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THE EXECUTIVE DIRECTOR 
OFFICE OF THE FEDERAL REGISTER 
WASHINGTON, D.C.
Standard Specification for
Seamless and Welded Steel Pipe for Low-Temperature Service

This specification covers nominal (average) wall seamless and welded carbon and alloy steel pipe intended for use at low temperatures. Several grades of ferritic steel are included as listed in Table 1. Some product sizes may not be available under this specification because heavier wall thicknesses have an adverse affect on low-temperature impact properties.

1. Scope

1.1 This specification covers nominal (average) wall seamless and welded carbon and alloy steel pipe intended for use at low temperatures. Several grades of ferritic steel are included as listed in Table 1. Some product sizes may not be available under this specification because heavier wall thicknesses have an adverse affect on low-temperature impact properties.

1.2 Supplementary Requirement S1 of an optional nature is provided. This shall apply only when specified by the purchaser.

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

NOTE 1—The dimensionless designator NPS (nominal pipe size) has been substituted in this standard for such traditional terms as “nominal diameter,” “size,” and “nominal size.”

2. Referenced Documents

2.1 ASTM Standards:

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

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

A 671 Specification for Electric-Fusion-Welded Steel Pipe for Atmospheric and Lower Temperatures

E 23 Test Methods for Notched Bar Impact Testing of Metallic Materials

3. General Requirements

3.1 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.

4. Ordering Information

4.1 Orders for material under this specification should include the following, as required, to describe the material adequately:

4.1.1 Quantity (feet, centimetres, or number of lengths),

4.1.2 Name of material (seamless or welded pipe),

4.1.3 Grade (Table 1),

4.1.4 Size (NPS or outside diameter and schedule number of average wall thickness),

4.1.5 Length (specific or random), (Section 12) (Permissible Variations in Length Section of Specification A 530/A 530M),

4.1.6 End finish (Ends Section of Specification A 530/A 530M),

4.1.7 Optional requirements, (heat analysis requirement in the Chemical composition Section of A530/A530M; 13.1.1 other temperatures for impact tests; 5.3.4 stress relieving; (see Hydrostatic Test Requirements Section of Specification A 530/A 530M); and 11.6 repair by welding),

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

4.1.9 Specification designation, and

4.1.10 Special requirements or exceptions to this specification.

5. Materials and Manufacture

5.1 Manufacture—The pipe shall be made by the seamless or welding process with the addition of no filler metal in the welding operation. Grade 4 shall be made by the seamless process.

NOTE 2—For electric-fusion-welded pipe, with filler metal added, see Specification A 671.

5.2 Heat Treatment:

5.2.1 All seamless and welded pipe, other than Grades 8 and 11, shall be treated to control their microstructure in accordance with one of the following methods:

5.2.1.1 Normalize by heating to a uniform temperature of not less than 1500°F [815°C] and cool in air or in the cooling chamber of an atmosphere controlled furnace.

5.2.1.2 Normalize as in 5.2.1.1, and, at the discretion of the manufacturer, reheat to a suitable tempering temperature.

5.2.1.3 For the seamless process only, reheat and control hot working and the temperature of the hot-finishing operation to a finishing temperature range from 1550 to 1750°F [845 to 945°C] and cool in a controlled atmosphere furnace from an initial temperature of not less than 1550°F [845°C].
5.2.1.4 Treat as in 5.2.1.3 and, at the discretion of the manufacturer, reheat to a suitable tempering temperature.

5.2.1.5 Seamless pipe of Grades 1, 6, and 10 may be heat treated by heating to a uniform temperature of not less than 1500°F [815°C], followed by quenching in liquid and reheating to a suitable tempering temperature, in place of any of the other heat treatments provided for in 5.2.1.

5.2.2 Grade 8 pipe shall be heat treated by the manufacturer by either of the following methods:

5.2.2.1 Quenched and Tempered—Heat to a uniform temperature of 1475 ± 25°F [800 ± 15°C]; hold at this temperature for a minimum time in the ratio of 1 h/in. [2 min/mm] of thickness, but in no case less than 15 min; quench by immersion in circulating water. Reheat until the pipe attains a uniform temperature within the range from 1050 to 1125°F [565 to 605°C]; hold at this temperature for a minimum time in the ratio of 1 h/in. [2 min/mm] of thickness, but in no case less than 15 min; cool in air or water quench at a rate no less than 300°F [165°C]/h.

