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Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service[1]

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This standard has been approved for use by agencies of the Department of Defense. Consult the DoD Index of Specifications and Standards for the specific year of issue which has been adopted by the Department of Defense.

1. Scope

1.1 This specification[2] covers seamless carbon steel pipe for high-temperature service (Note 1) in NPS ⅛ to NPS 48 inclusive, with nominal (average) wall thickness as given in ANSI B36.10. It shall be permissible to furnish pipe having other dimensions provided such pipe complies with all other requirements of this specification. Pipe ordered under this specification shall be suitable for bending, flanging, and similar forming operations, and for welding. When the steel is to be welded, it is presupposed that a welding procedure suitable to the grade of steel and intended use or service will be utilized (Note 2).

NOTE 1—It is suggested, consideration be given to possible graphitization.

NOTE 2—The purpose for which the pipe is to be used should be stated in the order. Grade A rather than Grade B or Grade C is the preferred grade for close coiling or cold bending. This note is not intended to prohibit the cold bending of Grade B seamless pipe.

1.2 Supplementary requirements (S1 to S7) of an optional nature are provided for seamless pipe intended for use in applications where a superior grade of pipe is required. These supplementary requirements call for additional tests to be made and when desired shall be so stated in the order.

1.3 When these products are to be used in applications conforming to ISO Recommendations for Boiler Construction, the requirements of Specification A 520 (Mechanical Property Requirements Section) shall supplement and supersede the requirements of this specification.

1.4 The values stated in inch-pound units are to be regarded as the standard.

NOTE 3—The dimensionless designator NPS (nominal pipe size) has been substituted in this standard for such traditional terms as "nominal diameter", "size", and "nominal size".

1.5 The following precautionary caveat pertains only to the test method portion, Sections 11, 12, 13, 14, and 15, 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:*

A 520 Specification for Supplementary Requirements for Seamless and Electric-Resistance-Welded Carbon Steel Tubular Products for High-Temperature Service Conforming to ISO Recommendations for Boiler Construction[3]

A 530/A530M Specification for General Requirements for Specialized Carbon and Alloy Steel Pipe[3]

E 29 Practice for Using Significant Digits in Test Data to Determine Conformance With Specifications[4]

E 213 Practice for Ultrasonic Examination of Metal Pipe and Tubing[5]

E 309 Practice for Eddy-Current Examination of Steel Tubular Products Using Magnetic Saturation[5]

E 381 Method of Macroetch Testing, Inspection, and Rating Steel Products, Comprising Bars, Billets, Blooms, and Forgings[6]

E 570 Practice for Flux Leakage Examination of Ferromagnetic Steel Tubular Products[5]

2.2 *ANSI Standard:*

ANSI B36.10 Welded and Seamless Wrought Steel Pipe[3]

2.3 *Military Standards:*

MIL-STD-129 Marking for Shipment and Storage[7]

MIL-STD-163 Steel Mill Products, Preparation for Shipment and Storage[7]

2.4 *Federal Standard:*

Fed. Std. No. 123 Marking for Shipments (Civil Agencies)[7]

Fed. Std. No. 183 Continuous Identification Marking of Iron and Steel Products[7]

2.5 *Other Standards:*

[1] This specification is under the jurisdiction of Committee A-1 on Steel, Stainless Steel, and Related Alloys, and is the direct responsibility of Subcommittee A01.09 on Carbon Steel Tubular Products.

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[2] For ASME Boiler and Pressure Vessel Code applications see related Specifications SA-106 in Section II of that Code.

[3] *Annual Book of ASTM Standards*, Vol 01.01.

[4] *Annual Book of ASTM Standards*, Vol 14.02.

[5] *Annual Book of ASTM Standards*, Vol 03.03.

[6] *Annual Book of ASTM Standards*, Vol 03.01.

[7] Available from Standardization Documents Order Desk, Bldg. 4 Section D, 700 Robbins Ave., Philadelphia, PA 19111-5094, Attn: NPODS.

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SSPC-SP 6 Surface Preparation Specification No. 6[8]

3. Ordering Information

3.1 The inclusion of the following, as required will describe the desired material adequately, when ordered under this specification:

3.1.1 Quantity (feet or number of lengths),

3.1.2 Name of material (seamless carbon steel pipe),

3.1.3 Grade (Table 1),

3.1.4 Manufacture (hot-finished or cold-drawn),

3.1.5 Size (either NPS and weight class or schedule number, or both, or outside diameter and nominal wall thickness, ANSI B36.10),

3.1.6 Length (specific or random, Section 20),

3.1.7 Optional requirements (Section 9 and S1 to S4),

3.1.8 Test report required (Section on Certification of Specification A 530/A 530M),

3.1.9 Specification designation,

3.1.10 End use of material,

3.1.11 Hydrostatic test in accordance with Specification A 530/A 530M or 13.3 of this specification, or NDE in accordance with Section 14 of this specification.

3.1.12 Special requirements.

4. Process

4.1 The steel shall be killed steel, with the primary melting process being open-hearth, basic-oxygen, or electric-furnace, possibly combined with separate degassing or refining. If secondary melting, using electroslag remelting or vacuum-arc remelting is subsequently employed, the heat shall be defined as all of the ingots remelted from a single primary heat.

4.2 Steel cast in ingots or strand cast is permissible. When steels of different grades are sequentially strand cast, identification of the resultant transition material is required. The producer shall remove the transition material by any established procedure that positively separates the grades.

4.3 For pipe NPS 1½ and under, it shall be permissible to furnish hot finished or cold drawn.

4.4 Unless otherwise specified, pipe NPS 2 and over shall be furnished hot finished. When agreed upon between the manufacturer and the purchaser, it is permissible to furnish cold-drawn pipe.

5. Heat Treatment

5.1 Hot-finished pipe need not be heat treated. Cold-drawn pipe shall be heat treated after the final cold draw pass at a temperature of 1200°F (650°C) or higher.

6. General Requirements

6.1 Material furnished to this specification shall conform to the applicable requirements of the current edition of Specification A 530/A 530M unless otherwise provided herein.

[8] Available from Steel Structures Painting Council, 4400 5th Ave., Pittsburgh, PA 15213-2683.

7. Chemical Composition

7.1 The steel shall conform to the requirements as to chemical composition prescribed in Table 1.

TABLE 1 Chemical Requirements

	Composition, %		
	Grade A	Grade B	Grade C
Carbon, max[A]	0.25	0.30	0.35
Manganese	0.27–0.93	0.29–1.06	0.29–1.06
Phosphorus, max	0.035	0.035	0.035
Sulfur, max	0.035	0.035	0.035
Silicon, min	0.10	0.10	0.10
Chrome, max[B]	0.40	0.40	0.40
Copper, max[B]	0.40	0.40	0.40
Molybdenum, max[B]	0.15	0.15	0.15
Nickel, max[B]	0.40	0.40	0.40
Vanadium, max[B]	0.08	0.08	0.08

[A] For each reduction of 0.01 % below the specified carbon maximum, an increase of 0.06 % manganese above the specified maximum will be permitted up to a maximum of 1.35 %.

