Designation: A 476/A 476M – 00 (Reapproved 2005)

Standard Specification for Ductile Iron Castings for Paper Mill Dryer Rolls[1, 2]

This standard is issued under the fixed designation A 476/A 476M; 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.

1. Scope

1.1 This specification covers ductile iron castings for use in pressure containing paper mill dryer rolls at temperatures up to 450°F [230°C].

1.2 No precise quantitative relationship can be stated between the properties of the iron in various locations of the same casting or between the properties of a casting and those of a test specimen cast from the same iron (see Appendix X1).

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 shall be used independently of the other. Combining values from the two systems may result in nonconformance with the specification.

2. Referenced Documents

2.1 *ASTM Standards:* [3]

A 644 Terminology Relating to Iron Castings

E 8 Test Methods for Tension Testing of Metallic Materials

E 10 Test Method for Brinell Hardness of Metallic Materials

E 94 Guide for Radiographic Examination

E 446 Reference Radiographs for Steel Castings Up to 2 in. [51 mm] in Thickness

3. Terminology

3.1 Definitions for many terms common to iron castings are found in Terminology A 644.

4. Ordering Information

4.1 Orders for material purchased to the requirements of this specification should include the following information:

4.1.1 Quantity,

4.1.2 Specification number and date of issue,

4.1.3 Description of casting by pattern number or drawing,

4.1.4 Heat treatment, if required (see 5.1),

4.1.5 Type of test coupon (see 9.2),

4.1.6 Certification, if required (see 13.1),

4.1.7 Marking location (see 14.1), and

4.1.8 Additional requirements.

5. Heat Treatment

5.1 The castings may be stress relieved at a temperature not to exceed 1200°F [650°C].

6. Chemical Requirements

6.1 The castings shall conform to the following chemical requirements:

Total carbon, min, %	3.0
Silicon, max, %	3.0
Phosphorus, max, %	0.08
Sulfur, max, %	0.05

6.2 The castings shall have a carbon equivalent of 3.8 to 4.5 inclusive.

NOTE 1—The carbon content equivalent is calculated as follows:
Total carbon + 0.3 (silicon + phosphorus)

[1] This specification is under the jurisdiction of ASTM Committee A04 on Iron Castings and is the direct responsibility of Subcommittee A04.02 on Malleable and Ductile Iron Castings.

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[2] For ASME Boiler and Pressure Vessel Code Applications see related Specifications SA-467 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.

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6.3 The chemical analysis for total carbon shall be made on either chilled cast pencil-type specimens or on thin wafers approximately 1/32 in. [0.8 mm] thick, cut from test coupons. Drillings shall not be used due to attendant loss of graphite.

7. Mechanical Properties

7.1 The iron represented by test coupons shall conform to tensile requirements prescribed in Table 1.

7.2 The yield strength prescribed in Table 1 may be determined by any of the approved procedures described in 7.3 of Test Methods E 8.

7.3 The Brinell hardness of the material shall be a minimum of 201 HB. Hardness tests shall be conducted in accordance with Test Method E 10, using a 3000-kgf load. The test may be made on either the casting or on a test coupon representing the casting.

8. Workmanship, Finish, and Appearance

8.1 The castings shall conform to the dimensions on the drawings furnished by the purchaser, or if no drawing has been provided, to the dimensions predicated by the pattern supplied by the purchaser. Surfaces of the castings shall be free of adhering sand. Runners, risers, fins, and other extraneous metal shall be removed.

9. Sampling

9.1 Test coupons shall be poured from the same iron as the castings represented.

9.2 Test coupons shall be cast either to the "Y" block size and shape shown in Fig. 1 or to the dimensions of the 1-in. [25-mm] keel block shown in Fig. 2. The type of test coupon and, when selected, the size of the "Y" block shall be specified by the purchaser.

9.3 The test coupons shall be cast in open molds made of suitable core sand with a minimum 1½ in. [38 mm] of sand for the 1-in. [25 mm] size and 3 in. [75 mm] of sand for the 3-in. [75-mm] size. The coupons shall be left in the mold until black.

9.4 Table 2 shows the equivalent geometrical shapes with various dimensions and the equivalent "Y" block, based on cooling rates, and may be used as a guide for selection of the proper "Y" block to be specified to represent the casting.