5.2.2.2 Double Normalized and Tempered—Heat to a uniform temperature of 1650 ± 25°F [900 ± 15°C]; hold at this temperature for a minimum time in the ratio of 1 h/in. [2 min/mm] of thickness, but in no case less than 15 min; cool in air. Reheat until the pipe attains a uniform temperature of 1450 ± 25°F [790 ± 15°C]; hold at this temperature for a minimum time in the ratio of 1 h/in. [2 min/mm] of thickness, but in no case less than 15 min; cool in air. Reheat to a uniform temperature within the range from 1050 to 1125°F [565 to 605°C]; hold at this temperature for a minimum time in the ratio of 1 h/in. [2 min/mm] of thickness, but in no case less than 15 min; cool in air or water quench at a rate not less than 300°F [165°C]/h.

5.2.3 Whether to anneal Grade 11 pipe is per agreement between purchaser and supplier. When Grade 11 pipe is annealed, it shall be normalized in the range of 1400 to 1600°F [760 to 870°C].

5.2.4 Material from which test specimens are obtained shall be in the same condition of heat treatment as the pipe furnished. Material from which specimens are to be taken shall be heat treated prior to preparation of the specimens.

5.2.5 When specified in the order the test specimens shall be taken from full thickness test pieces which have been stress relieved after having been removed from the heat-treated pipe. The test pieces shall be gradually and uniformly heated to the prescribed temperature, held at that temperature for a minimum time in the ratio of 1 h/in. [2 min/mm] of thickness, but in no case less than 15 min; cool in air or water quench at a rate not less than 300°F [165°C]/h.

5.2.6.5 Seamless pipe of Grades 1, 3, 6, 7, and 10 shall be stress relieved at 1025 to 1085°F, [550 to 585°C], held for a minimum of 2 h for thickness up to 1.0 in. [25.4 mm], plus a minimum of 1 h for each additional inch [25.4 mm] of thickness and cooled at a minimum rate of 600°F [315°C]/h in air or water to a temperature not exceeding 600°F [315°C].

6. Chemical Composition

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

6.2 When Grades 1, 6, or 10 are ordered under this specification, supplying an alloy grade that specifically requires the addition of any element other than those listed for each billet or two samples of flat-rolled stock from each heat or lot may be made, to conform to the requirements specified. A lot of pipe shall consist of the following:

7. Product Analysis

7.1 At the request of the purchaser, an analysis of one billet or two samples of flat-rolled stock from each heat of or two pipes from each lot shall be made by the manufacturer. A lot of pipe shall consist of the following:

<table>
<thead>
<tr>
<th>NPS Designator</th>
<th>Length of Pipe in Lot</th>
</tr>
</thead>
<tbody>
<tr>
<td>Under 2</td>
<td>400 or fraction thereof</td>
</tr>
<tr>
<td>2 to 6</td>
<td>200 or fraction thereof</td>
</tr>
<tr>
<td>Over 6</td>
<td>100 or fraction thereof</td>
</tr>
</tbody>
</table>

7.2 The results of these analyses shall be reported to the purchaser or the purchaser's representative and shall conform to the requirements specified.

7.3 If the analysis of one of the tests specified in 7.1 does not conform to the requirements specified, an analysis of each billet or pipe from the same heat or lot may be made, and all billets or pipe conforming to the requirements shall be accepted.
### TABLE 3 - Tensile Requirements

<table>
<thead>
<tr>
<th>Grade 1</th>
<th>Grade 3</th>
<th>Grade 4</th>
<th>Grade 6</th>
<th>Grade 7</th>
<th>Grade 8</th>
<th>Grade 9</th>
<th>Grade 10</th>
<th>Grade 11</th>
</tr>
</thead>
<tbody>
<tr>
<td>psi</td>
<td>MPa</td>
<td>psi</td>
<td>MPa</td>
<td>psi</td>
<td>MPa</td>
<td>psi</td>
<td>MPa</td>
<td>psi</td>
</tr>
<tr>
<td>55,000</td>
<td>380</td>
<td>55,000</td>
<td>460</td>
<td>50,000</td>
<td>415</td>
<td>85,000</td>
<td>450</td>
<td>100,000</td>
</tr>
<tr>
<td>50,000</td>
<td>350</td>
<td>450</td>
<td>1240</td>
<td>55,000</td>
<td>415</td>
<td>85,000</td>
<td>450</td>
<td>75,000</td>
</tr>
<tr>
<td>65,000</td>
<td>450</td>
<td>65,000</td>
<td>400</td>
<td>55,000</td>
<td>415</td>
<td>85,000</td>
<td>450</td>
<td>85,000</td>
</tr>
<tr>
<td>80,000</td>
<td>550</td>
<td>80,000</td>
<td>500</td>
<td>55,000</td>
<td>415</td>
<td>85,000</td>
<td>450</td>
<td>85,000</td>
</tr>
</tbody>
</table>

**Elongation in 2 in. or 50 mm, (or 4D), min, %:**

- Basic minimum elongation for walls 5/6 in. [8 mm] and over in thickness, strip tests, and for all small sizes tested in full section.
- When standard round 2-in. or 50-mm gage length or proportionally smaller size test specimen with the gage length equal to 4D (4 times the diameter) is used.
- For strip tests, a deduction for each 1/32 in. [0.8 mm] decrease in wall thickness below 5/6 in. [8 mm] from the basic minimum elongation of the following percentage.

