Designation: A220/A220M − 99 (Reapproved 2018)$^{\varepsilon 1}$

Standard Specification for Pearlitic Malleable Iron[1]

This standard is issued under the fixed designation A220/A220M; 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 U.S. Department of Defense.

ε[1] NOTE—Footnotes 5 and 6 were updated editorially in November 2018.

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 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 nonconformance with the standard.

1.4 *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:*[4]
A247 Test Method for Evaluating the Microstructure of Graphite in Iron Castings
A644 Terminology Relating to Iron Castings
E8/E8M Test Methods for Tension Testing of Metallic Materials
E10 Test Method for Brinell Hardness of Metallic Materials
E18 Test Methods for Rockwell Hardness of Metallic Materials
E140 Hardness Conversion Tables for Metals Relationship Among Brinell Hardness, Vickers Hardness, Rockwell Hardness, Superficial Hardness, Knoop Hardness, Scleroscope Hardness, and Leeb Hardness

2.2 *Military Standard:*[5]
MIL-STD-129 Marking for Shipment and Storage

2.3 *Federal Standard:*[6]
Fed. Std. No. 123 Marking for Shipment (Civil Agencies)

3. Terminology

3.1 *Definitions:*

3.1.1 Definitions for many terms common to iron castings are found in Terminology A644.

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

[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] Marshall, L. C., and Sommer, G. F., "Stress-Rupture Properties of Malleable Iron at Elevated Temperatures," *Proceedings,* ASTM International, 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] 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.

[5] Available from General Services Administration – Vendor Support Center, https://vsc.gsa.gov/administration/files/MIL-STD-129R.pdf.

[6] Available from General Services Administration – Vendor Support Center, https://vsc.gsa.gov/administration/files/Compliance-with-FED-STD-123H.pdf.

TABLE 1 Tensile Test Requirements

Inch-Pound Grades			
English Grade	Tensile Strength, min	Yield Strength, min	Elongation, mn
	psi	psi	2 in., %
40010	60 000	40 000	10
45008	65 000	45 000	8
45006	65 000	45 000	6
50005	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

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.

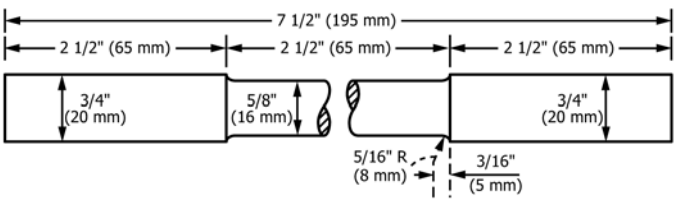
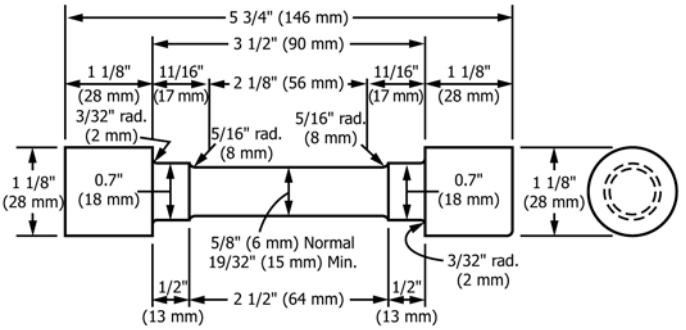


FIG. 1 Unmachined Tension Test Specimen



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

FIG. 2 Alternative Unmachined Tension Test Specimen

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

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.

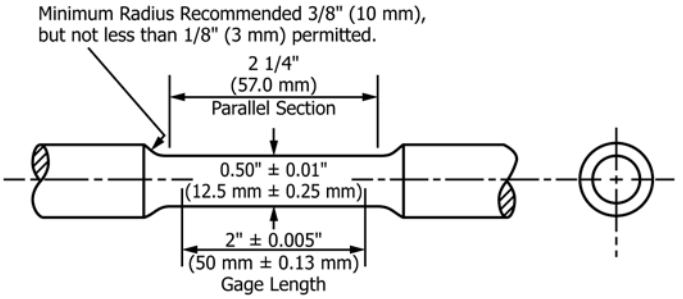
7.2.2 *Tensile Test Method:*

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

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] gauge 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.



NOTE 1—The gauge 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

7.2.2.5 *Yield Strength*—Yield strength may be determined by any of the approved techniques described in Test Methods E8/E8M. 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 gauge 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 gauge length after fracture of a tensile specimen, measured to the nearest 0.01 in. [0.25 mm] expressed as a percentage of the original gauge 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 gauge 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 retests 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 E10, 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 E18 with an appropriate Rockwell scale. Conversions of hardness values from one method to another according to Tables E140, 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.

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 A247 shall be followed.

9. Soundness Requirements

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

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 E10 using a 0.39-in. [10-mm] ball and 6600-lbf [3000-kgf] load.