9.5 When the castings are heat treated, the test coupons shall be heat treated with the castings they represent.

10. Tension Test

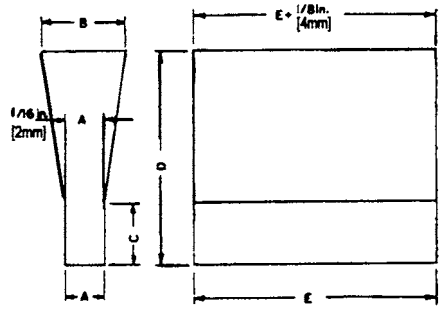
10.1 Tension test specimens shall be obtained from test coupons shown in either Fig. 1 or Fig. 2, and machined to the dimensions shown in Fig. 3. Test coupons cast as "Y" blocks (Fig. 1) shall be sectioned as shown in Fig. 4.

10.2 One tension test shall be performed for each casting.

10.3 If any specimen shows defective machining or flaws, it may be discarded and another substituted from the same casting represented.

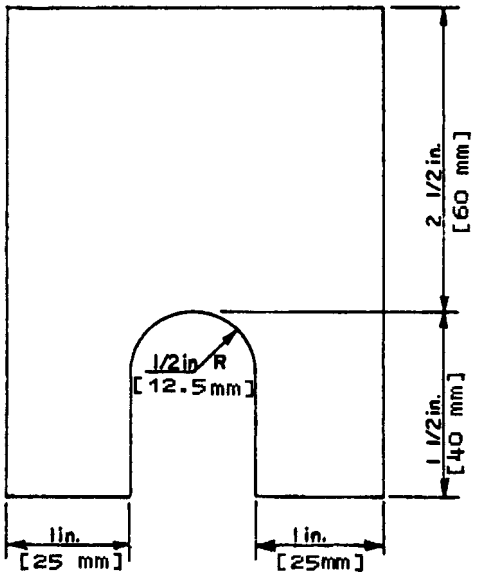
TABLE 1 Tensile Requirements

Test Coupon Section Thickness	1 in. [25 mm]	3 in. [75 mm]
Tensile strength, min, ksi [MPa]	80 [555]	80 [555]
Yield strength, min, ksi [MPa]	60 [415]	60 [415]
Elongation in 2 in. [50 mm], min, %	3.0 [3.0]	1.0 [1.0]



Dimensions	"Y" Block Size	
	For Castings of Thickness ½ in. to 1½ in. [12.5-40 mm]	For Castings of Thickness of 1½ in. [40 mm] and Over
	in. [mm]	in. [mm]
A	1 [25]	3 [75]
B	1⅛ [55]	5 [125]
C	3 [75]	4 [100]
D	6 [150]	8 [200]
E	7 [175] approx	7 [175] approx

FIG. 1 "Y" Blocks for Test Coupons



NOTE 1—The length of keel block shall be 6 in. [150 mm].

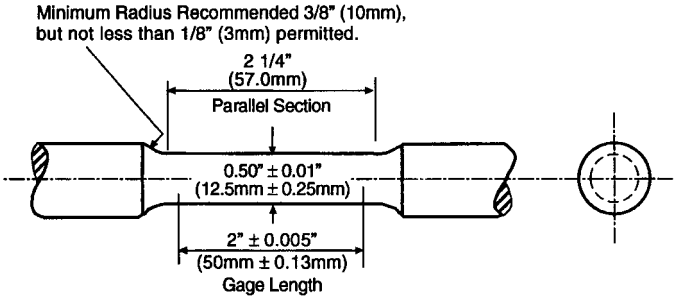
FIG. 2 Keel Block for Test Coupons

TABLE 2 Equivalent Geometric Shapes Corresponding to "Y" Blocks

"Y" Block Size, in. [mm]	Infinite Plate Thickness, in. [mm]	Round Diameter, in. [mm]	Cube Edge, in. [mm]
1 [25]	0.9 [22.5]	1.75 [44]	2.75 [44]
3 [75]	1.6 [40]	3.1 [78]	4.8 [120]

10.4 If an apparently sound test specimen fails to conform to the tensile requirements, two retests may be made. If either retest fails to conform to the requirements specified, the castings shall be rejected.

