Designation: A 220/A 220M – 99

Standard Specification for Pearlitic Malleable Iron[1]

This standard is issued under the fixed designation A 220/A 220M; 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 covers pearlitic malleable iron castings for general engineering usage at temperatures from normal ambient to approximately 750°F [400°C].

1.1.1 For continuous service at temperatures up to 1200°F [650°C] design factors should be incorporated to compensate for possible property changes, as demonstrated by Marshall and Sommer[2] and by Pearson.[3]

1.2 Without knowledge of casting geometry and process details, no quantitative relationship can be stated between the properties of the iron in the various locations of a casting and those of a test bar cast from the same iron.

1.3 The values stated in either inch-pound units or SI units are to be regarded separately as standard. Within the Test, 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:*

A 220M Specification for Pearlitic Malleable Iron (Metric)[4]

A 247 Test Method for Evaluating the Microstructure of Graphite in Iron Castings[4]

A 644 Terminology Relating to Iron Castings[4]

E 8 Test Methods for Tension Testing of Metallic Materials[5]

E 10 Test Method for Brinell Hardness of Metallic Materials[5]

E 18 Test Methods for Rockwell Hardness and Rockwell Superficial Hardness of Metallic Materials[5]

E 140 Hardness Conversion Tables for Metals[5]

2.2 *Military Standard:*

MIL-STD-129 Marking for Shipment and Storage[6]

2.3 *Federal Standard:*

Fed. Std. No. 123 Marking for Shipment (Civil Agencies)[6]

3. Terminology

3.1 *Definitions*:

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

4. Classification

4.1 Iron produced for castings ordered under this specification is classified in a number of grades as shown in Table 1 and is qualified by tests on separately cast test bars. Separately cast test bars shall be poured from the same lot of iron as the castings they represent and shall be heat treated with those castings.

5. Ordering Information

5.1 The purchase order for castings ordered under this specification shall state the specification designation, the year in which the specification was issued, and the grade of pearlitic malleable iron to be supplied.

5.2 Any options or special additions to the basic requirements of this specification shall be clearly and fully stipulated.

6. Chemical Composition

6.1 The chemical composition of the iron shall be such as to produce the mechanical properties required by this specification.

7. Mechanical Requirements

7.1 Factors influencing the properties of castings and their relationship to those of test specimens and separate test castings are discussed in Appendix X1.

7.2 *Tensile Test*:

7.2.1 *Tensile Test Specimens*:

7.2.1.1 The tensile test specimens shall be cast to the form and dimensions shown in Fig. 1 or Fig. 2 using the same kind of molding material used for the production castings.

7.2.1.2 All test specimens shall be suitably identified with the designation of the pour period.

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[1] This specification is under the jurisdiction of ASTM Committee A-4 on Iron Castings and is the direct responsibility of Subcommittee A04.02 on Malleable Iron Castings.

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[2] Marshall, L. C., and Sommer, G. F., "Stress-Rupture Properties of Malleable Iron at Elevated Temperatures," *Proceedings*, American Society of Testing and Materials, Vol 58, pp. 752–773.

[3] Pearson, D. A., "Stress-Rupture and Elongation Properties of Malleable Iron at Elevated Temperatures," *Transactions*, 70th Castings Congress and Exposition, May 9, 1966.

[4] *Annual Book of ASTM Standards*, Vol 01.02.

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

[6] Available from Standardization Documents Order Desk, Bldg. 4 Section D, 700 Robbins Ave., Philadelphia, PA 19111-5094, Attn: NPODS.

