfied.

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

2. Referenced Documents

2.1 *ASTM Standards:* [4]

A 178/A 178M Specification for Electric-Resistance-Welded Carbon Steel and Carbon-Manganese Steel Boiler and Superheater Tubes

A 179/A 179M Specification for Seamless Cold-Drawn Low-Carbon Steel Heat-Exchanger and Condenser Tubes

A 192/A 192M Specification for Seamless Carbon Steel Boiler Tubes for High-Pressure Service

A 210/A 210M Specification for Seamless Medium-Carbon Steel Boiler and Superheater Tubes

A 214/A 214M Specification for Electric-Resistance-Welded Carbon Steel Heat-Exchanger and Condenser Tubes

A 370 Test Methods and Definitions for Mechanical Testing of Steel Products

A 423/A 423M Specification for Seamless and Electric-Welded Low-Alloy Steel Tubes

A 530/A 530M Specification for General Requirements for Specialized Carbon and Alloy Steel Pipe

A 556/A 556M Specification for Seamless Cold-Drawn Carbon Steel Feedwater Heater Tubes

A 700 Practices for Packaging, Marking, and Loading Methods for Steel Products for Shipment

A 751 Test Methods, Practices, and Terminology for Chemical Analysis of Steel Products

A 822/A 822M Specification for Seamless Cold-Drawn Carbon Steel Tubing for Hydraulic System Service

A 941 Terminology Relating to Steel, Stainless Steel, Related Alloys, and Ferroalloys

D 3951 Practice for Commercial Packaging

E 92 Test Method for Vickers Hardness of Metallic Materials

[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 A01.09 on Carbon Steel Tubular Products.

Current edition approved Nov. 1, 2007. Published December 2007. Originally approved in 1961. Last previous edition approved in 2004 as A 450/A 450M – 04a.

[2] For ASME Boiler and Pressure Vessel Code applications see related Specification SA-450 in Section II of that Code.

[3] *Annual Book of ASTM Standards*, Vols 01.01 and 01.04.

[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.**

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E 213 Practice for Ultrasonic Examination of Metal Pipe and Tubing

E 273 Practice for Ultrasonic Examination of the Weld Zone of Welded Pipe and Tubing

E 309 Practice for Eddy-Current Examination of Steel Tubular Products Using Magnetic Saturation

E 426 Practice for Electromagnetic (Eddy-Current) Examination of Seamless and Welded Tubular Products, Austenitic Stainless Steel and Similar Alloys

E 570 Practice for Flux Leakage Examination of Ferromagnetic Steel Tubular Products

2.2 *Federal Standard:*

Fed. Std. No. 183 Continuous Identification Marking of Iron and Steel Products[5]

2.3 *Military Standards:*

MIL-STD-163 Steel Mill Products Preparation for Shipment and Storage[5]

MIL-STD-271 Nondestructive Testing Requirements for Metals[5]

MIL-STD-792 Identification Marking Requirements for Special Purpose Equipment[5]

2.4 *ASME Boiler and Pressure Vessel Code:*

Section IX Welding Qualifications[6]

2.5 *Steel Structures Painting Council:*

SSPC-SP 6 Surface Preparation Specification No. 6 Commercial Blast Cleaning[7]

2.6 *Other Document:*

SNT-TC-1A Recommended Practice for Nondestructive Personnel Qualification and Certification.

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *remelted heat*—in secondary melting, all of the ingots remelted from a single primary heat.

3.1.2 *thin-wall tube*—a tube meeting the specified outside diameter and specified wall thickness set forth as follows:

Specified Outside Diameter	Specified Wall Thickness
2 in. [50.8 mm] or less	2 % or less of specified outside diameter
Greater than 2 in. [50.8 mm]	3 % or less of specified outside diameter
Any	0.020 in. [0.5 mm] or less

3.2 *Other defined terms*—The definitions in Test Methods and Definitions A 370, Test Methods, Practices, and Terminology A 751, and Terminology A 941 are applicable to this specification and to those listed in 1.1.

4. Process

4.1 The steel may be made by any process.

4.2 If a specific type of melting is required by the purchaser, it shall be as stated on the purchase order.

4.3 The primary melting may incorporate separate degassing or refining and may be followed by secondary melting, such as electroslag remelting or vacuum-arc remelting.