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NOTE 1—The gage length and fillets shall be as shown, but the ends may be of any shape to fit the holders of the testing machine in such a way that the load shall be axial. The reduced section shall have a gradual taper from the ends toward the center, with the ends 0.003 to 0.005 in. [0.08-0.13 mm] larger in diameter than the center.

FIG. 3 Standard Round Tension Test Specimen with 2-in. [50-mm] Gage Length

11. Repairs

11.1 Castings made to this specification that leak on subsequent hydrostatic testing may be repaired by using threaded plugs provided the following requirements are met.

11.1.1 No welding or brazing shall be permitted.

11.1.2 The diameter of the plug shall not exceed the diameter of a standard 2-in. [ISO R2] iron pipe size pipe plug.

11.1.3 The plugs, where practical, shall conform in all dimensions to the standard iron pipe size pipe plugs. In addition, they shall have full thread engagement corresponding to the thickness of the repaired section. Where a tapered plug is impractical because of the excess wall thickness in terms of plug diameter and coincident thread engagement, other types of plugs may be used provided both full thread engagement and effective sealing against pressure are obtained. Where possible the ends of the plugs should be ground smooth after installation to conform to the inside and outside contours of the cylinder.

11.1.4 The material from which the plug is manufactured shall conform in all respects to this specification.

11.1.5 The area adjacent to the drilled hole should be examined radiographically in accordance with Guide E 94. The area examined shall meet the requirements of Severity Level 3 of Reference Radiographs E 446.

11.1.6 The thickness of any repaired section in relation to the size of plug used shall be not less than that given in Table 3.

11.1.7 The minimum radius of curvature of the repaired section of the cylinder in relation to the size of plug used shall be not less than that given in Table 4.

11.1.8 A repaired area may consist of a maximum of three plugs with a spacing such that the distance between adjacent plugs shall not be less than those listed in Table 5. Adjacent areas of repair, in which each contains more than one plug, shall be separated by at least twice the distance required in Table 5 for the two nearest plugs separating the two areas.

11.2 Surface imperfections not exceeding 20 % of the thickness of the section and other minor defects may be repaired by plugging provided the diameter of the plug does not exceed its length.

12. Inspection

12.1 The manufacturer shall afford the purchaser's inspector all reasonable facilities necessary to satisfy that the material is being produced and furnished in accordance with this specification. Foundry inspection by the purchaser shall not interfere unnecessarily with the manufacturer's operations. All tests and inspections shall be made at the place of manufacture unless otherwise agreed.

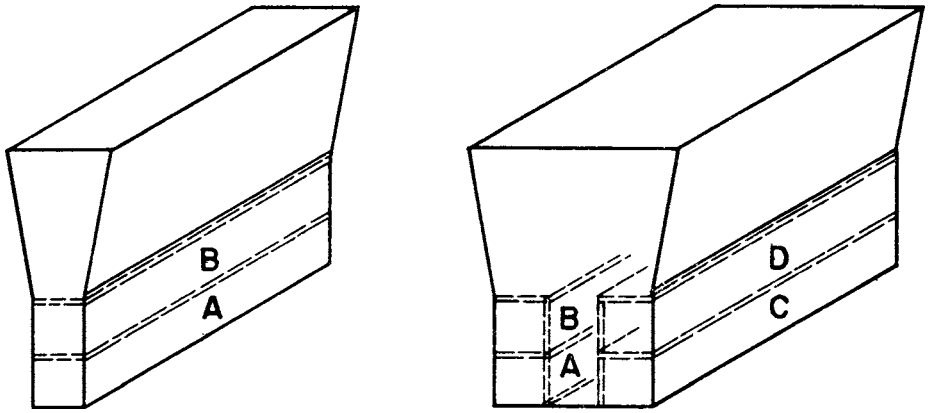
13. Certification

13.1 When specified in the order, the manufacturer's certification shall be furnished stating that the material was manufactured, sampled, tested, and inspected in accordance with the requirements of this specification and was found to meet the requirements. In addition to the certification, a test report shall be furnished showing the results of all tests performed.

14. Product Marking

14.1 Castings made in accordance with this specification shall have the name of the manufacturer or his recognized trade mark and this specification number cast on or indelibly stamped on a surface designated by the purchaser.