[B] These five elements combined shall not exceed 1 %.

8. Heat Analysis

8.1 An analysis of each heat of steel shall be made by the steel manufacturer to determine the percentages of the elements specified in Section 7. If the secondary melting processes of 5.1 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 manufacturer, if the latter has not manufactured the steel, shall be reported to the purchaser or the purchaser's representative, and shall conform to the requirements specified in Section 7.

9. Product Analysis

9.1 At the request of the purchaser, analyses of two pipes from each lot (Note 4) of 400 lengths or fraction thereof, of each size up to, but not including, NPS 6, and from each lot of 200 lengths or fraction thereof of each size NPS 6 and over, shall be made by the manufacturer from the finished pipe. The results of these analyses shall be reported to the purchaser or the purchaser's representative and shall conform to the requirements specified in Section 7.

9.2 If the analysis of one of the tests specified in 9.1 does not conform to the requirements specified in Section 7, analyses shall be made on additional pipes of double the original number from the same lot, each of which shall conform to requirements specified.

NOTE 4—A lot shall consist of the number of lengths specified in Sections 9 and 20 of the same size and wall thickness from any one heat of steel.

10. Tensile Requirements

10.1 The material shall conform to the requirements as to tensile properties prescribed in Table 2. Computed elongation values are contained in Table 3 and Table 4.

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TABLE 2 Tensile Requirements

	Grade A (Explanatory Note 2)		Grade B		Grade C	
Tensile strength, min, psi (MPa)	48 000 (330)		60 000 (415)		70 000 (485)	
Yield strength, min, psi (MPa)	30 000 (205)		35 000 (240)		40 000 (275)	
	Longitudinal	Transverse	Longitudinal	Transverse	Longitudinal	Transverse
Elongation in 2 in. or 50 mm, min, %:						
Basic minimum elongation transverse strip tests, and for all small sizes tested in full section	35	25	30	16.5	30	16.5
When standard round 2-in. or 50-mm gage length test specimen is used	28	20	22	12	20	12
For longitudinal strip tests	[A,B]		[A,B]		[A,B]	
For transverse strip tests, a deduction for each 1/32 -in. (0.8-mm) decrease in wall thickness below 5/16 in. (7.9 mm) from the basic minimum elongation of the following percentage shall be made		1.25[C]		1.00[C]		1.00[C]

[A]The minimum elogation in 2 in. (50.8 mm) shall be determined by the following equation:

$$e = 625\,000A^{0.2} / U^{0.9}$$

where:

e = minimum elongation in 2 in. (50.8 mm), %, rounded to the nearest 0.5%

A = cross-sectional area of the tension test specimen, in.^{2}, based on specified outside diameter or nominal specimen width and specified wall thickness rounded to the nearest 0.01 in.^{2}(if the area thus caluclated is greater than the value 0.75 in.^{2} shall be used), and

U = specified tensile strength, psi.

[B]See Table 4 for minimum elongation values for various size tension specimens and grades.

[C]Table 3 gives the computed minimum values:

TABLE 3 Computed Transverse Elongation[A]

Wall Thickness		Elongation in 2 in. or 50 mm, min, %	
in.	mm	Grade A, Transverse	Grades B and C, Transverse
5/16 (0.312)	7.9	25.00	16.50
9/32 (0.281)	7.1	23.75	15.50
1/4 (0.250)	6.4	22.50	14.50

[A]This table gives the computed minimum elongation values for each 1/32 -in. (0.8-mm) decrease in wall thickness. Where the wall thickness lies between two values shown above, the minimum elongation value is determined by the following equation:

Grade	Direction of Test	Equation
A	Transverse	$E = 40t + 12.50$
B and C	Transverse	$E = 32t + 6.50$

where:

E = elongation in 2 in. or 50 mm, %, and

t = actual thickness of specimen, in.

TABLE 4 Elongation Values

Area, in.^{2A}	Tension Test Specimen Wall Thickness, in.[B]				Elongation in 2 in. min., Specified Tensile Strength, psi		
					Grade A	*Grade B*	*Grade C*
	1/2 in. Specimen	3/4 in. Specimen	1 in. Specimen	1 1/2 in. Specimen	48 000	60 000	70 000
> 0.75	≥ 1.491	≥ 0.994	≥ 0.746	≥ 0.497	36.0	29.5	25.5
0.74	1.470–1.490	0.980–0.993	0.735–0.745	0.490–0.496	36.0	29.5	25.5
0.73	1.451–1.469	0.967–0.979	0.726–0.734	0.484–0.489	36.0	29.5	25.5
0.72	1.430–1.450	0.954–0.966	0.715–0.725	0.477–0.483	36.0	29.5	25.5
0.71	1.411–1.429	0.941–0.953	0.706–0.714	0.471–0.476	35.5	29.0	25.5
0.70	1.390–1.410	0.927–0.940	0.695–0.705	0.464–0.470	35.5	29.0	25.5
0.69	1.371–1.389	0.914–0.926	0.686–0.694	0.457–0.463	35.5	29.0	25.5
0.68	1.350–1.370	0.900–0.913	0.675–0.685	0.450–0.456	35.5	29.0	25.0
0.67	1.331–1.349	0.887–0.899	0.666–0.674	0.444–0.449	35.5	29.0	25.0
0.66	1.310–1.330	0.874–0.886	0.655–0.665	0.437–0.443	35.0	29.0	25.0
0.65	1.291–1.309	0.861–0.873	0.646–0.654	0.431–0.436	35.0	28.5	25.0
0.64	1.270–1.290	0.847–0.860	0.635–0.645	0.424–0.430	35.0	28.5	25.0
0.63	1.251–1.269	0.834–0.846	0.626–0.634	0.417–0.423	35.0	28.5	25.0
0.62	1.230–1.250	0.820–0.833	0.615–0.625	0.410–0.416	35.0	28.5	25.0
0.61	1.211–1.229	0.807–0.819	0.606–0.614	0.404–0.409	34.5	28.5	24.5
0.60	1.190–1.210	0.794–0.806	0.595–0.605	0.397–0.403	34.5	28.5	24.5