4.4 Steel may be cast in ingots or may be strand cast. When steel of different grades is sequentially strand cast, identification of the resultant transition material is required. The producer shall remove the transition material by an established procedure that positively separates the grades.

5. Chemical Composition

5.1 Samples for chemical analysis, and method of analysis shall be in accordance with Test Methods, Practices, and Terminology A 751.

5.2 *Heat Analysis*—If the heat analysis reported by the steel producer is not sufficiently complete for conformance with the heat analysis requirements of the applicable product specification to be fully assessed, the manufacturer may complete the assessment of conformance with such heat analysis requirements by using a product analysis for the specified elements that were not reported by the steel producer, provided that product analysis tolerances are not applied and the heat analysis is not altered.

5.3 *Product Analysis*—Product analysis requirements and options, if any, are contained in the product specification.

6. Tensile Properties

6.1 The material shall conform to the requirements as to tensile properties prescribed in the individual specification.

6.2 The yield strength 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 shall be determined.

6.3 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.

[5] Available from Standardization Documents Order Desk, DODSSP, Bldg. 4, Section D, 700 Robbins Ave., Philadelphia, PA 19111-5098.

[6] Available from American Society of Mechanical Engineers (ASME), ASME International Headquarters, Three Park Ave., New York, NY 10016-5990, http://www.asme.org.

[7] Available from Society for Protective Coatings (SSPC), 40 24th St., 6th Floor, Pittsburgh, PA 15222-4656, http://www.sspc.org.

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7. Standard Weights

7.1 The calculated weight per foot, based upon a specified minimum wall thickness, shall be determined by the following equation:

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

where:

C = 10.69 [0.0246615],
W = weight, lb/ft [kg/m],
D = specified outside diameter, in. [mm], and
t = specified minimum wall thickness, in. [mm]

7.2 The permissible variations from the calculated weight per foot [kilogram per metre] shall be as prescribed in Table 1.

8. Permissible Variations in Wall Thickness

8.1 Variations from the specified minimum wall thickness shall not exceed the amounts prescribed in Table 2.

8.2 For tubes 2 in. [50.8 mm] and over in outside diameter and 0.220 in. [5.6 mm] and over in thickness, the variation in wall thickness in any one cross section of any one tube shall not exceed the following percentage of the actual mean wall at the section. The actual mean wall is defined as the average of the thickest and thinnest wall in that section.

Seamless tubes ±10 %
Welded tubes ±5 %

8.3 When cold-finished tubes as ordered require wall thicknesses ¾ in. [19.1 mm] or over, or an inside diameter 60 % or less of the outside diameter, the permissible variations in wall thickness for hot-finished tubes shall apply.

9. Permissible Variations in Outside Diameter

9.1 Except as provided in 9.2, variations from the specified outside diameter shall not exceed the amounts prescribed in Table 3.

9.2 Thin-wall tubes usually develop significant ovality (out of roundness) during final annealing, or straightening, or both. The diameter tolerances of Table 3 are not sufficient to provide for additional ovality expected in thin-wall tubes, and, for such tubes, are applicable only to the *mean* of the extreme (maximum and minimum) outside diameter readings in any one cross section. However, for thin wall tubes the *difference* in extreme outside diameter readings (ovality) in any one cross section shall not exceed the following ovality allowances:

Outside Diameter	Ovality Allowance
1 in. [25.4 mm] and under	0.020 in. [0.5 mm]
Over 1 in. [25.4 mm]	2.0 % of specified outside diameter

TABLE 1 Permissible Variations in Weight Per Foot[A]

Method of Manufacture	Permissible Variation in Weight per Foot, %	
	Over	Under
Seamless, hot-finished	16	0
Seamless, cold-finished:		
1½ in. [38.1 mm] and under OD	12	0
Over 1½ in. [38.1 mm] OD	13	0
Welded	10	0

[A] These permissible variations in weight apply to lots of 50 tubes or more in sizes 4 in. [101.6 mm] and under in outside diameter, and to lots of 20 tubes or more in sizes over 4 in. [101.6 mm] in outside diameter.