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(*a*) *1-in. [25-mm] "Y" Block*—Two blanks for 0.50-in. [12.5 mm] diameter tension test specimens.

(*b*) *3-in. [75 mm] "Y" Block*—Four blanks for 0.50-in. [12.5-mm] diameter tension test specimens.

FIG. 4 Sectioning Procedure for "Y" Blocks

TABLE 3 Minimum Thickness of Repaired Sections

Iron Pipe Size Plug, in. [ISO Pipe Plug Size]	Minimum Section Thickness, in. [mm]
⅛ [R ⅛]	11/32 [8]
¼ [R ¼]	7/16 [10]
⅜ [R ⅜]	½ [13]
½ [R ½]	21/32 [17]
¾ [R ¾]	¾ [19]
1 [R 1]	13/16 [21]
1¼ [R 1¼]	⅞ [23]
1½ [R 1½]	15/16 [24]
2 [R 2]	1 [26]

TABLE 4 Minimum Radius of Repaired Sections

Iron Pipe Size Plug, in. [ISO Pipe Plug Size]	Minimum Radius of Curvature, in. [mm]
⅛ [R ⅛]	9/16 [15]
¼ [R ¼]	11/16 [18]
⅜ [R ⅜]	1 1/16 [28]
½ [R ½]	1¼ [32]
¾ [R ¾]	2 [52]
1 [R 1]	2½ [64]
1¼ [R 1¼]	4 [104]
1½ [R 1½]	5¼ [136]
2 [R 2]	8⅛ [208]

APPENDIX

(Nonmandatory Information)

X1. MECHANICAL PROPERTIES OF CASTINGS

X1.1 The mechanical properties of iron castings are influenced by the cooling rate during and after solidification, by chemical composition, by heat treatment, by the design of the casting, by the design and nature of the mold, by the location and effectiveness of gates and risers, and by certain other factors.

X1.2 The cooling rate in the mold and, therefore, the properties developed in any particular section are influenced by the presence of cores, chills and chaplets, changes in section thickness, and the existence of bosses, projections, and intersections, such as junctions of ribs and bosses. Because of the complexity of the interactions of these factors, no precise quantitative relationship can be stated between the properties of the iron in various locations of the same casting or between the properties of a casting and those of a test specimen cast

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TABLE 5 Minimum Distance Between Plug Centers (Based on Ligament Efficiency of 80 %)[A]

Adjacent Plug Diameters, in. [ISO Pipe Plug Size]	Minimum Distance Between Plug Centers, in. [mm]			
	⅛ [R ⅛], ¼ [R ¼], ⅜ [R ⅜]	½ [R ½], ¾ [R ¾]	1 [R 1], 1¼ [R 1¼]	1½ [R 1½], 2 [R 2]
⅛ [R ⅛], ¼ [R ¼], ⅜ [R ⅜]	2⅝ [67]	4⅛ [105]	6⅝ [169]	9½ [242]
½ [R ½], ¾ [R ¾]	4⅛ [105]	4⅛ [105]	6⅝ [169]	9½ [242]
1 [R 1], 1¼ [R 1¼]	6⅝ [169]	6⅝ [169]	6⅝ [169]	9½ [242]
1½ [R 1½], 2 [R 2]	9½ [242]	9½ [242]	9½ [242]	9½ [242]

[A] *Example*—Assume three plugs are required for repair, one ⅛ in. [R ⅛], one ⅜ in. [R ⅜], and one 1½ in. The minimum distance permitted is as follows.

Ligament distance between ⅛ [R ⅛] and ⅜-in. [R ⅜] plugs = 2⅝ in. [67 mm]

Ligament distance between ⅛ [R ⅛] and 1½-in. [R 1½] plugs = 9½ in. [242 mm]

Ligament distance between ⅜ [R ⅜] and 1½-in. [R 1½] plugs = 9½ in. [242 mm]

from the same iron. When such a relationship is important and must be known for a specific application, it may be more closely ascertained by appropriate experimentation.

X1.3 When reliable information is unavailable on the relationship between properties in a casting and those in a separately cast test specimen, and where experimentation would be unfeasible, the size of the test casting should be so selected as to approximate the thickness of the main or controlling section of the casting.

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