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TABLE 4 *Continued*

Area, in.[2A]	Tension Test Specimen Wall Thickness, in.[B]				Elongation in 2 in. min., Specified Tensile Strength, psi		
					Grade A	*Grade B*	*Grade C*
	½ in. Specimen	¾ in. Specimen	1 in. Specimen	1 ½ in. Specimen	48 000	60 000	70 000
0.59	1.171–1.189	0.781–0.793	0.586–0.594	0.391–0.396	34.5	28.0	24.5
0.58	1.150–1.170	0.767–0.780	0.575–0.585	0.384–0.390	34.5	28.0	24.5
0.57	1.131–1.149	0.754–0.766	0.566–0.574	0.377–0.383	34.0	28.0	24.5
0.56	1.110–1.130	0.740–0.753	0.555–0.565	0.370–0.376	34.0	28.0	24.5
0.55	1.091–1.109	0.727–0.739	0.546–0.554	0.364–0.369	34.0	28.0	24.9
0.54	1.070–1.090	0.714–0.726	0.535–0.545	0.357–0.363	34.0	27.5	24.0
0.53	1.051–1.069	0.701–0.713	0.526–0.534	0.351–0.356	33.5	27.5	24.0
0.52	1.030–1.050	0.687–0.700	0.515–0.525	0.344–0.350	33.5	27.5	24.0
0.51	1.011–1.029	0.674–0.686	0.506–0.514	0.337–0.343	33.5	27.5	24.0
0.50	0.990–1.010	0.660–0.673	0.495–0.505	0.330–0.336	33.5	27.0	23.5
0.49	0.971–0.989	0.647–0.659	0.486–0.494	0.324–0.329	33.0	27.0	23.5
0.48	0.950–0.970	0.634–0.646	0.475–0.485	0.317–0.323	33.0	27.0	23.5
0.47	0.931–0.949	0.621–0.633	0.466–0.474	0.311–0.316	33.0	27.0	23.5
0.46	0.910–0.930	0.607–0.620	0.455–0.465	0.304–0.310	33.0	27.0	23.5
0.45	0.891–0.909	0.594–0.606	0.446–0.454	0.297–0.303	32.5	26.5	23.0
0.44	0.870–0.890	0.580–0.593	0.435–0.445	0.290–0.296	32.5	26.5	23.0
0.43	0.851–0.869	0.567–0.579	0.426–0.434	0.284–0.289	32.5	26.5	23.0
0.42	0.830–0.850	0.554–0.566	0.415–0.425	0.277–0.283	32.0	26.5	23.0
0.41	0.811–0.829	0.541–0.553	0.406–0.414	0.271–0.276	32.0	26.0	23.0
0.40	0.790–0.810	0.527–0.540	0.395–0.405	0.264–0.270	32.0	26.0	22.5
0.39	0.771–0.789	0.514–0.526	0.386–0.394	0.257–0.263	31.5	26.0	22.5
0.38	0.750–0.770	0.500–0.513	0.375–0.385	0.250–0.256	31.5	26.0	22.5
0.37	0.731–0.749	0.487–0.499	0.366–0.374	0.244–0.249	31.5	25.5	22.5
0.36	0.710–0.730	0.474–0.486	0.355–0.365	0.237–0.243	31.0	25.5	22.0
0.35	0.691–0.709	0.461–0.473	0.346–0.354	0.231–0.236	31.0	25.5	22.0
0.34	0.670–0.690	0.447–0.460	0.335–0.345	0.224–0.230	31.0	25.0	22.0
0.33	0.651–0.669	0.434–0.446	0.326–0.334	0.217–0.223	30.5	25.0	22.0
0.32	0.630–0.650	0.420–0.433	0.315–0.325	0.210–0.216	30.5	25.0	21.5
0.31	0.611–0.629	0.407–0.419	0.306–0.314	0.204–0.209	30.5	25.0	21.5
0.30	0.590–0.610	0.394–0.406	0.295–0.305	0.197–0.203	30.0	24.5	21.5
0.29	0.571–0.589	0.381–0.393	0.286–0.294	0.191–0.196	30.0	24.5	21.5
0.28	0.550–0.570	0.367–0.380	0.275–0.285	0.184–0.190	29.5	24.5	21.0
0.27	0.531–0.549	0.354–0.366	0.266–0.274	0.177–0.183	29.5	24.0	21.0
0.26	0.510–0.530	0.340–0.353	0.255–0.265	0.170–0.176	29.0	24.0	21.0
0.25	0.491–0.509	0.327–0.339	0.246–0.254	0.164–0.169	29.0	23.5	20.5
0.24	0.470–0.490	0.314–0.326	0.235–0.245	0.157–0.163	29.0	23.5	20.5
0.23	0.451–0.469	0.301–0.313	0.226–0.234	0.151–0.156	28.5	23.5	20.5
0.22	0.430–0.450	0.287–0.300	0.215–0.225	0.144–0.150	28.5	23.0	20.0
0.21	0.411–0.429	0.274–0.286	0.206–0.214	0.137–0.143	28.0	23.0	20.0
0.20	0.390–0.410	0.260–0.273	0.195–0.205	0.130–0.136	27.5	22.5	19.5
0.19	0.371–0.389	0.247–0.259	0.186–0.194	0.124–0.129	27.5	22.5	19.5
0.18	0.350–0.370	0.234–0.246	0.175–0.185	0.117–0.123	27.0	22.0	19.5
0.17	0.331–0.349	0.221–0.233	0.166–0.174	0.111–0.116	27.0	22.0	19.0
0.16	0.310–0.330	0.207–0.220	0.155–0.165	0.104–0.110	26.5	21.5	19.0
0.15	0.291–0.309	0.194–0.206	0.146–0.154	0.097–0.103	26.0	21.5	18.5
0.14	0.270–0.290	0.180–0.193	0.135–0.145	0.091–0.096	26.0	21.0	18.5
0.13	0.251–0.269	0.167–0.179	0.126–0.134	0.084–0.090	25.5	21.0	18.0
0.12	0.230–0.250	0.154–0.166	0.115–0.125	0.077–0.083	25.0	20.5	18.0
0.11	0.211–0.229	0.141–0.153	0.106–0.114	0.071–0.076	24.5	20.0	17.5
0.10	0.190–0.210	0.127–0.140	0.095–0.105	0.064–0.070	24.0	19.5	17.0
0.09	0.171–0.189	0.114–0.126	0.086–0.094	0.057–0.063	23.5	19.5	17.0
0.08	0.150–0.170	0.100–0.113	0.075–0.085	0.050–0.056	23.0	19.0	16.5
0.07	0.131–0.149	0.087–0.099	0.066–0.074	0.044–0.049	22.5	18.5	16.0
0.06	0.110–0.130	0.074–0.086	0.055–0.065	0.037–0.043	22.0	18.0	15.5
0.05	0.091–0.109	0.061–0.073	0.046–0.054	0.031–0.036	21.0	17.0	15.0
0.04	0.070–0.090	0.047–0.060	0.035–0.045	0.024–0.030	20.0	16.5	14.5
0.03	0.051–0.069	0.034–0.046	0.026–0.034	0.017–0.023	19.0	15.5	13.5
0.02	0.030–0.050	0.020–0.033	0.015–0.025	0.010–0.016	17.5	14.5	12.5
≤0.01	≤ 0.029	≤ 0.019	≤ 0.014	≤ 0.009	15.0	12.5	11.0

[A] 1 in.^{2} = 645.16 mm^2.
[B] 1 in. = 25.4 mm.