TABLE 2 Permissible Variations in Wall Thickness[A]

Outside Diameter, in. [mm]	Wall Thickness, %							
	0.095 [2.4] and Under		Over 0.095 to 0.150 [2.4 to 3.8], incl		Over 0.150 to 0.180 [3.8 to 4.6], incl		Over 0.180, [4.6]	
	Over	Under	Over	Under	Over	Under	Over	Under
Seamless, Hot-Finished Tubes								
4 [101.6] and under	40	0	35	0	33	0	28	0
Over 4 [101.6]	...	...	35	0	33	0	28	0

	Seamless, Cold-Finished Tubes	
	Over	Under
1½ [38.1] and under	20	0
Over 1½ [38.1]	22	0
Welded Tubes		
All sizes	18	0

[A] These permissible variations in wall thickness apply only to tubes, except internal-upset tubes, as rolled or cold-finished, and before swaging, expanding, bending, polishing, or other fabricating operations.

TABLE 3 Permissible Variations in Outside Diameter[A]

Outside Diameter, in. [mm]	Permissible Variations, in. [mm]	
	Over	Under
Hot-Finished Seamless Tubes		
4 [101.6] and under	1/64 [0.4]	1/32 [0.8]
Over 4 to 7½ [101.6 to 190.5], incl	1/64 [0.4]	3/64 [1.2]
Over 7½ to 9 [190.5 to 228.6], incl	1/64 [0.4]	1/16 [1.6]
Welded Tubes and Cold-Finished Seamless Tubes		
Under 1 [25.4]	0.004 [0.1]	0.004 [0.1]
1 to 1½ [25.4 to 38.1], incl	0.006 [0.15]	0.006 [0.15]
Over 1½ to 2 [38.1 to 50.8], excl	0.008 [0.2]	0.008 [0.2]
2 to 2½ [50.8 to 63.5], excl	0.010 [0.25]	0.010 [0.25]
2½ to 3 [63.5 to 76.2], excl	0.012 [0.3]	0.012 [0.3]
3 to 4 [76.2 to 101.6], incl	0.015 [0.38]	0.015 [0.38]
Over 4 to 7½ [101.6 to 190.5], incl	0.015 [0.38]	0.025 [0.64]
Over 7½ to 9 [190.5 to 228.6], incl	0.015 [0.38]	0.045 [1.14]

[A] Except as provided in 9.2, these permissible variations include out-of-roundness. These permissible variations in outside diameter apply to hot-finished seamless, welded and cold-finished seamless tubes before other fabricating operations such as upsetting, swaging, expanding, bending, or polishing.

10. Permissible Variations in Length

10.1 Variations from the specified length shall not exceed the amounts prescribed in Table 4.

TABLE 4 Permissible Variations in Length[A]

Method of Manufacture	Outside Diameter, in. [mm]	Cut Length, in. [mm]	
		Over	Under
Seamless, hot-finished	All sizes	3/16 [5]	0 [0]
Seamless, cold-finished	Under 2 [50.8]	1/8 [3]	0 [0]
	2 [50.8] and over	3/16 [5]	0 [0]
Welded	Under 2 [50.8]	1/8 [3]	0 [0]
	2 [50.8] and over	3/16 [5]	0 [0]

[A] These permissible variations in length apply to tubes before bending. They apply to cut lengths up to and including 24 ft [7.3 m]. For lengths greater than 24 ft [7.3 m], the above over-tolerances shall be increased by 1/8 in. [3 mm] for each 10 ft [3 m] or fraction thereof over 24 ft or ½ in. [13 mm], whichever is the lesser.

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11. Permissible Variations in Height of Flash on Electric-Resistance-Welded Tubes

11.1 For tubes over 2 in. [50.8 mm] in outside diameter, or over 0.135 in. [3.44 mm] in wall thickness, the flash on the inside of the tubes shall be mechanically removed by cutting to a maximum height of 0.010 in. [0.25 mm] at any point on the tube.

11.2 For tubes 2 in. [50.8 mm] and under in outside diameter and 0.135 in. [3.4 mm] and under in wall thickness, the flash on the inside of the tube shall be mechanically removed by cutting to a maximum height of 0.006 in. [0.15 mm] at any point on the tube.

12. Straightness and Finish

12.1 Finished tubes shall be reasonably straight and have smooth ends free of burrs. They shall have a workmanlike finish. Surface imperfections (see Note 1) may be removed by grinding, provided that a smooth curved surface is maintained, and the wall thickness is not decreased to less than that permitted by this or the product specification. The outside diameter at the point of grinding may be reduced by the amount so removed.

