



# Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service<sup>1</sup>

This standard is issued under the fixed designation A106/A106M; 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 ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

## 1. Scope\*

1.1 This specification<sup>2</sup> covers seamless carbon steel pipe for high-temperature service (**Note 1**) in NPS 1/8 to NPS 48 [DN 6 to DN 1200] (**Note 2**) inclusive, with nominal (average) wall thickness as given in ASME B 36.10M. 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 1—It is suggested, consideration be given to possible graphitization.

NOTE 2—The dimensionless designator NPS (nominal pipe size) [DN (diameter nominal)] has been substituted in this standard for such traditional terms as “nominal diameter,” “size,” and “nominal size.”

1.2 Supplementary requirements 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 either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in non-conformance with the standard.

1.4 The following precautionary caveat pertains only to the test method portion, Sections 11, 12, and 13 of this specification: *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.5 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

## 2. Referenced Documents

### 2.1 ASTM Standards:<sup>3</sup>

[A530/A530M Specification for General Requirements for Specialized Carbon and Alloy Steel Pipe](#)

[E213 Practice for Ultrasonic Testing of Metal Pipe and Tubing](#)

[E309 Practice for Eddy Current Examination of Steel Tubular Products Using Magnetic Saturation](#)

[E381 Method of Macroetch Testing Steel Bars, Billets, Blooms, and Forgings](#)

[E570 Practice for Flux Leakage Examination of Ferromagnetic Steel Tubular Products](#)

### 2.2 ASME Standard:

[ASME B 36.10M Welded and Seamless Wrought Steel Pipe<sup>4</sup>](#)

### 2.3 Military Standards:

[MIL-STD-129 Marking for Shipment and Storage<sup>5</sup>](#)

[MIL-STD-163 Steel Mill Products, Preparation for Shipment and Storage<sup>5</sup>](#)

<sup>1</sup> 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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<sup>2</sup> For ASME Boiler and Pressure Vessel Code applications see related Specifications SA-106 in Section II of that Code.

<sup>3</sup> For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

<sup>4</sup> Available from American Society of Mechanical Engineers (ASME), ASME International Headquarters, Two Park Ave., New York, NY 10016-5990, http://www.asme.org.

<sup>5</sup> Available from Standardization Documents Order Desk, DODSSP, Bldg. 4, Section D, 700 Robbins Ave., Philadelphia, PA 19111-5098.

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

2.4 *Federal Standard:*

Fed. Std. No. 123 Marking for Shipments (Civil Agencies)<sup>5</sup>

Fed. Std. No. 183 Continuous Identification Marking of Iron and Steel Products<sup>5</sup>

2.5 *Other Standards:*

SSPC-SP 6 Surface Preparation Specification No. 6<sup>6</sup>

### 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, metres, 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 (NPS [DN] 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. [250 mm] ID (16.2.3),
- 3.1.8 Length (specific or random, Section 17),
- 3.1.9 Optional requirements (Section (S1 9 and S1 to S8); S9),
- 3.1.10 Test report required (Section on Certification of Specification A530/A530M),
- 3.1.11 Specification designation (A106 or A106M, including year-date),
- 3.1.12 End use of material,
- 3.1.13 Hydrostatic test in accordance with Specification A530/A530M 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 [DN 40] and under, it shall be permissible to furnish hot finished or cold drawn.

4.4 Unless otherwise specified, pipe NPS 2 [DN 50] and over shall be furnished hot finished. When agreed upon between the manufacturer and the purchaser, it is permissible to furnish cold-drawn pipe.

**TABLE 1 Chemical Requirements**

	Composition, %		
	Grade A	Grade B	Grade C
Carbon, max	0.25 <sup>A</sup>	0.30 <sup>B</sup>	0.35 <sup>B</sup>
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
Chromium, max <sup>C</sup>	0.40	0.40	0.40
Copper, max <sup>C</sup>	0.40	0.40	0.40
Molybdenum, max <sup>C</sup>	0.15	0.15	0.15
Nickel, max <sup>C</sup>	0.40	0.40	0.40
Vanadium, max <sup>C</sup>	0.08	0.08	0.08

<sup>A</sup> 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 %.

<sup>B</sup> Unless otherwise specified by the purchaser, 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 1.65 %.

<sup>C</sup> These five elements combined shall not exceed 1 %.

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

## 5. Heat Treatment

5.1 Hot-finished pipe need not be heat treated. When hot-finished pipe is heat treated, it shall be heat treated at a temperature of 1200 °F [650 °C] or higher.

5.2 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 **A530/A530M** 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 (see 20.1) 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.

## 10. Tensile Requirements

10.1 The material shall conform to the requirements as to tensile properties given in **Table 2**.

## 11. Bending Requirements

11.1 For pipe NPS 2 [DN 50] 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 ASME B 36.10M) of the pipe, without

**TABLE 2 Tensile Requirements**

	Grade A		Grade B		Grade C	
	Longitudinal	Transverse	Longitudinal	Transverse	Longitudinal	Transverse
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]	
Elongation in 2 in. [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. [50-mm] gauge length test specimen is used	28	20	22	12	20	12
For longitudinal strip tests	A		A		A	
For transverse strip tests, a deduction for each 1/32-in. [0.8-mm] decrease in wall thickness below 9/16 in. [7.9 mm] from the basic minimum elongation of the following percentage shall be made		1.25		1.00		1.00