11. Bending Requirements

11.1 For pipe NPS 2 and under a sufficient length of pipe shall stand being bent cold through 90° around a cylindrical mandrel, the diameter of which is twelve times the outside diameter (as shown in ANSI B36.10) of the pipe, without developing cracks. When ordered for close coiling (Note 2), the pipe shall stand being bent cold through 180° around a cylindrical mandrel, the diameter of which is eight times the outside diameter (as shown in ANSI B36.10) of the pipe, without failure.

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11.2 Subject to the approval of the purchaser, for pipe whose diameter exceeds 10 in. (254 mm), it shall be permissible for the bend test to be substituted for the flattening test described in Section 12. The bend test specimens shall be bent at room temperature through 180° with the inside diameter of the bend being 1 in. (25.4 mm), without cracking on the outside portion of the bent portion.

11.3 For pipe whose diameter exceeds 25 in. (635 mm) and whose diameter to wall thickness ratio is 7.0 or less, the bend test described in 11.2 shall be conducted instead of the flattening test.

NOTE 5—Diameter to wall thickness ratio = specified outside diameter/nominal wall thickness.

Example: For 28 in. diameter 5.000 in. thick pipe the diameter to wall thickness ratio = 28/5 = 5.6.

12. Flattening Tests

12.1 Except as allowed by 11.2, for pipe over NPS 2, a section of pipe not less than 2½ in. (63.5 mm) in length shall be flattened cold between parallel plates until the opposite walls of the pipe meet. Flattening tests shall be in accordance with Specification A 530/A 530M, except that in the formula used to calculate the "*H*" value, the following "*e*" constants shall be used:

0.08 for Grade A
0.07 for Grades B and C

12.2 When low *D*-to- *t* ratio tubulars 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.

NOTE 6—The "*H*" values have been calculated for sizes from NPS 2½ to 24, inclusive, and are shown in Table X1.1 of this specification.

13. Hydrostatic Test

13.1 Each length of pipe shall withstand without leakage through the pipe wall, a hydrostatic test, except as provided for in 13.2, 13.3, and 13.4.

13.2 When specified by the purchaser, it shall be permissible for pipe to be tested by the nondestructive electric test described in Section 14 in lieu of the hydrostatic test.

13.3 When specified in the order, pipe shall be furnished without hydrostatic test and without the NDE in Section 14. In this case, each length so furnished shall include the mandatory marking of the letters "NH."

13.4 When the hydrostatic test and the NDE test are omitted and the lengths marked with the letters "NH", the certification, when required, shall clearly state "Not Hydro statically Tested", the specification number and material grade, as shown on the certification, shall be followed by the letters "NH".

14. Nondestructive Electric Test

14.1 When allowed by 13.2, each pipe shall be tested with a nondestructive electric test in accordance with Practice E 213, Practice E 309, or Practice E 570. In such cases, the marking of each length of pipe so furnished shall include the letters "NDE". It is the intent of this test to reject pipe with imperfections that produce test signals equal or greater than that of the calibration standard.

14.2 When the nondestructive electric test is performed, the lengths shall be marked with the letters "NDE". The certification, when required, shall state "Nondestructive Electric Tested" and shall indicate which of the tests was applied. Also the letters "NDE" shall be appended to the product specification number and material grade shown on the certification.

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

14.3.1 The reference standards defined in 14.4 through 14.6 are convenient standards for calibration of nondestructive testing equipment. The dimensions of such standards are not to be construed as the minimum sizes of imperfections detectable by such equipment.

14.3.2 The ultrasonic testing referred to in this specification is capable of detecting the presence and location of significant longitudinally or circumferentially oriented imperfections: however, different techniques need to be employed for the detection of such differently oriented imperfections. Ultrasonic testing is not necessarily capable of detecting short, deep imperfections.

14.3.3 The eddy current examination referenced in this specification has the capability of detecting significant imperfections, especially of the short abrupt type.

14.3.4 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, different techniques need to be employed for the detection of such differently oriented imperfections.

14.3.5 The hydrostatic test referred to in Section 13 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. Hydrostatic testing is not necessarily capable of detecting very tight, through-the-wall imperfections or imperfections that extend an appreciable distance into the wall without complete penetration.

14.3.6 A purchaser interested in ascertaining the nature (type, size, location, and orientation) of discontinuities that can be detected in the specific applications of these examinations is directed to discuss this with the manufacturer of the tubular product.

14.4 For ultrasonic testing, the calibration reference notches shall be, at the option of the producer, any one of the three common notch shapes shown in Practice E 213. The depth of notch shall not exceed 12½ % of the specified wall thickness of the pipe or 0.004 in. (0.102 mm), whichever is greater.

14.5 For eddy current testing, the calibration pipe shall contain, at the option of the producer, any one of the following discontinuities to establish a minimum sensitivity level for rejection:

14.5.1 *Drilled Hole*—The calibration pipe shall contain depending upon the pipe diameter three holes spaced 120° apart or four holes spaced 90° apart and sufficiently separated longitudinally to ensure separately distinguishable responses. The holes shall be drilled radially and completely through the pipe wall, care being taken to avoid distortion of the pipe while drilling. Depending upon the pipe diameter the calibration pipe

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shall contain the following hole:

≤½ in.	0.039 in. (1 mm)
>½ ≤1¼ in.	0.055 in. (1.4 mm)
>1¼ ≤2 in.	0.071 in. (1.8 mm)
>2 ≤5 in.	0.087 in. (2.2 mm)
>5 in.	0.106 in. (2.7 mm)

14.5.2 *Transverse Tangential Notch*—Using a round tool or file with a ¼in. (6.4-mm) diameter, a notch shall be filed or milled tangential to the surface and transverse to the longitudinal axis of the pipe. Said notch shall have a depth not exceeding 12½ % of the specified wall thickness of the pipe or 0.004 in. (0.102 mm), whichever is greater.

14.5.3 *Longitudinal Notch*—A notch 0.031 in. (0.787 mm) or less in width shall be machined in a radial plane parallel to the tube axis on the outside surface of the pipe, to have a depth not exceeding 12½ % of the specified wall thickness of the tube or 0.004 in. (0.102 mm), whichever is greater. The length of the notch shall be compatible with the testing method.

14.5.4 *Compatibility*—The discontinuity in the calibration pipe shall be compatible with the testing equipment and the method being used.

14.6 For flux leakage testing, the longitudinal calibration reference notches shall be straight-sided notches machined in a radial plane parallel to the pipe axis. For wall thickness under ½ in. (12.7 mm), outside and inside notches shall be used; for wall thickness equal and above ½ in. (12.7 mm), only an outside notch shall be used. Notch depth shall not exceed 12½ % of the specified wall thickness, or 0.004 in. (0.102 mm), whichever is greater. Notch length shall not exceed 1 in. (25.4 mm), and the width shall not exceed the depth. Outside diameter and inside diameter notches shall be located sufficiently apart to allow separation and identification of the signals.

14.7 Pipe containing one or more imperfections that produce a signal equal to or greater than the signal produced by the calibration standard shall be rejected or the area producing the signal shall be reexamined.