NOTE 1—An imperfection is any discontinuity or irregularity found in the tube.

13. Repair by Welding

13.1 Repair welding of base metal defects in tubing is permissible only with the approval of the purchaser and with the further understanding that the tube shall be marked "WR" and 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 specification. Each length of repaired tube shall be tested hydrostatically as required by the product specification.

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

14. Retests

14.1 If the results of the mechanical tests of any group or lot do not conform to the requirements specified in the individual specification, retests may be made on additional tubes of double the original number from the same group or lot, each of which shall conform to the requirements specified.

15. Retreatment

15.1 If the individual tubes or the tubes selected to represent any group or lot fail to conform to the test requirements, the individual tubes or the group or lot represented may be retreated and resubmitted for test. Not more than two reheat treatments shall be permitted.

16. Test Specimens

16.1 Test specimens shall be taken from the ends of finished tubes prior to upsetting, swaging, expanding, or other forming operations, or being cut to length. They shall be smooth on the ends and free of burrs and flaws.

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

17. Method of Mechanical Testing

17.1 The specimens and mechanical tests required shall be made in accordance with Annex A2 of Test Methods and Definitions A 370.

17.2 Specimens shall be tested at room temperature.

17.3 Small or subsize specimens as described in Test Methods and Definitions A 370 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.

18. Flattening Test

18.1 A section of tube not less than 2 ½ in. [63 mm] in length for seamless and not less than 4 in. [100 mm] in length for welded shall be flattened cold between parallel plates in two steps. For welded tubes, the weld shall be placed 90° from the direction of the applied force (at a point of maximum bending). During the first step, which is a test for ductility, no cracks or breaks, except as provided for in 18.4, on the inside, outside, or end surfaces shall occur in seamless tubes, or on the inside or outside surfaces of welded tubes, until the distance between the plates is less than the value of H calculated by the following equation:

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

where:

H = distance between flattening plates, in. [mm],
t = specified wall thickness of the tube, in. [mm],
D = specified outside diameter of the tube, 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 low alloy 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 tube meet. Evidence of laminated or unsound material, or of incomplete weld that is revealed during the entire flattening test shall be cause for rejection.

18.2 Surface imperfections in the test specimens before flattening, but revealed during the first step of the flattening test, shall be judged in accordance with the finish requirements.

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

18.4 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.

19. Reverse Flattening Test

19.1 A 5 in. [100 mm] in length of finished welded tubing in sizes down to and including ½ in. [12.7 mm] in outside

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diameter shall be split longitudinally 90° on each side of the weld and the sample opened and flattened with the weld at the point of maximum bend. There shall be no evidence of cracks or lack of penetration or overlaps resulting from flash removal in the weld.

20. Flaring Test

20.1 A section of tube approximately 4 in. [100 mm] in length shall stand being flared with a tool having a 60° included angle until the tube at the mouth of the flare has been expanded to the percentages specified in Table 5 without cracking or showing imperfections rejectable under the provisions of the product specification.

21. Flange Test

21.1 A section of tube shall be capable of having a flange turned over at a right angle to the body of the tube without cracking or showing imperfections rejectable under the provisions of the product specification. The width of the flange for carbon and alloy steels shall be not less than the percentages specified in Table 6.

22. Hardness Test

22.1 For tubes 0.200 in. [5.1 mm] and over in wall thickness, either the Brinell or Rockwell hardness test shall be used. When Brinell hardness testing is used, a 10-mm ball with 3000, 1500, or 500-kg load, or a 5-mm ball with 750-kg load may be used, at the option of the manufacturer.

22.2 For tubes less than 0.200 in. [5.1 mm] to and including 0.065 in. [1.7 mm] in wall thickness, the Rockwell hardness test shall be used.

22.3 For tubes less than 0.065 in. [1.7 mm] in wall thickness, the hardness test shall not be required.

22.4 The Brinell hardness test may be made on the outside of the tube near the end, on the outside of a specimen cut from the tube, or on the wall cross section of a specimen cut from the tube at the option of the manufacturer. This test shall be made so that the distance from the center of the impression to the edge of the specimen is at least 2.5 times the diameter of the impression.