TABLE 1 Tensile Test Requirements

English Grade	Tensile Strength, min	Yield Strength, min	Elongation, mn
	Inch-Pound Grades		
	psi	psi	2 in., %
40010	60 000	40 000	10
45008	65 000	45 000	8
45006	65 000	45 000	6
50006	70 000	50 000	5
60004	80 000	60 000	4
70003	85 000	70 000	3
80002	95 000	80 000	2
90001	105 000	90 000	1
	Metric Grades		
Metric Grade	Tensile Strength, min	Yield Strength, min	Elongation, min
	MPa	MPa	50 mm, %
280M10	400	280	10
310M8	450	310	8
310M6	450	310	6
340M5	480	340	5
410M4	550	410	4
480M3	590	480	3
550M2	650	550	2
620M1	720	620	1

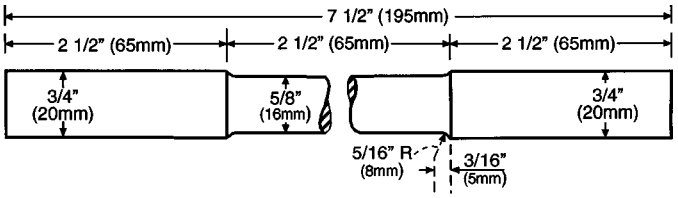
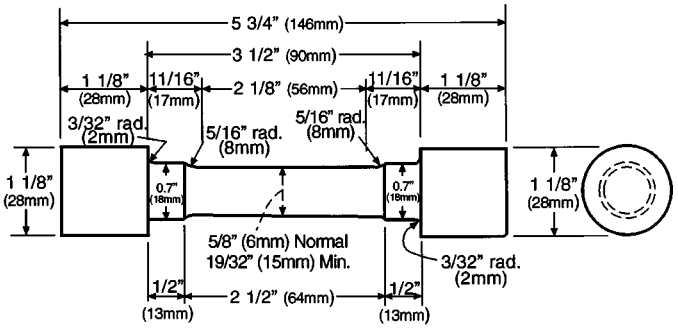


FIG. 1 Unmachined Tension Test Specimen



NOTE 1—Modification may be made in the dimensions indicated above for those details of the specimen outside of the gage length as required by testing procedure and equipment.

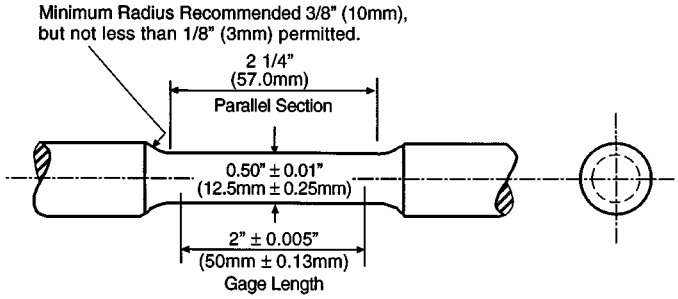
FIG. 2 Alternative Unmachined Tension Test Specimen

7.2.1.3 All test specimens shall be heat treated in the same production furnace and for the same cycles as the castings they represent.

7.2.2 *Tensile Test Method*:

7.2.2.1 The tensile test is usually performed on unmachined specimens. However, for referee work the specimen may be machined from the standard cast bar to the dimensions shown in Fig. 3.

7.2.2.2 *Gage Length*—The gage length of the standard tensile specimen shall be 2.00 ± 0.01 in. [50.0 ± 0.3 mm].



NOTE 1—The gage length and filets 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 to 0.13 mm] larger in diameter than the center.

FIG. 3 Machined Tension Test Specimen

7.2.2.3 *Cross-Sectional Area*—The diameter used to compute the cross-sectional area shall be the average between the largest and smallest diameter in that section of the 2-in. [50-mm] gage length having the smallest diameter and shall be measured to the nearest 0.001 in. [0.02 mm]. No cast bar having a mean diameter less than $^{19}/_{32}$ in. [15 mm] shall be accepted for test.

7.2.2.4 *Speed of Testing*—After reaching a stress equivalent to approximately half of the anticipated yield stress, the speed of the moving head of the testing machine shall not exceed 0.50 in./mm [12.5 mm/min] through the breaking load.