14.7.1 Test signals produced by imperfections which cannot be identified, or produced by cracks or crack-like imperfections shall result in rejection of the pipe, unless it is repaired and retested. To be accepted, the pipe must pass the same specification test to which it was originally subjected, provided that the remaining wall thickness is not decreased below that permitted by this specification. The OD at the point of grinding may be reduced by the amount so reduced.

14.7.2 Test signals produced by visual imperfections such as those listed below may be evaluated in accordance with the provisions of Section 18:

14.7.2.1 Dinges,

14.7.2.2 Straightener marks,

14.7.2.3 Cutting chips,

14.7.2.4 Scratches,

14.7.2.5 Steel die stamps,

14.7.2.6 Stop marks, or

14.7.2.7 Pipe reducer ripple.

14.8 The test methods described in this section are not necessarily capable of inspecting the end portion of pipes, a condition referred to as "end effect". The length of such end effect shall be determined by the manufacturer and, when specified in the purchase order, reported to the purchaser.

15. Nipples

15.1 Nipples shall be cut from pipe of the same dimensions and quality described in this specification.

16. Dimensions, Weight, and Permissible Variations

16.1 *Weight*—The weight of any length of pipe shall not vary more than 10 % over and 3.5 % under that specified. Unless otherwise agreed upon between the manufacturer and the purchaser, pipe in NPS 4 and smaller may be weighed in convenient lots; pipe larger than NPS 4 shall be weighed separately.

16.2 *Diameter*—Variations in outside diameter shall not exceed those specified in Table 5.

16.3 *Thickness*—The minimum wall thickness at any point shall not be more than 12.5 % under the nominal wall thickness specified.

NOTE 7—The minimum wall thicknesses on inspection of some of the available sizes are shown in Table X2.1.

17. Lengths

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

17.1.1 The lengths required shall be specified in the order, and

17.1.2 No jointers are permitted unless otherwise specified.

17.1.3 If definite lengths are not required, pipe may be ordered in single random lengths of 16 to 22 ft (4.8 to 6.7 m) with 5 % 12 to 16 ft (3.7 to 4.8 m), or in double random lengths with a minimum average of 35 ft (10.7 m) and a minimum length of 22 ft with 5 % 16 to 22 ft.

18. Workmanship, Finish and Appearance

18.1 The pipe manufacturer shall explore a sufficient number of visual surface imperfections to provide reasonable assurance that they have been properly evaluated with respect to depth. Exploration of all surface imperfections is not required but consideration should be given to the necessity of exploring all surface imperfections to assure compliance with 18.2.

18.2 Surface imperfections that penetrate more than 12½ % of the nominal wall thickness or encroach on the minimum wall thickness shall be considered defects. Pipe with such defects shall be given one of the following dispositions:

18.2.1 The defect shall be removed by grinding, provided that the remaining wall thickness is within the limits specified in 16.3.

TABLE 5 Variations in Outside Diameter

NPS Designator	Permissible Variations in Outside Diameter			
	Over		Under	
	in.	mm	in.	mm
⅛ to 1½, incl	1/64 (0.015)	0.40	1/64 (0.015)	0.40
Over 1½ to 4, incl	1/32 (0.031)	0.79	1/32 (0.031)	0.79
Over 4 to 8, incl	1/16 (0.062)	1.59	1/32 (0.031)	0.79
Over 8 to 18, incl	3/32 (0.093)	2.38	1/32 (0.031)	0.79
Over 18 to 26, incl	⅛ (0.125)	3.18	1/32 (0.031)	0.79
Over 26 to 34, incl	5/32 (0.156)	3.97	1/32 (0.031)	0.79
Over 34 to 48, incl	3/16 (0.187)	4.76	1/32 (0.031)	0.79

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18.2.2 Repaired in accordance with the repair welding provisions of 18.6.

18.2.3 The section of pipe containing the defect may be cut off within the limits of requirements on length.

18.2.4 Rejected.

18.3 To provide a workmanlike finish and basis for evaluating conformance with 18.2 the pipe manufacturer shall remove by grinding the following noninjurious imperfections:

18.3.1 Mechanical marks, abrasions (Note 8) and pits, any of which imperfections are deeper than 1/16 in. (1.58 mm).

18.3.2 Visual imperfections commonly referred to as scabs, seams, laps, tears, or slivers found by exploration in accordance with 18.1 to be deeper than 5 % of the nominal wall thickness.

18.4 At the purchaser's discretion, pipe shall be subjected to rejection if surface imperfections acceptable under 18.2 are not scattered, but appear over a large area in excess of what is considered a workmanlike finish. Disposition of such pipe shall be a matter of agreement between the manufacturer and the purchaser.

18.5 When imperfections or defects are removed by grinding, a smooth curved surface shall be maintained, and the wall thickness shall not be decreased below that permitted by this specification. The outside diameter at the point of grinding is permitted to be reduced by the amount so removed.

18.5.1 Wall thickness measurements shall be made with a mechanical caliper or with a properly calibrated nondestructive testing device of appropriate accuracy. In case of dispute, the measurement determined by use of the mechanical caliper shall govern.

18.6 Weld repair shall be permitted only subject to the approval of the purchaser and in accordance with Specification A 530/A 530M.

18.7 The finished pipe shall be reasonably straight.

NOTE 8—Marks and abrasions are defined as cable marks, dinges, guide marks, roll marks, ball scratches, scores, die marks, etc.

19. End Finish

19.1 The Pipe shall be furnished to the following practice, unless otherwise specified.

19.1.1 *NPS 1-1/2 and Smaller*—All walls shall be either plain-end square cut, or plain-end beveled at the option of the manufacturer.

19.1.2 *NPS 2 and Larger*—Walls through extra strong weights, shall be plain end-beveled.

19.1.3 *NPS 2 and Larger*—Walls over extra strong weights, shall be plain-end square cut.

NOTE 9—Plain-end beveled is defined as plain-end pipe having a bevel angle of 30°, +5° or -0°, as measured from a line drawn perpendicular to the axis of the pipe with a root face of 1/16 in. ± 1/32 in. (1.5875 ± 0.7938 mm). Other bevel angles may be specified by agreement between the purchaser and the manufacturer.

20. Number of Tests

20.1 The tensile requirements specified in Section 7 shall be determined on one length of pipe from each lot (Note 4) of 400 lengths or fraction thereof of each size under NPS 6, and from each lot of 200 lengths or fraction thereof of each size NPS 6 and over.

20.2 For pipe NPS 2 and under, the bend test specified in 11.1 shall be made on one pipe from each lot of 400 lengths or fraction thereof of each size. The bend test, where used as permitted by 11.2 or required by 11.3, shall be made on one end of 5 % of the pipe from each lot. For small lots, at least one pipe shall be tested.

20.3 The flattening test specified in Section 12 shall be made on one length of pipe from each lot of 400 lengths or fraction thereof of each size over NPS 2, up to but not including NPS 6, and from each lot of 200 lengths or fraction thereof, of each size NPS 6 and over.