**NOTE:** The preceding table gives the computed minimum elongation values for each 1/32-in. [0.80-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:

\[
E = \frac{56t + 17.50}{t} \quad \text{for Grade 1, Grade 3, Grade 4, Grade 6, Grade 7, Grade 8, Grade 9, and Grade 10.}
\]

\[
E = \frac{1.87t + 15.00}{t} \quad \text{for Grade 11.}
\]

Where:

\[
E = \text{elongation in 2 in. or 50 mm, in %, and}
\]

\[
t = \text{actual thickness of specimen, in. [mm].}
\]
8. Tensile Requirements

8.1 The material shall conform to the requirements as to tensile properties prescribed in Table 3.

9. Impact Requirements

9.1 For Grades 1, 3, 4, 6, 7, 9, and 10, the notched-bar impact properties of each set of three impact specimens, including specimens for the welded joint in welded pipe with wall thicknesses of 0.120 in. (3 mm) and larger, when tested at temperatures in conformance with 14.1 shall be not less than the values prescribed in Table 4. The impact test is not required for Grade 11.

9.1.1 If the impact value of one specimen is below the minimum value, or the impact values of two specimens are less than the minimum average value but not below the minimum value permitted on a single specimen, a retest shall be allowed. The retest shall consist of breaking three additional specimens and each specimen must equal or exceed the required average value. When an erratic result is caused by a defective specimen, or there is uncertainty in test procedures, a retest will be allowed.

9.2 For Grade 8 each of the notched bar impact specimens shall display a lateral expansion opposite the notch of not less than 0.015 in. [0.38 mm].

9.2.1 When the average lateral expansion value for the three impact specimens equals or exceeds 0.015 in. [0.38 mm] and the value for one specimen is below 0.015 in. [0.38 mm] but not below 0.010 in. [0.25 mm], a retest of three additional specimens may be made. The lateral expansion of each of the retest specimens must equal or exceed 0.015 in. [0.38 mm].

9.2.2 Lateral expansion values shall be determined by the procedure in Test Methods and Definitions A 370.

9.2.3 The values of absorbed energy in foot-pounds and the fracture appearance in percentage shear shall be recorded for information. A record of these values shall be retained for a period of at least 2 years.

10. Lengths

10.1 If definite lengths are not required, pipe may be ordered in single random lengths of 16 to 22 ft (Note 3) with 5% 16 to 22 ft (Note 4) with 5% 16 to 22

9.2.4 The defective pipe may be rejected.

9.3 To provide a workmanlike finish and basis for evaluating conformance with 11.2, the pipe manufacturer shall remove by grinding the following:

11. Workmanship, Finish, and Appearance

11.1 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 may be necessary to assure compliance with 11.2.

11.2 Surface imperfections that penetrate more than 12 1/2 % 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:

11.2.1 The defect may be removed by grinding provided that the remaining wall thickness is within specified limits.

11.2.2 Repaired in accordance with the repair welding provisions of 11.6.

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

11.2.4 The defective pipe may be rejected.

11.3 When imperfections or defects are removed by grinding, a smooth curved surface shall be maintained, and the finished pipe shall be reasonably straight.

11.4 At the purchaser's discretion, pipe shall be subject to rejection if surface imperfections acceptable under 11.2 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.

11.5 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 may be reduced by the amount so removed.

11.5.1 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.

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

11.7 The finished pipe shall be reasonably straight.

12. Number of Tests Required

12.1 Transverse or Longitudinal Tensile Test and Flattening Test—For material heat treated in a batch-type furnace, tests shall be made on 5% of the pipe from each lot. When heat treated by the continuous process, tests shall be made on a sufficient number of pipe to constitute 5% of the lot, but in no case less than 2 pipes.

*Note 4*—The term "lot" applies to all pipe of the same nominal size and wall thickness (or schedule) which is produced from the same heat value(s) shall be agreed upon between the manufacturer and purchaser.