TABLE 5 Flaring Test Requirements

Ratio of Inside Diameter to Outside Diameter[A]	Minimum Expansion of Inside Diameter, %	
	Carbon Steels	Low Alloy Steels
0.9	21	15
0.8	22	17
0.7	25	19
0.6	30	23
0.5	39	28
0.4	51	38
0.3	68	50

[A] In determining the ratio of inside diameter to specified outside diameter, the inside diameter shall be defined as the actual mean inside diameter of the material tested.

TABLE 6 Flange Requirements

Outside Diameter of Tube, in. [mm]	Width of Flange
To 2½ [63.5], incl	15 % of OD
Over 2½ to 3¾ [63.5 to 95.2], incl	12½ % of OD
Over 3¾ to 8 [95.2 to 203.2], incl	10 % of OD

22.5 The Rockwell hardness test may be made on the inside surface, on the wall cross section, or on a flat on the outside surface at the option of the manufacturer.

22.6 For tubes furnished with upset, swaged, or otherwise formed ends, the hardness test shall be made as prescribed in 22.1 and 22.2 on the outside of the tube near the end after the forming operation and heat treatment.

22.7 For welded or brazed tubes, the hardness test shall be made away from the joints.

22.8 When the product specification provides for Vickers hardness, such testing shall be in accordance with Test Method E 92.

23. Hydrostatic Test

23.1 Except as provided in 23.2 and 23.3, each tube shall be tested by the manufacturer to a minimum hydrostatic test pressure determined by the following equation:

$$\textit{Inch–Pound Units: } P = 32000\,t/D$$
$$\textit{SI Units: } P = 220.6t/D \qquad (3)$$

where:

P = hydrostatic test pressure, psi or MPa,
t = specified wall thickness, in. or mm, and
D = specified outside diameter, in. or mm.

23.1.1 The hydrostatic test pressure determined by Eq 3 shall be rounded to the nearest 50 psi [0.5 MPa] for pressure 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, or both.

23.2 Regardless of the determination made by Eq 3, the minimum hydrostatic test pressure required to satisfy these requirements need not exceed the values given in Table 7. This does not prohibit testing at higher pressures at manufacturer's option or as provided in 23.3.

TABLE 7 Hydrostatic Test Pressures

Outside Diameter of Tube, in. [mm]	Hydrostatic Test Pressure, psi [MPa]
Under 1 [25.4]	1000 [7]
1 to 1½ [25.4 to 38.1], excl	1500 [10]
1½ to 2 [38.1 to 50.8], excl	2000 [14]
2 to 3 [50.8 to 76.2], excl	2500 [17]
3 to 5 [76.2 to 127], excl	3500 [24]
5 [127] and over	4500 [31]

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23.3 With concurrence of the manufacturer, a minimum hydrostatic test pressure in excess of the requirements of 23.2 or 23.1, or both, may be stated on the order. The tube wall stress shall be determined by the following equation:

$$S = PD/2t \quad (4)$$

where:

S = tube wall stress, psi or MPa, and all other symbols as defined in 23.1.1.

23.4 The test pressure shall be held for a minimum of 5 s.

23.5 If any tube shows leaks during the hydrostatic test, it shall be rejected.

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

24. Air Underwater Pressure Test

24.1 When this test is employed, each tube, with internal surface clean and dry, shall be internally pressurized to 150 psi [1000 kPa] minimum with clean and dry compressed air while being submerged in clear water. The tube shall be well-lighted, preferably by underwater illumination. Any evidence of air leakage of the pneumatic couplings shall be corrected prior to testing. Inspection shall be made of the entire external surface of the tube after holding the pressure for not less than 5 s after the surface of the water has become calm. If any tube shows leakage during the air underwater test, it shall be rejected. Any leaking areas may be cut out and the tube retested.

25. Nondestructive Examination

25.1 When nondestructive examination is specified by the purchaser or the product specification, each tube shall be examined by a nondestructive examination method in accordance with Practice E 213, Practice E 309 (for ferromagnetic materials), Practice E 426 (for non-magnetic materials), or Practice E 570. Upon agreement, Practice E 273 shall be employed in addition to one of the full periphery tests. The range of tube sizes that may be examined by each method shall be subject to the limitations in the scope of that practice. In case of conflict between these methods and practices and this specification, the requirements of this specification shall prevail.