<sup>A</sup> The minimum elongation in 2 in. [50 mm] shall be determined by the following equation:

$$e = 625000A^{0.2}/U^{0.9}$$

for inch-pound units, and

$$e = 1940A^{0.2}/U^{0.9}$$

for SI units,

where:

$e$  = minimum elongation in 2 in. [50 mm], %, rounded to the nearest 0.5 %,

$A$  = cross-sectional area of the tension test specimen, in.<sup>2</sup> [mm<sup>2</sup>], based upon specified outside diameter or nominal specimen width and specified wall thickness, rounded to the nearest 0.01 in.<sup>2</sup> [1 mm<sup>2</sup>]. (If the area thus calculated is equal to or greater than 0.75 in.<sup>2</sup> [500 mm<sup>2</sup>], then the value 0.75 in.<sup>2</sup> [500 mm<sup>2</sup>] shall be used.), and

$U$  = specified tensile strength, psi [MPa].

developing cracks. When ordered for close coiling, 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 ASME B 36.10M) of the pipe, without failure.

11.2 For pipe whose diameter exceeds 25 in. [635 mm] and whose diameter to wall thickness ratio, where the diameter to wall thickness ratio is the specified outside diameter divided by the nominal wall thickness, is 7.0 or less, the bend test shall be conducted. The bend test specimens shall be bent at room temperature through 180° with the inside diameter of the bend being 1 in. [25 mm] without cracking on the outside portion of the bent portion.

Example: For 28 in. [711 mm] diameter 5.000 in. [127 mm] thick pipe the diameter to wall thickness ratio =  $28/5 = 5.6$  [711/127 = 5.6].

## 12. Flattening Tests

12.1 Although testing is not required, pipe shall be capable of meeting the flattening test requirements of Supplementary Requirement S3, if tested.

## 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, it shall be permissible for pipe to 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.” It shall be permissible for pipe meeting the requirements of 13.1 or 13.2 to be furnished where pipe without either the hydrostatic or nondestructive electric test has been specified in the purchase order; in this case, such pipe need not be marked with the letters “NH.” Pipe that has failed either the hydrostatic test of 13.1 or the nondestructive electric test of 13.2 shall not be furnished as “NH” pipe.

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 E213, E309, or E570. 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 E213. The depth of notch shall not exceed 12½ % of the specified wall thickness of the pipe or 0.004 in. [0.1 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:

NPS	DN	Diameter of Drilled Hole
≤ ½	≤ 15	0.039 in. [1 mm]
> ½ ≤ 1¼	> 15 ≤ 32	0.055 in. [1.4 mm]
> 1¼ ≤ 2	> 32 ≤ 50	0.071 in. [1.8 mm]
> 2 ≤ 5	> 50 ≤ 125	0.087 in. [2.2 mm]
> 5	> 125	0.106 in. [2.7 mm]

14.5.2 *Transverse Tangential Notch*—Using a round tool or file with a ¼-in. [6-mm] diameter, a notch shall be filed or milled tangential to the surface and transverse to the longitudinal axis of the pipe. The notch shall have a depth not exceeding 12½ % of the specified wall thickness of the pipe or 0.004 in. [0.1 mm], whichever is greater.

14.5.3 *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 pipe, 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.

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 thicknesses under ½ in. [12.7 mm], outside and inside notches shall be used; for wall thicknesses equal to 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. [0.1 mm], whichever is greater. Notch length shall not exceed 1 in. [25 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, Mass, and Permissible Variations

16.1 *Mass*—The mass 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 [DN 100] and smaller may be weighed in convenient lots; pipe larger than NPS 4 [DN 100] shall be weighed separately.

16.2 *Diameter*—Except as provided for thin-wall pipe in paragraph 12.2 of Specification A530/A530M, 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 given in **Table 3**.

16.2.2 For pipe over 10 in. [250 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. [250 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 specified wall thickness.

## 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 or in double random lengths meeting the following requirements:

17.1.3.1 Single random lengths shall be 16 to 22 ft [4.8 to 6.7 m] in length, except that 5 % shall be permitted to be less than 16 ft [4.8 m] and none shall be less than 12 ft [3.7 m].

17.1.3.2 Double random lengths shall have a minimum average length of 35 ft [10.7 m] and shall have a minimum length of 22 ft [6.7 m], except that 5 % shall be permitted to be less than 22 ft [6.7 m] and none shall be less than 16 ft [4.8 m].

## 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**.

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 and abrasions—such as cable marks, dinges, guide marks, roll marks, ball scratches, scores, and die marks—and pits, any of which imperfections are deeper than 1/16 in. [1.6 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.

**TABLE 3 Variations in Outside Diameter**

NPS [DN Designator]	Permissible Variations in Outside Diameter			
	Over		Under	
	in.	mm	in.	mm
1/8 to 1½ [6 to 40], incl	1/64 (0.015)	0.4	1/64 (0.015)	0.4
Over 1½ to 4 [40 to 100], incl	1/32 (0.031)	0.8	1/32 (0.031)	0.8
Over 4 to 8 [100 to 200], incl	1/16 (0.062)	1.6	1/32 (0.031)	0.8
Over 8 to 18 [200 to 450], incl	3/32 (0.093)	2.4	1/32 (0.031)	0.8
Over 18 to 26 [450 to 650], incl	1/8 (0.125)	3.2	1/32 (0.031)	0.8
Over 26 to 34 [650 to 850], incl	5/32 (0.156)	4.0	1/32 (0.031)	0.8
Over 34 to 48 [850 to 1200], incl	3/16 (0.187)	4.8	1/32 (0.031)	0.8