Designation: A 106 – 02a

Used in USDOE-NE standards

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

This standard is issued under the fixed designation A 106; 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 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 B 36.10. 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 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."

1.4 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 530/A 530M Specification for General Requirements for Specialized Carbon and Alloy Steel Pipe[3]

E 213 Practice for Ultrasonic Examination of Metal Pipe and Tubing[4]

E 309 Practice for Eddy-Current Examination of Steel Tubular Products Using Magnetic Saturation[4]

E 381 Method of Macroetch Testing Steel Bars, Billets, Blooms, and Forgings[5]

E 570 Practice for Flux Leakage Examination of Ferromagnetic Steel Tubular Products[4]

2.2 *ANSI Standard:*

ANSI B 36.10 Welded and Seamless Wrought Steel Pipe[6]

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:*

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),

[1] This specification is under the jurisdiction of Committee A01 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 03.03.

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

[6] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036.

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

[8] Available from Steel Structures Painting Council (SSPC), 40 24th St., 6th Floor, Pittsburgh, PA 15222-4656.

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

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 (NPS and weight class or schedule number, or both; outside diameter and nominal wall thickness; or inside diameter and nominal wall thickness),
3.1.6 Special outside diameter tolerance pipe (16.2.2),
3.1.7 Inside diameter tolerance pipe, over 10 in. (254 mm) ID (16.2.3),
3.1.8 Length (specific or random, Section 20),
3.1.9 Optional requirements (Section 9 and S1 to S7),
3.1.10 Test report required (Section on Certification of Specification A 530/A 530M),
3.1.11 Specification designation,
3.1.12 End use of material,
3.1.13 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.
3.1.14 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.



**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 %.

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.

## 7. Chemical Composition

7.1 The steel shall conform to the requirements as to chemical composition prescribed in Table 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 21 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.

**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**

| | | | | | Elongation in 2 in. min., Specified Tensile Strength, psi | | |
|---|---|---|---|---|---|---|---|
| | Tension Test Specimen Wall Thickness, in.[B] | | | | *Grade A* | *Grade B* | *Grade C* |
| Area, in.$^2$[A] | 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 |
| 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 |

**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 |
| 0.55 | 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 B 36.10) 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 B 36.10) of the pipe, without failure.

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 ten.

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 Except as allowed by 13.2, 13.3, and 13.4, each length of pipe shall be subjected to the hydrostatic test without leakage through the pipe wall.

13.2 As an alternative to the hydrostatic test at the option of the manufacturer or where specified in the purchase order, it shall be permissible for the full body of each pipe to be tested with a nondestructive electric test described in Section 14.

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

13.4 Where the hydrostatic test and the nondestructive electric test are omitted and the lengths marked with the letters "NH," the certification, where required, shall clearly state "Not Hydrostatically Tested," and the letters "NH" shall be appended to the product specification number and material grade shown on the certification.

## 14. Nondestructive Electric Test

14.1 As an alternative to the hydrostatic test at the option of the manufacturer or where specified in the purchase order as an alternative or addition to the hydrostatic test, the full body of each pipe shall be tested with a nondestructive electric test in accordance with Practice E 213, E 309, or 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 nondestructive electric test to reject pipe with imperfections that produce test signals equal to or greater than that produced by the applicable calibration standard.

14.2 Where the nondestructive electric test is performed, the lengths shall be marked with the letters "NDE." The certification, where 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 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 ¼ in. (6.4-mm) diameter, a notch shall be filed or milled tangential to the surface and transverse to the longitudinal axis of the pipe. Said notch shall have a depth not exceeding 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*—The tolerances for diameter shall be in accordance with the following:

16.2.1 Except for pipe ordered as special outside diameter tolerance pipe or as inside diameter tolerance pipe, variations in outside diameter shall not exceed those precribed in Table 5.

16.2.2 For pipe over 10 in. (254 mm) OD ordered as special outside diameter tolerance pipe, the outside diameter shall not vary more than 1 % over or 1 % under the specified outside diameter.

16.2.3 For pipe over 10 in. (254 mm) ID ordered as inside diameter tolerance pipe, the inside diameter shall not vary more than 1 % over or 1 % under the specified inside diameter.

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

**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 |