7.2.2.5 *Yield Strength*—Yield strength may be determined by any of the approved techniques described in Test Methods E 8. In referee work it shall be determined at an offset of 0.2 % from the stress-strain curve. Yield strength shall be reported to the nearest 100 psi [megapascal].

7.2.2.6 *Tensile Strength*—The tensile strength shall be the maximum load carried by the specimen during the test divided by the original cross-sectional area of the gage length, as found in accordance with 7.2.2.3. It shall be reported to the nearest 100 psi [megapascal].

7.2.2.7 *Elongation*—The increase in gage length after fracture of a tensile specimen, measured to the nearest 0.01 in. [0.25 mm] expressed as a percentage of the original gage length. It shall be reported to the nearest 0.5 %.

7.2.3 *Number of Tests and Retests*:

7.2.3.1 At least three tensile test specimens shall be cast from a representative ladle of iron from each 4-h pour period during which the purchaser's castings were poured.

7.2.3.2 Only one test specimen need be tested to qualify each pour period and heat treatment batch provided the requirements of this specification are met by that test specimen.

7.2.3.3 If after testing a specimen shows evidence of a defect, another tensile test may be made on a companion specimen. Also, a retest shall be permitted whenever fracture occurs outside the central 50 % of the gage length.

7.2.3.4 If the result of a valid test fails to conform to the requirements of this specification, two retests shall be made. If either of the retest fails to meet specification, the castings represented by these test specimens shall be rejected. A valid test is one wherein the test specimen has been properly prepared and appears to be sound and on which the approved

test procedure has been followed.

7.2.3.5 If the first test results indicate that a reheat treatment is needed to meet the test requirements, the entire lot of castings and the representative test specimens shall be reheat treated together. Testing shall then be repeated in accordance with 7.2.3.1-7.2.3.4.

7.2.4 The results of all tests, including retests, shall be posted in permanent records, that shall state any abnormalities observed during the test and in the fractured ends. Such records shall be kept for at least one year after production of the castings and shall be available for examination by the purchaser or by an authorized representative.

7.2.5 Tensile test results, obtained in accordance with this section, must conform to the requirements of Table 1.

7.2.6 When agreed upon between the manufacturer and the purchaser, tested specimens or unbroken test bars, or both, shall be saved by the manufacturer for a period of three months after the date of the test report.

7.3 *Hardness Test*:

7.3.1 If the purchase agreement requires hardness testing, the acceptable hardness range shall be stated and a location shall be clearly shown on the covering drawing(s).

7.3.2 *Hardness Test Method*:

7.3.2.1 The Brinell method of hardness testing in accordance with Test Method E 10, shall be employed whenever possible.

7.3.2.2 For castings of such size or shape that do not permit Brinell testing with the standard 3000-kgf load, the 500-kgf load may be employed; the hardness number being reported as HB 10/500/15. In very unusual cases where it is impossible to use the Brinell method, the Rockwell test may be substituted, using Test Methods E 18 with an appropriate Rockwell scale. Conversions of hardness values from one method to another according to Tables E 140, that does not specifically cover cast irons, are approximate only and are generally inadvisable.

7.3.2.3 Sufficient material shall be removed from the cast surface to ensure that the measured hardness is representative.

7.3.3 Sampling procedures and the frequency of hardness testing shall be fully detailed on the purchase agreement. Otherwise hardness tests shall be performed at the discretion of the producer.

7.3.4 Castings failing to conform to the required hardness range may be reheat treated and retested. If after reheat treating they still fail the hardness requirements, they shall be rejected.

7.3.5 Typical hardness ranges for the various grades of pearlitic malleable iron are listed in Table 2.

TABLE 2 Typical Hardness Ranges[A]

Inch-Pound Grade [Metric Grade}	Typical Hardness, HB	Typical Indentation Diameters, mm
40010 [280M10]	149–197	4.3–4.9
45008 [310M8]	156–197	4.3–4.8
45006 [310M6]	156–207	4.2–4.8
50005 [340M5]	179–229	4.0–4.5
60004 [410M4]	197–241	3.9–4.3
70003 [480M3]	217–269	3.7–4.1
80002 [550M2]	241–285	3.6–3.9
90001 [620M1]	269–321	3.4–3.7

[A]Hardness test in accordance with Test Method E 10 using a 0.39-in. [10-mm] ball and 6600–lbf [3000-kgf] load.