**TABLE 4 Impact Requirements for Grades 1, 3, 4, 6, 7, 9, and 10**

<table>
<thead>
<tr>
<th>Size of Specimen, mm</th>
<th>Minimum Average Notched Bar Impact Value of Each Set of Three Specimens</th>
<th>Minimum Notched Bar Impact Value of One Specimen Only of a Set</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 by 10</td>
<td>13</td>
<td>10</td>
</tr>
<tr>
<td>10 by 7.5</td>
<td>10</td>
<td>8</td>
</tr>
<tr>
<td>10 by 6.67</td>
<td>9</td>
<td>7</td>
</tr>
<tr>
<td>10 by 5</td>
<td>7</td>
<td>5</td>
</tr>
<tr>
<td>10 by 3.33</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>10 by 2.5</td>
<td>4</td>
<td>3</td>
</tr>
</tbody>
</table>

*Straight line interpolation for intermediate values is permitted.*
of steel and subjected to the same finishing treatment in a continuous furnace. When final heat treatment is in a batch-type furnace, the lot shall include only that pipe which is heat treated in the same furnace charge.

12.2 Hydrostatic Test—Each length of pipe shall be subjected to the hydrostatic test.

12.3 Impact Test—One notched bar impact test, consisting of breaking three specimens, shall be made from each heat represented in a heat-treatment load on specimens taken from the finished pipe. This test shall represent only pipe which is heat treated in the same furnace. When final heat treatment is in a batch-type furnace, the lot charge. "When final heat treatment is in a batch-type furnace, the lot charge."

12.4 Impact Tests (Welded Pipe)—On welded pipe, additional impact tests of the same number as required in 12.3 or 12.4 shall be made to test the weld.

12.5 Specimens showing defects while being machined or prior to testing may be discarded and replacements shall be considered as original specimens.

12.6 Results obtained from these tests shall be reported to the purchaser or his representative.

13. Specimens for Impact Test

13.1 Notched bar impact specimens shall be of the simple beam, Charpy-type, in accordance with Test Methods E 23, Type A with a V notch. Standard specimens 10 by 10 mm in cross section shall be used unless the material to be tested is of insufficient thickness, in which case the largest obtainable subsize specimens shall be used. Charpy specimens of width along the notch larger than 0.394 in. [10 mm] or smaller than 0.099 in. [2.5 mm] are not provided for in this specification.

13.2 Test specimens shall be obtained so that the longitudinal axis of the specimen is parallel to the longitudinal axis of the pipe while the axis of the notch shall be perpendicular to the surface. On wall thicknesses of 1 in. [25 mm] or less, the specimens shall be obtained with their axial plane located at the midpoint; on wall thicknesses over 1 in. [25 mm], the specimens shall be obtained with their axial plane located 1/2 in. [12.5 mm] from the outer surface.

13.3 When testing welds the specimen shall be, whenever diameter and thickness permit, transverse to the longitudinal axis of the pipe with the notch of the specimen in the welded joint and perpendicular to the surface. When diameter and thickness do not permit obtaining transverse specimens, longitudinal specimens in accordance with 13.2 shall be obtained; the bottom of the notch shall be located at the weld joint.

14. Impact Test

14.1 Except when the size of the finished pipe is insufficient to permit obtaining subsize impact specimens, all material furnished to this specification and marked in accordance with Section 15 shall be tested for impact resistance at the minimum temperature for the respective grades as shown in Table 5.

14.1.1 Special impact tests on individual lots of material may be made at other temperatures as agreed upon between the manufacturer and the purchaser.

14.1.2 When subsize Charpy impact specimens are used and the width along the notch is less than 80% of the actual wall thickness of the original material, the specified Charpy impact test temperature for Grades 1, 3, 4, 6, 7, 9, and 10 shall be lower than the minimum temperature shown in Table 5 for the respective grade. Under these circumstances the temperature reduction values shall be by an amount equal to the difference (as shown in Table 6) between the temperature correction corresponding to the actual material thickness and the temperature reduction corresponding to the Charpy specimen width actually tested. Appendix X1 shows some examples of how the temperature reductions are determined.

14.2 The notched bar impact test shall be made in accordance with the procedure for the simple beam, Charpy-type test of Methods E 23.

14.3 Impact tests specified for temperatures lower than 70°F [20°C] should be made with the following precautions. The impact test specimens as well as the handling tongs shall be cooled a sufficient time in a suitable container so that both reach the desired temperature. The temperature shall be measured with thermocouples, thermometers, or any other suitable devices and shall be controlled within 3°F [2°C]. The specimens shall be quickly transferred from the cooling device to the anvil of the Charpy impact testing machine and broken with a time lapse of not more than 5 s.

