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

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1. Scope

1.1 This specification[2] covers carbon steel pipe made by the centrifugal casting process intended for use in high-temperature, high-pressure service. Pipe ordered under this specification shall be suitable for fusion welding, bending, and other forming operations.

1.2 Several grades of carbon steels are covered. Their compositions are given in Table 1.

1.3 Supplementary requirements (S1 to S9) of an optional nature are provided. The supplementary requirements call for additional tests to be made, and when desired shall be so stated in the order, together with the number of such tests required.

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

2. Referenced Documents

2.1 *ASTM Standards:* [3]

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

E 94 Guide for Radiographic Testing

E 114 Practice for Ultrasonic Pulse-Echo Straight-Beam Examination by the Contact Method

E 125 Reference Photographs for Magnetic Particle Indications on Ferrous Castings

E 142 Method for Controlling Quality of Radiographic Testing

E 186 Reference Radiographs for Heavy-Walled (2 to 4½-in. (51 to 114-mm)) Steel Castings

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

E 446 Reference Radiographs for Steel Castings up to 2 in. (51 mm) in Thickness

TABLE 1 Chemical Requirements

	Composition, max,%		
	Grade WCA	Grade WCB	Grade WCC
Carbon	0.25[A]	0.30	0.25[B]
Manganese	0.70[A]	1.00	1.20[B]
Phosphorus	0.035	0.035	0.035
Sulfur	0.035	0.035	0.035
Silicon	0.60	0.60	0.60

[A] For each reduction of 0.01 % below the specified maximum carbon content, an increase of 0.04 % manganese above the specified maximum will be permitted up to a maximum of 1.10 %.

[B] For each reduction of 0.01 % below the specified maximum carbon content, an increase of 0.04 % manganese above the specified maximum will be permitted to a maximum of 1.40 %.

2.2 *ANSI Standards:*

B36.10 American Standard for Welded and Seamless Wrought Steel Pipe[4]

B46.1 Surface Texture[4]

2.3 *MSS Standards:*

SP-54 Quality Standard for Steel Castings—Radiographic Inspection Method[5]

3. Ordering Information

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

3.1.1 Quantity (feet, metres, or number of lengths),

3.1.2 Name of material (centrifugally cast pipe),

3.1.3 Grade (Table 1),

3.1.4 Size (outside or inside diameter and minimum wall thickness),

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

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

3.1.7 Optional Requirements (Sections 7.2, 8.2, 8.3, 11.1, Section 12 and S1 to S9 (Supplementary Requirements),

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

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

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[2] For ASME Boiler and Vessel Code applications see related Specification SA-660 in Section II of that Code.

[3] 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.

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

[5] Available from Manufacturers Standardization Society of the Valve and Fittings Industry (MSS), 127 Park St., NE, Vienna, VA 22180-4602.

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3.1.9 Specification designation, and
3.1.10 Special requirements.

4. General Requirements

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

5. Materials and Manufacture

5.1 *Machining*:
5.1.1 All centrifugally cast pipe shall have both the inner and outer surfaces machined.
5.1.2 After heat treatment, the pipe shall be machined to a finish with a roughness value no greater than 250 µin. (6.35 µm) arithmetical average deviation (AA), terms as defined in ANSI B46.1 unless otherwise specified.
5.2 *Heat Treatment*:
5.2.1 All pipe shall receive a heat treatment proper for its design and chemical composition.
5.2.2 Castings shall be heat treated after they have been allowed to cool below the transformation range.

6. Temperature Control

6.1 Furnace temperatures for heat treating shall be effectively controlled by pyrometers.

7. Chemical Requirements

7.1 The steel shall conform to the requirements as to chemical composition prescribed in Table 1.
7.2 *Product Analysis*:
7.2.1 At the request of the purchaser, a product analysis shall be made by the manufacturer on every heat.
7.2.2 The results of these analyses shall be reported to the purchaser or his representative, and shall conform to the requirements specified in Table 1.
7.2.3 If the analysis of one of the tests specified in 7.2.1 does not conform to the requirements specified, an analysis of each pipe from the same heat may be made, and all pipes conforming to the requirements shall be accepted.

8. Mechanical Requirements

8.1 *Tensile Properties*:
8.1.1 The material shall conform to the requirements as to tensile properties prescribed in Table 2.
8.1.2 *Transverse or Longitudinal Tension Test*—One test shall be made on a specimen from one end of one length of pipe representing each heat in each heat-treatment lot.
8.2 *Flattening Test*:

TABLE 2 Tensile Requirements

	WCA		WCB		WCC	
	ksi	MPa	ksi	MPa	ksi	MPa
Tensile strength, min	60	414	70	483	70	483
Yield strength, min	30	207	36	248	40	276
Elongation in 2 in. or 50 mm, min, %	24		22		22	
Reduction of area, min, %	35		35		35	

8.2.1 A flattening test shall be performed when requested by the purchaser or when stated by the purchaser on the order that the pipe is to be upset, swaged, expanded, bent, or formed by some other operation.
8.2.2 A flattening test need not be performed on heavy wall pipe which is not to be upset, swaged, expanded, bent, or formed in some other manner.
8.2.3 When required by 8.2, a test shall be made on specimens cut from one end of each length of pipe.
8.2.4 A flattening test when required shall be performed in accordance with the requirements for seamless and centrifugally cast pipe in the Flattening Test Requirements Section of Specification A 530/A 530M.