8. Microstructure Requirements

8.1 The microstructure of the pearlitic malleable iron shall consist of temper carbon nodules uniformly distributed in a matrix of ferrite, pearlite, and tempered transformation products of austenite.

8.2 When agreed upon between the purchaser and the producer, the maximum decarburization at any as-cast surface after heat treatment may be stipulated in writing as measured by visual depletion of combined carbon after polishing, etching in nital, and viewing at 100×.

8.3 If the castings are to be subsequently hardened, the selected grade designation should be preceded by the letter *L*. Such castings shall contain sufficient combined carbon in the matrix to respond satisfactorily to any of the common hardening processes properly applied. A minimum hardness of 197 HB is recommended. Free ferrite shall be as low as is consistent with other properties.

8.4 In referee work, the metallographic practice recommended in Test Method A 247 shall be followed.

9. Soundness Requirements

9.1 All castings on visual examination, shall be sound and free from obvious shrinkage and porosity.

9.2 If the purchaser requires soundness tests to be performed, it shall be so stated in the purchase agreement and the method and soundness requirements shall be detailed.

10. Dimensional Requirements

10.1 The castings shall conform to the dimensions given on drawings furnished by the purchaser, or to the dimensions established by the patterns supplied by the purchaser.

10.1.1 Variations of solid casting dimensions as shown in Table 3 will be permitted unless otherwise agreed upon between the purchaser and the producer.

11. Workmanship, Finish and Appearance

11.1 The surface of the castings shall be clean, free from sand, and have a workmanlike finish.

11.2 No repairing by plugging or welding of any kind shall be permitted unless written permission is granted by the purchaser.

12. Identification Marking

12.1 When the size of the casting permits, each casting shall bear the identifying mark of the manufacturer and the part or pattern number at a location shown on the covering drawing and, if not shown on the drawing, at such a location at the discretion of the producer that the identification will not interfere with subsequent processing and service of the casting.

TABLE 3 Permissible Variations in Any Solid Dimension

Solid Casting Dimension, in. [mm]	Permissible Variation, ± in. [mm]
Up to 1 [up to 25]	1/32 [0.8]
1–6 [25–150]	1/16[1.6]
6–12 [150–300]	1/8[3.2]
12–18 [300–450]	6/32[4.0]
18–24 [450–600]	3/16[4.8]
24–38 [600–900]	7/32[5.6]

13. Responsibility for Inspection

13.1 Unless otherwise specified in the contract or purchase order, the manufacturer shall be responsible for carrying out all the tests and inspections required by this specification, using his own or other reliable facilities. The manufacturer shall maintain complete records of all such tests and inspections. Such records shall be available for review by the purchaser.

13.2 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 the applicable specification. Foundry inspection by the purchaser shall not interfere unnecessarily with the manufacturer's operations.

13.3 The purchaser reserves the right to perform any of the tests and inspections set forth in this specification where such tests and inspections are deemed necessary to assure that compliance with this specification is being met.

14. Rejection and Rehearing

14.1 Any casting or lot of castings failing to comply with the requirements of this specification may, where possible, be reprocessed, retested, and reinspected. If the tests and inspections on the reprocessed casting(s) show compliance with the specification, the casting(s) shall be acceptable; if they do not, they shall be rejected.

14.2 Material that fails to conform to the requirements of this specification may be rejected. Rejection should be reported to the producer or supplier promptly and in writing. In case of dissatisfaction with the results of the test, the producer or supplier may make claim for a rehearing.

15. Certification

15.1 When specified in the purchase order or contract, the purchaser shall be furnished certification that samples representing each lot have been either tested or inspected as directed in this specification and the requirements have been met. When specified in the purchase order or contract, a report of the test results shall be furnished.