25.2 The following information is for the benefit of the user of this specification.

25.2.1 Calibration standards for the nondestructive electric test are convenient standards for calibration of nondestructive testing equipment only. For several reasons, including shape, orientation, width, etc., the correlation between the signal produced in the electric test from an imperfection and from calibration standards is only approximate. 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.

25.2.2 The ultrasonic examination referred to in this specification is intended to detect longitudinal discontinuities having a reflective area similar to or larger than the calibration reference notches specified in 25.4. The examination may not detect circumferentially oriented imperfections or short, deep defects.

25.2.3 The eddy current examination referenced in this specification has the capability of detecting significant discontinuities, especially of the short abrupt type. Practices E 309 and E 426 contain additional information regarding the capabilities and limitations of eddy-current examination.

25.2.4 The flux leakage examination referred to in this specification is capable of detecting the presence and location of significant longitudinally or transversely oriented discontinuities. The provisions of this specification only provide for longitudinal calibration for flux leakage. It should be recognized that different techniques should be employed to detect differently oriented imperfections.

25.2.5 The hydrostatic test referred to in Section 22 is a test method provided for in many product specifications. This test has the capability of finding defects of a size permitting the test fluid to leak through the tube wall and may be either visually seen or detected by a loss of pressure. This test may not detect very tight, through-the-wall defects or defects that extend an appreciable distance into the wall without complete penetration.

25.2.6 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 products.

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

25.4 *Surface Condition*:

25.4.1 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.

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

25.5 *Extent of Examination*:

25.5.1 The relative motion of the tube and the transducer(s), coil(s), or sensor(s) shall be such that the entire tube surface is scanned, except for end effects as noted in 25.5.2.

25.5.2 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.

25.6 *Operator Qualifications*:

25.6.1 The test unit operator shall be certified in accordance with SNT-TC-1A, or an equivalent documented standard agreeable to both purchaser and manufacturer.

25.7 *Test Conditions*:

25.7.1 For examination by the ultrasonic method, the minimum nominal transducer frequency shall be 2.0 MHz, and the maximum transducer size shall be 1.5 in. (38 mm).

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

25.7.2.1 The maximum coil frequency shall be:

Specified Wall Thickness	Maximum Frequency
<0.050 in.	100 KHz
0.050 to 0.150	50
>0.150	10

25.8 *Reference Standards*:

25.8.1 Reference standards of convenient length shall be prepared from a length of tube of the same grade, specified size (outside diameter and wall thickness), surface finish and heat treatment condition as the tubing to be examined.

25.8.2 *For eddy current testing*, the reference standard shall contain, at the option of the manufacturer, any one of the following discontinuities:

25.8.2.1 *Drilled Hole*—The reference standard shall contain three or more holes, equally spaced circumferentially around the tube 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 tube wall, with care being taken to avoid distortion of the tube while drilling. The holes shall not be larger than 0.031 in. (0.8 mm) in diameter. As an alternative, the producer may choose to drill one hole and run the calibration standard through the test coil three times, rotating the tube approximately 120° each time. More passes with smaller angular increments may be used, provided testing of the full 360° of the coil is obtained. For welded tubing, if the weld is visible, one of the multiple holes or the single hole shall be drilled in the weld.

25.8.2.2 *Transverse Tangential Notch*—Using a round tool or file with a ¼ in. (6.4 mm) diameter, a notch shall be milled or filed tangential to the surface and transverse to the longitudinal axis of the tube. Said notch shall have a depth not exceeding 12½ % of the specified wall thickness of the tube or 0.004 in. (0.1 mm), whichever is greater.

25.8.2.3 *Longitudinal Notch*—A notch 0.031 in. (0.8 mm) or less in width shall be machined in a radial plane parallel to the tube axis on the outside surface of the tube, to have a depth not exceeding 12½ % of the specified wall thickness of the tube or 0.004 in. (0.1 mm), whichever is greater. The length of the notch shall be compatible with the testing method.

25.8.3 *For ultrasonic testing*, the reference ID and OD notches shall be any one of the three common notch shapes shown in Practice E 213, at the option of the manufacturer. The depth of the notches shall not exceed 12½ % of the specified wall thickness of the tube or 0.004 in. (0.1 mm), whichever is greater. The width of the notch shall not exceed two times the depth. For welded tubing, the notches shall be placed in the weld, if the weld is visible.