NOTE 1—In heavy-walled small-diameter tubing the flattening test specimen may be bored out so that the *OD/t* ratio will be greater than 11.0.

8.3 *Hydrostatic Test*:
8.3.1 Each length of pipe shall be hydrostatically tested in accordance with the Hydrostatic Test Requirements Section of Specification A 530/A 530M when requested by the purchaser and stated on the order. If performance of the hydrostatic test is not required by the purchaser, the manufacturer shall guarantee pipe to pass the test and mark each length of pipe with the letters "NH" immediately following the specification number, indicating that the pipe has not been hydrostatically tested.
8.3.2 When required by 8.3, each length of pipe shall be subjected to the hydrostatic test. The test pressure shall be maintained for not less than 5 min.

9. Permissible Variation in Wall Thickness

9.1 The wall thickness shall not vary over the specified minimum wall thickness by more than 10 %. There shall be no variation under the specified minimum wall thickness.

NOTE 2—A system of standard pipe sizes has been approved by the American National Standards Institute, as ANSI B36.10. This system may be used for obtaining pipe under this specification.

10. Workmanship and Finish

10.1 The pipe shall have a finish as provided in 5.2 and it shall be reasonably straight and free from injurious defects.

11. Rework and Retreatment

11.1 *Imperfections*—The surface of the casting shall be inspected visually for cracks and hot tears. These imperfections shall be removed, and their removal verified by visual inspection of the resultant cavities. Imperfections located by inspecting with Supplementary Requirements S7, S8, or S9 shall be removed or reduced to an acceptable size.
11.2 *Blending*—If removal of the imperfection does not infringe upon the minimum wall thickness, the depression may be blended uniformly into the surrounding surface.
11.3 *Repair by Welding*—Imperfections that infringe upon the minimum wall thickness may be repaired by welding subject to approval by the purchaser. Only qualified operators and procedures in accordance with ASME Boiler and Pressure Vessel Code, Section IX, shall be used. All weld repairs shall be inspected to the same quality standards used to inspect the pipe.

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11.4 *Reheat Treatment*—Local or full heat treatment in accordance with 5.2 shall follow welding. Local grinding following welding and retreating shall be considered as meeting the requirements of 5.1.

12. Product Marking

12.1 In addition to the marking prescribed in Specification A 530/A 530M, the marking shall include the wall thickness, piece mark, length and additional symbol "S" if the pipe conforms to one or more of the supplementary requirements specified in S1 to S9, and the heat number or manufacturer's number by which the heat can be identified. Identification stamping instead of stenciling will be permitted only with the written approval of the purchaser.

12.2 *Bar Coding*—In addition to the requirements in 12.1, bar coding is acceptable as a supplemental identification method. The purchaser may specifiy in the order a specific bar coding system to be used.

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. Additional Tension Tests

S2.1 An additional tension test shall be made on a specimen from one or each end of each pipe. If this supplementary requirement is specified, the number of tests per pipe required shall 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. Additional Flattening Tests

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 Tests

S4.1 The steel shall be homogeneous as shown by etching tests conducted in accordance with the appropriate portions 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 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. Photomicrographs

S5.1 The manufacturer shall furnish one photomicrograph at 100 diameters from a specimen of pipe in the as-finished condition representing each heat in each heat-treatment lot. Such photomicrographs shall be suitably identified as to pipe size, wall thickness, and heat. No photomicrographs for the individual pieces purchased shall be required except as specified in Supplementary Requirement S6. Such photomicrographs are for information only, to show the actual metal structure of the pipe as furnished.

S6. Photographs for Individual Pieces

S6.1 In addition to the photomicrographs required in accordance with Supplementary Requirement S5, the purchaser may specify that photomicrographs shall be furnished from one or both ends of each pipe. All photomicrographs required shall be properly identified as to heat number, size, and wall thickness of pipe from which the section was taken. Photomicrographs shall be further identified to permit association of each photomicrograph with the individual length of pipe it represents.

S7. Radiographic Inspection

S7.1 The pipe shall be examined for internal defects by means of X rays or gamma rays. The inspection procedure shall be in accordance with Practice E 94 or Method E 142 and the types and severity levels of discontinuities considered shall be judged by Reference Radiographs E 446, or Reference Radiographs E 186. The extent of examination and the basis for acceptance shall be subject to agreement between the manufacturer and the purchaser. A specification which may be used as a basis for such agreement is "Quality Standard for Steel Castings for Valves, Flanges and Fittings and Other Piping Components (Radiographic Inspection Method SP-54)" of the Manufacturer's Standardization Society of the Valve and Fittings Industry.

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S8. Ultrasonic Tests

S8.1 Each pipe shall be ultrasonically tested to determine its soundness throughout the entire length of the pipe. Evidence of the existence of defects in excess of 5 % of the wall thickness shall be cause for rejection or repair.

S8.2 The ultrasonic test shall be made in accordance with Practice E 114, or by any other established method mutually agreed upon between the manufacturer and the purchaser.

S9. Magnetic Particle or Fluid Penetrant Examination

S9.1 Each pipe along outside and inside surfaces shall be subjected, after machining, to examination by a magnetic particle method or a penetrant fluid and powder method.

S9.2 The extent of examination and the basis for acceptance shall be subject to agreement between the manufacturer and the purchaser. Reference Photographs E 125 may be used to define acceptance criteria.

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