15. Product Marking

15.1 Except as modified in 15.1.1, in addition to the

| TABLE 5 Impact Temperature
<table>
<thead>
<tr>
<th>Grade</th>
<th>Minimum Impact Test Temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>°F</td>
</tr>
<tr>
<td>1</td>
<td>-50</td>
</tr>
<tr>
<td>3</td>
<td>-150</td>
</tr>
<tr>
<td>4</td>
<td>-150</td>
</tr>
<tr>
<td>6</td>
<td>-50</td>
</tr>
<tr>
<td>7</td>
<td>-100</td>
</tr>
<tr>
<td>8</td>
<td>-320</td>
</tr>
<tr>
<td>9</td>
<td>-100</td>
</tr>
<tr>
<td>10</td>
<td>-75</td>
</tr>
</tbody>
</table>

| TABLE 6 Impact Temperature Reduction
<table>
<thead>
<tr>
<th>Specimen Width Along Notch or Actual Material Thickness</th>
<th>Temperature Reduction, Degrees Colder</th>
</tr>
</thead>
<tbody>
<tr>
<td>in.</td>
<td>mm</td>
</tr>
<tr>
<td>0.394</td>
<td>10 (standard size)</td>
</tr>
<tr>
<td>0.354</td>
<td>9</td>
</tr>
<tr>
<td>0.315</td>
<td>8</td>
</tr>
<tr>
<td>0.295</td>
<td>7.5 (% std. size)</td>
</tr>
<tr>
<td>0.276</td>
<td>7</td>
</tr>
<tr>
<td>0.262</td>
<td>6.67 (% std. size)</td>
</tr>
<tr>
<td>0.236</td>
<td>6</td>
</tr>
<tr>
<td>0.197</td>
<td>5 (% std. size)</td>
</tr>
<tr>
<td>0.186</td>
<td>4</td>
</tr>
<tr>
<td>0.151</td>
<td>3.33 (% std. size)</td>
</tr>
<tr>
<td>0.118</td>
<td>3</td>
</tr>
<tr>
<td>0.099</td>
<td>2.5 (% std. size)</td>
</tr>
</tbody>
</table>

* Straight line interpolation for intermediate values is permitted.
A 333/A 333M

marking prescribed in Specification A 530/A 530M, the marking shall include whether hot finished, cold drawn, seamless or welded, the schedule number and the letters "LT" followed by the temperature at which the impact tests were made, except when a lower test temperature is required because of reduced specimen size, in which case, the higher impact test temperature applicable to a full-size specimen should be marked.

15.1.1 When the size of the finished pipe is insufficient to obtain subsize impact specimens, the marking shall not include the letters LT followed by an indicated test temperature unless Supplementary Requirement S1 is specified.

15.1.2 When the pipe is furnished in the quenched and tempered condition, the marking shall include the letters "QT", and the heat treatment condition shall be reported to the purchaser or his representative.

16. Keywords

16.1 low temperature service; seamless steel pipe; stainless steel pipe; steel pipe; temperature service applications, low

SUPPLEMENTARY REQUIREMENTS

The following supplementary requirement shall apply only when specified by the purchaser in the contract or order.

S1. Subsize Impact Specimens

S1.1 When the size of the finished pipe is insufficient to permit obtaining subsize impact specimens, testing shall be a matter of agreement between the manufacturer and the purchaser.

APPENDIX

(Nonmandatory Information)

X1. DETERMINATION OF TEMPERATURE REDUCTIONS

X1.1 Under the circumstances stated in 14.1.2, the impact test temperatures specified in Table 5 must be lowered. The following examples are offered to describe the application of the provisions of 14.1.2.

X1.1.1 When subsize specimens are used (see 11.1) and the width along the notch of the subsize specimen in 80% or greater of the actual wall thickness of the original material, the provisions of 14.1.2 do not apply.

X1.1.1.1 For example, if the actual wall thickness of pipe was 0.200 in. [5.0 mm] and the width along the Charpy specimen notch was 0.160 in. [4 mm] or greater, no reduction in test temperature is required.

X1.1.2 When the width along the subsize specimen notch is less than 80% of the actual wall thickness of the pipe, the required reduction in test temperature is computed by taking the difference between the temperature reduction values shown in Table 6 for the actual pipe thickness and the specimen width used.

X1.1.2.1 For example, if the pipe were 0.262 in. [6.67 mm] thick and the width along the Charpy specimen notch was 3.33 mm (1/3 standard size), the test temperature would have to be lowered by 25°F [14°C]. That is, the temperature reduction corresponding to the subsize specimen is 35°F [19°C]; the temperature reduction corresponding to the actual pipe thickness is 10°F [5°C]; the difference between these two values is the required reduction in test temperature.

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