25.8.4 *For flux leakage testing*, the longitudinal reference notches shall be straight-sided notches machined in a radial plane parallel to the tube axis on the inside and outside surfaces of the tube. Notch depth shall not exceed 12½ % of the specified wall thickness or 0.004 in. (0.1 mm), whichever is greater. Notch length shall not exceed 1 in. (25.4 mm), and the width shall not exceed the depth. Outside and inside notches shall have sufficient separation to allow distinct identification of the signal from each notch.

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

25.9 *Standardization Procedure*:

25.9.1 The test apparatus shall be standardized at the beginning and end of each series of tubes of the same specified size (diameter and wall thickness), grade and heat treatment condition, and at intervals not exceeding 4 h during the examination of such tubing. More frequent standardizations may be performed at the manufacturer's option or may be required upon agreement between the purchaser and the manufacturer.

25.9.2 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 or shutdown.

25.9.3 The reference standard shall be passed through the test apparatus at the same speed and test system settings as the tube to be tested, except that, at the manufacturer's discretion, the tubes may be tested at a higher sensitivity.

25.9.4 The signal-to-noise ratio for the reference standard shall be 2.5:1 or greater, and the reference signal amplitude for each discontinuity shall be at least 50 % of full scale of the display. In establishing the noise level, extraneous signals from identifiable surface imperfections on the reference standard may be ignored. When reject filtering is used during UT testing, linearity must be demonstrated.

25.9.5 If, upon any standardization, the reference signal amplitude has decreased by 29 % (3.0 dB), the test apparatus shall be considered out of standardization. The test system settings may be changed, or the transducer(s), coil(s), or sensor(s) adjusted, and the unit restandardized, but all tubes tested since the last acceptable standardization must be retested.

25.10 *Evaluation of Imperfections*:

25.10.1 Tubing producing a test signal to or greater than the lowest signal produced by the reference standard shall be designated suspect, shall be clearly marked or identified, and shall be separated from the acceptable tubing.

25.10.2 Such suspect tubing shall be subject to one of the following three dispositions:

25.10.2.1 The tubes may be rejected without further examination, at the discretion of the manufacturer.

25.10.2.2 If the test signal was produced by imperfections such as scratches, surface roughness, dings, straightener marks, loose ID bead and cutting chips, steel die stamps, stop marks, tube reducer ripple, or chattered flash trim, the tubing may be accepted or rejected depending on visual observation of the severity of the imperfection, the type of signal it produces on the testing equipment used, or both.

25.10.2.3 If the test signal was produced by imperfections which cannot be identified, or was produced by cracks or crack-like imperfections, the tubing shall be rejected.

25.10.3 Any tubes with imperfections of the types in 25.10.2.2 and 25.10.2.3, exceeding 0.004 in. (0.1 mm) or 12½ % of the specified minimum wall thickness (whichever is greater) in depth shall be rejected.

25.10.4 Rejected tubes may be reconditioned and retested providing the wall thickness is not decreased to less than that

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required by this or the product specification. If grinding is performed, the outside diameter in the area of grinding may be reduced by the amount so removed. To be accepted, reconditioned tubes must pass the nondestructive examination by which they were originally rejected.

26. Certified Test Report

26.1 When specified in the purchase order or contract, the producer or supplier shall furnish a certified test report certifying that the material 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 that the results met the requirements of that specification, the supplementary requirements and the other requirements. A signature or notarization is not required on the certified test report, but the document shall be dated and shall clearly identify the organization submitting the report.

NOTE 2—Notwithstanding the absence of a signature or notarization, the organization submitting the report is responsible for the contents of the report.

26.2 In addition, the certified test report shall include the following information and test results, when applicable:

26.2.1 Heat Number,

26.2.2 Heat Analysis,

26.2.3 Product Analysis, when specified,

26.2.4 Tensile Properties,

26.2.5 Width of the gage length, when longitudinal strip tension test specimens are used,

26.2.6 Flattening Test acceptable,

26.2.7 Reverse Flattening Test acceptable,

26.2.8 Flaring Test acceptable,

26.2.9 Flange Test acceptable,

26.2.10 Hardness Test values,

26.2.11 Hydrostatic Test pressure,

26.2.12 Non-destructive Electric Test method,

26.2.13 Impact Test results, and

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

26.3 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.

26.4 The certified test report shall include a statement of explanation for the letter added to the specification number marked on the tubes (see 29.2), when 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 removal of the letter (that is, X, Y, or Z).