20.4 Each length of pipe shall be subjected to the hydrostatic test specified in Section 13.

20.5 If any test specimen shows defective machining or develops flaws, it is permissible to discard the flawed specimen and substitute another specimen.

21. Retests

21.1 If the percentage of elongation of any tension test specimen is less than that prescribed in Table 1 and any part of the fracture is more than 3/4in. (19.0 mm) from the center of the gage length of a 2-in., or 50-mm, specimen as indicated by scribe scratches marked on the specimen before testing, a retest shall be allowed. If a specimen breaks in an inside or outside surface flaw, a retest shall be allowed.

21.2 Should a crop end of a finished pipe fail in the flattening test, one retest is permitted to be made from the failed end. Pipe shall be normalized either before or after the first test, but pipe shall be subjected to only two normalizing treatments.

22. Test Specimens and Test Methods

22.1 On NPS 8 and larger, specimens cut either longitudinally or transversely shall be acceptable for the tension test. On sizes smaller than NPS 8, the longitudinal test only shall be used.

22.2 Test specimens for the bend test specified in Section 11 and for the flattening tests shall consist of sections cut from a pipe. Specimens for flattening tests shall be smooth on the ends and free from burrs, except when made on crop ends.

22.3 Test specimens for the bend test specified in 11.2 and 11.3 shall be cut from one end of the pipe and, unless otherwise specified, shall be taken in a transverse direction. One test specimen shall be taken as close to the outer surface as possible and another from as close to the inner surface as possible. The specimens shall be either 1/2 by 1/2 in. (12.7 by 12.7 mm) in section or 1 by 1/2 in. (25.4 by 12.7 mm) in section with the corners rounded to a radius not over 1/16 in. (1.6 mm) and need not exceed 6 in. (152 mm) in length. The side of the samples placed in tension during the bend shall be the side closest to the inner and outer surface of the pipe respectively.

22.4 All routine check tests shall be made at room temperature.

23. Certification

23.1 When test reports are requested, in addition to the requirements of Specification A 530/A 530M, the producer or supplier shall furnish to the purchaser a chemical analysis report for the elements specified in Table 1.

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24. Product Marking

24.1 In addition to the marking prescribed in Specification A 530/A 530M, the marking shall include heat number, the information as per Table 6, an additional symbol "S" if one or more of the supplementary requirements apply; the length; the schedule number, weight class, or nominal wall thickness, and for sizes larger than NPS 4 the weight. Length shall be marked in feet and tenths of a foot, or metres to two decimal places, depending on the units to which the material was ordered, or other marking subject to agreement. For sizes NPS 1½, 1¼, 1, and ¾, each length shall be marked as prescribed in Specification A 530/A 530M. These sizes shall be bundled in accordance with standard mill practice and the total bundle footage marked on the bundle tag; individual lengths of pipe need not be marked with footage. For sizes less than NPS ¾, all the required markings shall be on the bundle tag or on each length of pipe and shall include the total footage; individual lengths of pipe need not be marked with footage. If not marked on the bundle tag, all required marking shall be on each length.

24.2 When pipe sections are cut into shorter lengths by a subsequent processor for resale as material, the processor shall transfer complete identifying information, including the name or brand of the manufacturer to each unmarked cut length, or to metal tags securely attached to bundles of unmarked small diameter pipe. The same material designation shall be included with the information transferred, and the processor's name, trademark, or brand shall be added.

24.3 *Bar Coding*—In addition to the requirements in24.1 and 24.2, bar coding is acceptable as a supplementary identification method. The purchaser may specify in the order a specific bar coding system to be used.

TABLE 6 Marking

Hydro	NDE	Marking
Yes	No	Test Pressure
No	Yes	NDE
No	No	NH
Yes	Yes	Test Pressure/NDE

25. Government Procurement

25.1 When specified in the contract, material shall be preserved, packaged, and packed in accordance with the requirements of MIL-STD-163. The applicable levels shall be as specified in the contract. Marking for the shipment of such material shall be in accordance with Fed. Std. No. 123 for civil agencies and MIL-STD-129 or Fed. Std. No. 183 if continuous marking is required for military agencies.

25.2 *Inspection*—Unless otherwise specified in the contract, the producer is responsible for the performance of all inspection and test requirements specified herein. Except as otherwise specified in the contract, the producer shall use his own, or any other suitable facilities for the performance of the inspection and test requirements specified herein, unless disapproved by the purchaser. The purchaser shall have the right to perform any of the inspections and tests set forth in this specification where such inspections are deemed necessary to ensure that the material conforms to the prescribed requirements.

26. Keywords

26.1 carbon steel pipe; seamless steel pipe; steel pipe

SUPPLEMENTARY REQUIREMENTS

One or more of the following supplementary requirements shall apply only when specified in the purchase order. The purchaser may specify a different frequency of test or analysis than is provided in the supplementary requirement. Subject to agreement between the purchaser and manufacturer, retest and retreatment provisions of these supplementary requirements may also be modified.

S1. Product Analysis

S1.1 Product analysis shall be made on each length of pipe. Individual lengths failing to conform to the chemical composition requirements shall be rejected.

S2. Transverse Tension Test

S2.1 A transverse tension test shall be made on a specimen from one end or both ends of each pipe NPS 8 and over. If this supplementary requirement is specified, the number of tests per pipe shall also be specified. If a specimen from any length fails to meet the required tensile properties (tensile, yield, and elongation), that length shall be rejected subject to retreatment in accordance with Specification A 530/A 530M and satisfactory retest.

S3. Flattening Test

S3.1 The flattening test of Specification A 530/A 530M shall be made on a specimen from one end or both ends of each pipe. Crop ends may be used. If this supplementary requirement is specified, the number of tests per pipe shall also be specified. If a specimen from any length fails because of lack of ductility prior to satisfactory completion of the first step of the flattening test requirement, that pipe shall be rejected subject to retreatment in accordance with Specification A 530/A 530M and satisfactory retest. If a specimen from any length of pipe fails because of a lack of soundness, that length shall be rejected, unless subsequent retesting indicates that the remaining length is sound.

S4. Metal Structure and Etching Test

S4.1 The steel shall be homogeneous as shown by etching tests conducted in accordance with the appropriate sections of Method E 381. Etching tests shall be made on a cross section from one end or both ends of each pipe and shall show sound and reasonably uniform material free from injurious laminations, cracks, and similar objectionable defects. If this

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supplementary requirement is specified, the number of tests per pipe required shall also be specified. If a specimen from any length shows objectionable defects, the length shall be rejected, subject to removal of the defective end and subsequent retests indicating the remainder of the length to be sound and reasonably uniform material.

S5. Carbon Equivalent

S5.1 The steel shall conform to a carbon equivalent (CE) of 0.50 maximum as determined by the following formula:

$$CE = \%C + \frac{\%Mn}{6} + \frac{\%Cr + \%Mo + \%V}{5} + \frac{\%Ni + \%Cu}{15}$$

S5.2 A lower CE maximum may be agreed upon between the purchaser and the producer.