16. Packaging and Package Marking

16.1 Unless otherwise stated in the contract or order, the cleaning, preservation, and packing of castings for shipment shall be in accordance with the manufacturer's commercial practice. Packaging and package marking shall also be adequate to identify the contents and to ensure acceptance and safe delivery by the carrier for the mode of transportation employed.

16.2 *U.S. Government Procurement*—When specified in the contract or purchase order, marking for shipment shall be in accordance with the requirements of Fed. Std. No. 123 for civil agencies and MIL-STD-129 for military activities.

17. Keywords

17.1 casting; malleable iron; mechanical properties; pearlitic; tensile strength; tension test; yield strength

SUPPLEMENTARY REQUIREMENTS

S1. Test Lugs

S1.1 If requested in writing or included on the pattern or pattern drawing, a test lug or lugs may be cast on all castings of sufficient size to permit their incorporation. The size of such lugs shall be proportional to the thickness of the castings. On castings over 24 in. [600 mm] in length, a test lug shall be cast near each end, such as not to interfere with any subsequent processing of the castings. The purchase order shall stipulate whether the foundry's inspector or the purchaser's inspector shall break, inspect, and pass judgement on the fracture quality of these test lugs.

S2. Destructive Tests

S2.1 At the option of the purchaser or his representative, a casting of each design ordered may be tested to destruction, or otherwise broken up, to determine the presence of any manufacturing condition that might be detrimental to the serviceability of the casting.

S3. Special Composition

S3.1 For improved resistance to atmospheric corrosion, the basic chemical composition of the iron may be modified slightly as suggested by research conducted by ASTM Committee A-4[7] and this shall be so stated in the purchase agreement.

[7] Appendix, Report on ASTM Committee A-4 on Iron Castings, "Corrosion Test Results on 15 Ferrous Metals after 12-years Atmospheric Exposure," *Proceedings*, American Society of Testing and Materials, Vol 72, 1972, pp. 42–63.

APPENDIX

(Nonmandatory Information)

X1. MECHANICAL PROPERTIES OF CASTINGS

X1.1 The mechanical properties of pearlitic malleable iron castings are influenced by a number of factors, which include the cooling rate during solidification, chemical composition, heat treatment, design of the casting, section thickness, and location and effectiveness of gates, risers, and chills.

X1.2 Because of the complexity of these factors in influencing the properties of the final product, 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. When such a relationship is important and must be known for a specific application, it may be determined by appropriate experimentation.

X1.3 The specimen specified in 7.2.1.1, as the standard tensile test bar for pearlitic malleable iron, has a ⅝-in. [16-mm] diameter test section that reasonably represents a typical section of the general run of pearlitic malleable iron castings. Furthermore, the initial freezing of malleable irons as homogeneous white iron, together with the heat treatment which is inherent in the manufacture of malleable iron, tends to reduce the section-sensitivity effect. Therefore, where experimentation into the precise properties within a given casting would be unfeasible, this standard test bar, made like any typical casting, should provide a practical approximation of the properties that can be expected in any average sound malleable iron castings. When the number of standard test bars to determine specification compliance is insufficient, the manufacturer may wish to seek purchaser approval by comparing tension test results from the casting in question with those of two other castings having the same design and test bar location and from which acceptable standard bar results were obtained.

X1.4 If pearlitic malleable iron castings are welded, the microstructure of the iron is markedly affected, particularly in the heat-affected zone. Since this may adversely affect the properties of the casting, the welding of pearlitic malleable iron castings should be under strict metallurgical control, followed by appropriate post-weld heat treatment, to minimize the substantial reductions in ductility, impact resistance, and machinability that could result, particularly in the vicinity of the weldment. Nevertheless, it is generally considered inadvisable to join castings to similar castings or to other materials, by fusion welding out in the field, or in manufactured assemblies, without fully testing the entire completed part.