26.5 A test report, certificate of compliance, or similar document printed from or used in electronic form from an electronic data interchange (EDI) transmission shall be regarded as having the same validity as a counterpart printed in the certifier'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 supplier. Notwithstanding the absence of a signature, the organization submitting the EDI transmission is responsible for the content of the report.

27. Inspection

27.1 The inspector representing the purchaser shall have entry at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works that concern the manufacture of the material ordered. The manufacturer shall afford the inspector all reasonable facilities to satisfy him that the material is being furnished in accordance with 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 operation of the works.

28. Rejection

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

28.2 Material 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 material's suitability. Disposition of such material shall be a matter for agreement.

29. Product Marking

29.1 Each length of tube shall be legibly stenciled with the manufacturers's name or brand, the specification number, and grade. The marking need not include the year date of the specification. For tubes less than 1¼ in. [31.8 mm] in diameter and tubes 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 tubes are shipped.

29.2 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 Section 26.

29.3 *Bar Coding*—In addition to the requirements in 29.1 and 29.2, bar coding is acceptable as a supplemental identification method. The purchaser may specifiy in the order a specific bar coding system to be used.

30. Packaging, Marking, and Loading

30.1 When specified on the purchase order, packaging, marking, and loading for shipment shall be in accordance with the procedures of Practices A 700.

31. Government Procurement

31.1 *Scale Free Pipe*:

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31.1.1 When specified in the contract or order, the following requirements shall be considered in the inquiry contract or order, for agencies of the U.S. Government where scale free tube is required. These requirements shall take precedence if there is a conflict between these requirements and the product specification.

31.1.2 Tube shall be ordered to outside diameter (OD) and wall thickness.

31.1.3 *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. 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 his 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 when such inspections and tests are deemed necessary to ensure that the material conforms to the prescribed requirements.

31.1.4 *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
2 to 8	Entire lot
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

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

31.1.6 *Sampling for Tension and Bend Test*— One sample shall be taken from each lot. A lot shall consist of all tube 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.

31.1.7 *Hydrostatic and Ultrasonic Tests*— Each tube shall be tested by the ultrasonic (when specified) and hydrostatic tests.

31.1.8 Tube shall be free from heavy oxide or scale. The internal surface of hot finished ferritic steel tube shall be pickled or blast cleaned to a free of scale condition equivalent to the CSa2 visual standard listed in SSPC-SP 6. Cleaning shall be performed in accordance with a written procedure that has been shown to be effective. This procedure shall be available for audit.

31.1.9 In addition to the marking in Specification A 530/A 530M, each length of tube ¼ in. outside diameter and larger shall be marked with the following listed information. Marking shall be in accordance with Fed. Std. No. 183 and MIL-STD-792. (*a*) Outside diameter, wall thickness, and length (*b*) Heat or lot identification number.

31.1.10 Tube shall be straight to within the tolerances specified in Table 8:

31.1.11 When specified, each tube shall be ultrasonically examined in accordance with MIL-STD-271, except that the notch depth in the calibration standard shall be 5 % of the wall thickness or 0.005 in., whichever is greater. Any tube which produces an indication equal to or greater than 100 % of the indication from the calibration standard shall be rejected.

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

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

31.1.14 No weld repair by the manufacturer is permitted.

31.1.15 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 A 700 or Practice D 3951.

32. Keywords

32.1 alloy steel tube; austenitic stainless steel; carbon steel tube; general delivery; stainless steel tube; steel tube

TABLE 8 Straightness Tolerances

Specified OD (in.)	Specified Wall Thickness (in.)	Maximum Curvature in Any 3 ft (in.)	Maximum Curvature in Total Length (in.)
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

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SUMMARY OF CHANGES

Committee A01 has identified the location of selected changes to this specification since the last issue, A 450/A 450M – 04a, which may impact the use of this specification. (Approved November 1, 2007)

(*1*) Revised the title.
(*2*) Deleted reference to Specification A 539 in 1.1 and Referenced Documents.
(*3*) Revised 9.1.
(*4*) Deleted 9.3.
(*5*) Revised 18.1.
(*6*) Revised 21.1.
(*7*) Deleted 29.2 and renumbered subsequent paragraphs.
(*8*) Revised 29.3.
(*9*) Revised Table 5.

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