S5.3 The CE shall be reported on the test report.

S6. Heat Treated Test Specimens

S6.1 At the request of the purchaser, one tensile test shall be performed by the manufacturer on a test specimen from each heat of steel furnished which has been either stress relieved at 1250°F or normalized at 1650°F, as specified by the purchaser. Other stress relief or annealing temperatures, as appropriate to the analysis, may be specified by agreement between the purchaser and the manufacturer. The results of this test shall meet the requirements of Table 2.

S7. Internal Cleanliness–Government Orders

S7.1 The internal surface of hot finished ferritic steel pipe and tube shall be manufactured to a free of scale condition equivalent to the visual standard listed 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.

APPENDIXES

(Nonmandatory Information)

X1. CALCULATED H VALUES FOR SEAMLESS PIPE

X1.1 Tables X1.1 and X1.2 list values for H to be used for the test of Section 12.

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TABLE X1.1 Calculated "H" Values for Seamless Pipe

Inch-Pound Units

NPS Designator	Outside Diameter, in.	Wall Thickness, in.	Schedule Number	Distance, in Inches, Between Plates "H" by Equation: $H = -\frac{(1+e)t}{e+t/D}$ Grade A	Grades B & C
2½	2.875	0.203	40	1.456	1.545
		0.276	80	1.694	1.779
		0.375	160	1.925	2.002
3	3.500	0.216	40	1.646	1.755
		0.300	80	1.955	2.062
		0.438	160	2.306	2.398
3½	4.000	0.226	40	1.788	1.912
		0.318	80	2.153	2.276
4	4.500	0.237	40	1.929	2.067
		0.337	80	2.350	2.489
		0.438	120	2.687	2.818
		0.531	160	2.896	3.022
5	5.563	0.258	40	2.205	2.372
		0.375	80	2.747	2.920
		0.500	120	3.179	3.346
		0.625	160	3.509	3.667
6	6.625	0.280	40	2.473	2.669
		0.432	80	3.213	3.419
		0.562	120	3.682	3.884
		0.719	160	4.116	4.307
8	8.625	0.250	20	2.477	2.702
		0.277	30	2.668	2.902
		0.322	40	2.964	3.210
		0.406	60	3.451	3.711
		0.500	80	3.914	4.181
		0.593	100	4.305	4.573
		0.719	120	4.750	5.013
		0.812	140	5.036	5.293
		0.906	160	5.288	5.538
10	10.750	0.250	20	2.615	2.868
		0.307	30	3.054	3.333
		0.365	40	3.459	3.757
		0.500	60	4.268	4.592
		0.593	80	4.738	5.070
		0.719	100	5.320	5.621
		0.843	120	5.747	6.077
		1.000	140	6.242	6.564
		1.125	160	6.580	6.892
12	12.750	0.250	20	2.711	2.985
		0.330	30	3.366	3.683
		0.406	40	3.921	4.266
		0.562	60	4.892	5.271
		0.687	80	5.542	5.934
		0.843	100	6.231	6.627
		1.000	120	6.817	7.209
		1.125	140	7.222	7.607
		1.312	160	7.747	8.119
14	14.000	0.250	10	2.759	3.045
		0.312	20	3.294	3.617
		0.375	30	3.792	4.146
		0.438	40	4.669	5.125
		0.593	60	5.234	5.647
		0.750	80	6.064	6.494
		0.937	100	6.887	7.322
		1.093	120	7.479	7.902
		1.250	140	7.974	8.397
		1.406	160	8.416	8.827
16	16.000	0.250	10	2.284	3.124
		0.312	20	3.387	3.730
		0.375	30	3.915	4.294
		0.500	40	4.854	5.284
		0.656	60	5.855	6.324
		0.843	80	6.861	7.352
		1.031	100	7.709	8.206
		1.218	120	8.426	8.919
		1.438	140	9.141	9.625
		1.593	160	9.579	10.050
18	18.000	0.250	10	2.876	3.189
		0.312	20	3.462	3.823
		0.438	30	4.535	4.963
		0.562	40	5.457	5.941
		0.750	60	6.656	7.185
		0.937	80	7.663	8.214
		1.156	100	8.657	9.216
		1.375	120	9.495	10.043
		1.562	140	10.115	10.660
		1.781	160	10.665	11.198
20	20.000	0.250	10	2.919	3.242
		0.375	20	4.101	4.521
		0.500	30	5.143	5.632
		0.593	40	5.841	6.367
		0.812	60	7.272	7.856
		1.031	80	8.464	9.072
		1.281	100	9.601	10.221
		1.500	120	10.452	11.069
		1.750	140	11.284	11.889
		1.968	160	11.913	12.504
24	24.000	0.250	10	2.986	3.326
		0.375	20	4.236	4.686
		0.562	30	5.869	6.437
		0.687	40	6.831	7.454
		0.968	60	8.690	9.390
		1.218	80	10.061	10.793
		1.531	100	11.449	12.244
		1.812	120	12.585	13.332
		2.062	140	13.424	14.150
		2.343	160	14.248	14.958

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TABLE X1.2 Calculated "H" Values for Seamless Pipe Continued

