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# Standard Specification for Cupola Malleable Iron[1]

This standard is issued under the fixed designation A 197/A 197M; 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 malleable irons for castings made by the cupola process.

1.2 Without knowledge of casting geometry and process details, quantitative relationships cannot 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 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:* [2]

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

A 644 Terminology Relating to Iron Castings

E 8 Test Methods for Tension Testing of Metallic Materials

## 3. Terminology

3.1 *Definitions*—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 single grade 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 and the year in which the specification was issued.

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 and 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.

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 Perform the tensile test on unmachined specimens.

7.2.2.2 *Gage Length*—The gage length of the standard tensile specimen shall be 2.00 ± 0.01 in. [50.0 ± 0.03 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 diameters 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 0.590 in. [15 mm] shall be accepted for test.

[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 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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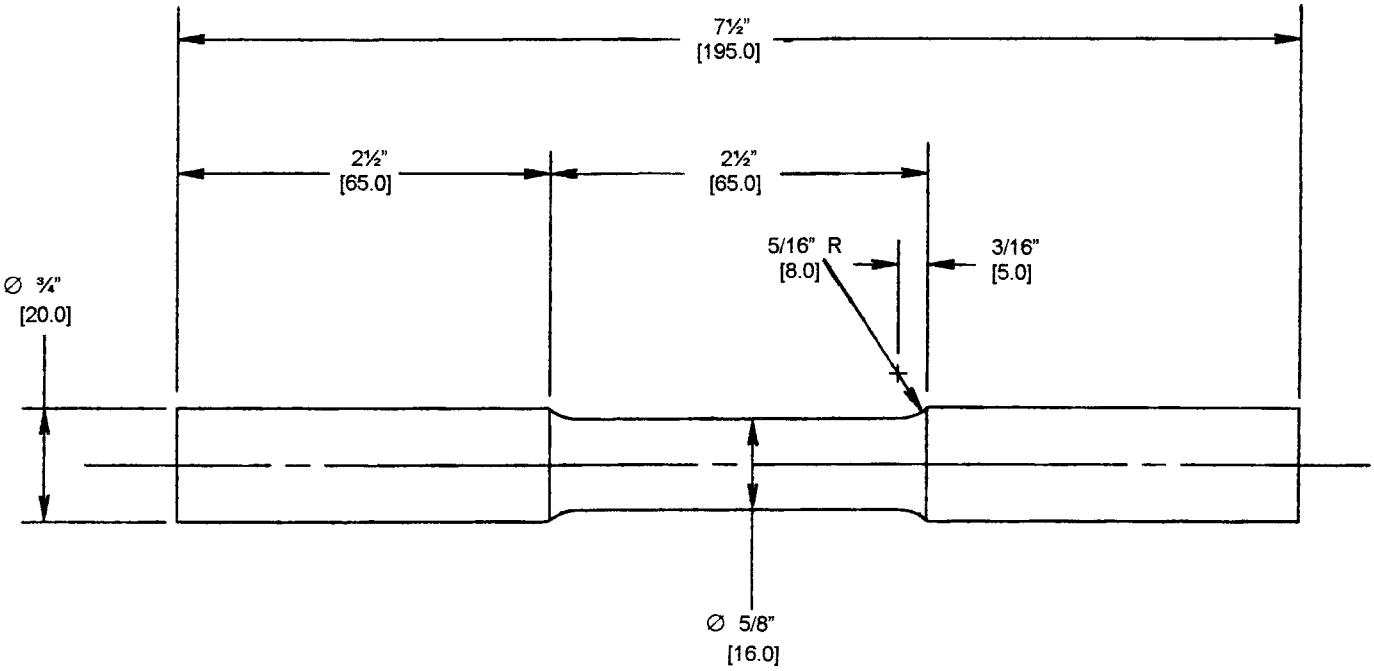
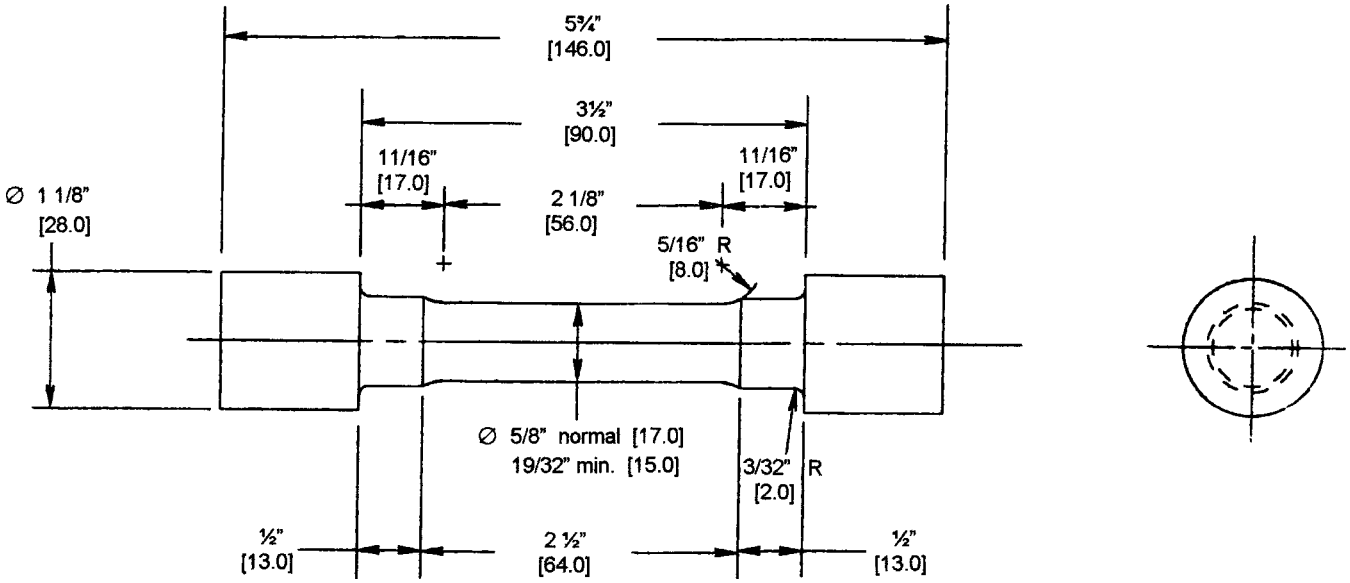



**FIG. 1 Tension Test Specimen**




NOTE 1—Modifications 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**

7.2.2.4 *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./min [12.5 mm/min] through the breaking load.

7.2.2.5 *Yield Strength*—While the values for yield point and yield strength are not identical, they are sufficiently close for most applications to be used interchangeably. They shall be determined by an approved technique described in Test Methods E 8 or by an equivalent method. If determined as yield strength, that stress producing an extension under load of 0.01 in. [0.25 mm] over the 2-in. [50 mm] gage length (for example, 0.5 % extension) or an offset of 0.2 % shall be taken as the yield stress, which shall be converted to yield strength by dividing by the original cross-sectional area of the gage length found in accordance with 7.2.2.3. It shall be reported to the nearest 100 psi [1 MPa]. In referee work, yield strength shall be determined at an offset of 0.2 % from the stress strain curve.

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 [1 MPa].



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7.2.2.7 *Elongation*—The elongation is 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 the specification, all the castings from the pour period and the heat treat batch represented by these test specimens shall be rejected.

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 through 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 his 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.

## 8. Microstructural Requirements

8.1 The microstructure of the malleable iron shall consist of temper carbon nodules uniformly distributed in a ferritic matrix and shall be free from excessive pearlite, massive carbides, and primary graphite.

8.2 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.

**TABLE 1 Tensile Test Requirements**

| | |
|---|---|
| Tensile strength, min, psi [MPa] | 40 000 [275] |
| Yield strength, min, psi [MPa] | 30 000 [200] |
| Elongation in 2 in. [50 mm], min, % | 5 [5] |

## 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 pattern equipment supplied by the purchaser.

## 11. Workmanship, Finish, and Appearance

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

## 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.

12.2 For steam service pressures in excess of 150 psi [1000 KPa], the castings shall be marked with the manufacturer's name or trademark, numerals to indicate the steam service intended, and any other marks that will clearly indicate the maximum service for which the casting is intended. These identifying marks shall be located where they will not interfere with service of the casting.

## 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 test 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. Foundary inspection by the purchaser shall not interfere unnecessarily with the manufacturer's operations.

13.3 The purchaser reserves the right to perform any tests and inspections set forth in the 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 this specification, the castings 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



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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 casting 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.

## APPENDIX

**(Nonmandatory Information)**

## X1. MECHANICAL PROPERTIES OF CASTINGS

X1.1 The mechanical properties of malleable iron castings are influenced by a number of factors, that include the cooling rate during solidification, chemical composition, the heat treatment, the design of the casting, section thickness, and the 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 a given 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 malleable iron has a ⅝-in. [16 mm] diameter test section that reasonably represents a typical section of the general run of malleable iron castings. Furthermore, the initial freezing and malleable irons as homogeneous white iron, together with the heat treatment that is inherent in the manufacture of malleable iron, tends to reduce the section-sensitivity effect. Therefore, where experimentation into 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 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 malleable iron castings should be done 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.

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