SI Units

NPS Designator	Outside Diameter, mm	Wall Thickness, mm	Schedule Number	Distance, in mm, Between Plates "H" by Equation: $H = -\frac{(1+e)t}{e+t/D}$ Grade A	Grades B & C
2½	73.0	5.16	40	37.0	39.2
		7.01	80	43.0	45.2
		9.52	160	48.9	50.8
3	88.9	5.49	40	41.8	44.6
		7.62	80	49.6	52.4
		11.13	160	58.6	60.9
3½	101.6	5.74	40	45.4	48.6
		8.08	80	54.7	57.8
4	114.3	6.02	40	49.0	52.5
		8.56	80	59.7	63.2
		11.13	120	67.0	71.6
		13.49	160	73.6	76.8
5	141.3	6.55	40	56.0	60.2
		9.52	80	69.8	74.2
		12.70	120	80.8	85.0
		15.88	160	89.1	93.1
6	168.3	7.11	40	62.8	67.8
		10.97	80	81.6	86.8
		14.27	120	93.5	98.6
		18.24	160	104.6	109.4
8	219.1	6.35	20	63.0	68.6
		7.04	30	67.8	73.7
		8.18	40	75.3	81.5
		10.31	60	87.7	94.3
		12.70	80	99.4	106.2
		15.06	100	109.4	116.2
		18.24	120	120.6	127.3
		20.62	140	127.9	134.4
		23.01	160	134.3	140.7
10	273.0	6.35	20	66.4	72.8
		7.80	30	77.6	84.7
		9.27	40	87.9	95.4
		12.70	60	108.4	116.6
		15.06	80	120.4	128.8
		18.24	100	135.1	142.8
		21.41	120	146.0	154.4
		25.40	140	158.6	166.7
		28.58	160	167.1	175.1
12	323.8	6.35	20	68.9	75.8
		8.38	30	85.5	93.6
		10.31	40	99.6	108.4
		14.27	60	124.3	133.9
		17.35	80	140.8	150.7
		21.41	100	158.3	168.3
		25.40	120	173.2	183.1
		28.58	140	183.4	193.2
		33.32	160	196.8	206.2
14	355.6	6.35	10	70.1	77.3
		7.92	20	83.7	91.8
		9.52	30	96.3	105.3
		11.13	40	118.6	130.2
		15.06	60	132.9	143.4
		19.05	80	154.0	165.0
		23.80	100	174.9	186.0
		27.76	120	190.0	200.7
		31.75	140	202.5	213.3
		35.71	160	213.8	224.2
16	406.4	6.35	10	71.7	79.4
		7.92	20	89.0	94.7
		9.52	30	99.4	109.1
		12.70	40	123.3	143.2
		16.66	60	148.7	160.6
		21.41	80	174.3	186.7
		26.19	100	195.8	208.4
		30.94	120	214.0	226.6
		36.53	140	232.2	244.5
		40.46	160	243.3	255.3
18	457.2	6.35	10	73.0	81.0
		7.92	20	87.9	97.1
		11.13	30	115.2	126.1
		14.27	40	139.5	150.9
		19.05	60	169.1	182.5
		23.80	80	194.6	208.6
		29.36	100	219.9	234.1
		34.92	120	241.2	255.1
		39.67	140	256.9	270.7
		45.24	160	270.9	284.4
20	508.0	6.35	10	74.1	82.4
		9.52	20	104.2	114.8
		12.70	30	130.6	143.0
		15.06	40	148.4	161.7
		20.62	60	184.7	199.5
		26.19	80	215.0	230.4
		32.54	100	243.9	259.6
		38.10	120	265.5	281.2
		44.45	140	286.6	302.0
		49.99	160	302.6	317.6
24	609.6	6.35	10	75.8	84.5
		9.52	20	107.6	119.0
		14.27	30	149.1	163.5
		17.35	40	173.5	189.3
		24.59	60	220.7	238.5
		30.94	80	255.6	274.1
		38.89	100	290.8	311.0
		46.02	120	319.7	338.6
		52.37	140	341.0	359.4
		59.51	160	361.9	379.9

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X2. MINIMUM WALL THICKNESS

X2.1 Table X2.1 lists minimum wall thicknesses for nominal pipe wall thickness.

TABLE X2.1 Mimimum 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. and
t_m = minimum wall thickness, in.
The wall thickness is expressed to three decimal places, the fourth decimal place being carried forward or dropped, in accordance with Practice E 29.

NOTE 2—This table covers some wall thicknesses associated with standard pipe sizes but is not meant to imply that these are the only thicknesses obtainable under this 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	1.73	0.060	1.52	0.281	7.14	0.246	6.25	0.864	21.94	0.756	19.20
0.083	2.11	0.073	1.85	0.294	7.47	0.257	6.53	0.875	22.22	0.766	19.46
0.088	2.24	0.077	1.96	0.300	7.62	0.262	6.65	0.906	23.01	0.793	20.14
0.091	2.31	0.080	2.03	0.307	7.80	0.269	6.83	0.938	23.82	0.821	20.85
0.095	2.41	0.083	2.11	0.308	7.82	0.270	6.86	0.968	24.59	0.847	21.51
0.109	2.77	0.095	2.41	0.312	7.92	0.273	6.93	1.000	25.40	0.875	22.22
0.113	2.87	0.099	2.51	0.318	8.07	0.278	7.06	1.031	26.19	0.902	22.91
0.119	3.02	0.104	2.64	0.322	8.18	0.282	7.16	1.062	26.97	0.929	23.60
0.125	3.18	0.109	2.77	0.330	8.38	0.289	7.34	1.094	27.79	0.957	24.31
0.126	3.20	0.110	2.79	0.337	8.56	0.295	7.49	1.125	28.58	0.984	24.99
0.133	3.38	0.116	2.95	0.344	8.74	0.301	7.64	1.156	29.36	1.012	25.70
0.140	3.56	0.122	3.10	0.358	9.09	0.313	7.95	1.219	30.96	1.066	27.08
0.141	3.58	0.123	3.12	0.365	9.27	0.319	8.10	1.250	31.75	1.094	27.79
0.145	3.68	0.127	3.23	0.375	9.52	0.328	8.33	1.281	32.54	1.121	28.47
0.147	3.73	0.129	3.28	0.382	9.70	0.334	8.48	1.312	33.32	1.148	29.16
0.154	3.91	0.135	3.43	0.400	10.16	0.350	8.89	1.375	34.92	1.203	30.56
0.156	3.96	0.136	3.45	0.406	10.31	0.355	9.02	1.406	35.71	1.230	31.24
0.172	4.37	0.150	3.81	0.432	10.97	0.378	9.60	1.438	36.53	1.258	31.95
0.179	4.55	0.157	3.99	0.436	11.07	0.382	9.70	1.500	38.10	1.312	33.32
0.188	4.78	0.164	4.17	0.438	11.12	0.383	9.73	1.531	38.89	1.340	34.04
0.191	4.85	0.167	4.24	0.469	11.91	0.410	10.41	1.562	39.67	1.367	34.72
0.200	5.08	0.175	4.44	0.500	12.70	0.438	11.13	1.594	40.49	1.395	35.43
0.203	5.16	0.178	4.52	0.531	13.49	0.465	11.81	1.635	41.53	1.431	36.35
0.210	5.33	0.184	4.67	0.552	14.02	0.483	12.27	1.750	44.45	1.531	38.89
0.216	5.49	0.189	4.80	0.562	14.27	0.492	12.50	1.781	45.24	1.558	39.57
0.218	5.54	0.191	4.85	0.594	15.09	0.520	13.21	1.812	46.02	1.586	40.28
0.219	5.56	0.192	4.88	0.600	15.24	0.525	13.34	1.875	47.62	1.641	41.68
0.226	5.74	0.198	5.03	0.625	15.88	0.547	13.89	1.969	50.01	1.723	43.76
0.237	6.02	0.207	5.26	0.656	16.66	0.574	14.58	2.000	50.80	1.750	44.45
0.250	6.35	0.219	5.56	0.674	17.12	0.590	14.99	2.062	52.37	1.804	45.82
0.258	6.55	0.226	5.74	0.688	17.48	0.602	15.29	2.125	53.98	1.859	47.22
0.276	7.01	0.242	6.15	0.719	18.26	0.629	15.98	2.200	55.88	1.925	48.90
0.277	7.04	0.242	6.15	0.750	19.05	0.656	16.66	2.344	59.54	2.051	52.10
0.279	7.09	0.244	6.19	0.812	20.62	0.710	18.03	2.500	63.50	2.188	55.58
0.280	7.11	0.245	6.22	0.844	21.44	0.739	18.77				

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