SAE International™ SURFACE VEHICLE STANDARD

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Automotive Malleable Iron Castings

1. ***Scope—***This SAE Standard covers the hardness and microstructural requirements for malleable iron castings-ferritic, pearlitic, tempered pearlitic, and tempered martensitic grades used in automotive and allied industries. Castings shall be heat treated to meet this SAE Standard. The Appendix provides general information on the application of malleable iron castings and their chemical composition to meet hardness, microstructure, and other properties needed for particular service conditions. The mechanical properties in the Appendix are provided for design purposes.

2. References

2.1 Applicable Publication—The following publication forms a part of this specification to the extent specified herein. Unless otherwise indicated, the latest issue of SAE publications shall apply.

2.1.1 ASTM PUBLICATION—Available from 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959.

ASTM E 10—Test for Brinell Hardness of Metallic Materials

2.2 Related Publications—The following publications are provided for information purposes only and are not a required part of this document.

ASTM STP-455—Gray, Ductile, and Malleable Iron Casting Current Capabilities
Cast Metals Handbook, American Foundrymen's Society, Des Plaines, IL
Malleable Iron Castings, Malleable Founders Society, Cleveland, OH
Metals Handbook, Vol. 1, 8th Edition, American Society for Metals, Metals Park, OH
Moderan Pearlitic Malleable Castings Handbook, Malleable Research and Development Foundation, Dayton, OH
H. D. Angus, Physical and Engineering Properties of Cast Iron, British Iron Research Association, Birmingham, England, 1960
G .N. J. Gilbert, Engineering Data on Malleable Cast Iron, British Cast Iron Research Association, Birmingham, England, 1968

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3. ***Grades—***The specified grades, hardness range, and final heat treatment are shown in Table 1.

TABLE 1—GRADES OF MALLEABLE IRON

Grade	Casting Hardness Range at Locations Shown on Drawing	Heat Treatment
M3210	156 HB max or as agreed (4.8 BID min)	Annealed
M4504	163–217 HB or as agreed (4.7-4.1 BID)	Air quenched and tempered (1)
M5003	187-241 HB or as agreed (4.4-3.9 BID)	Air quenched and tempered(1)
M5503	187–241 HB or as agreed (4.4-3.9 BID)	Liquid quenched and tempered
M7002	229–269 HB or as agreed (4.0-3.7 BID)	Liquid quenched and tempered
M8501	269–302 HB or as agreed (3.7-3.5 BID)	Liquid quenched and tempered

NOTE: Brinell impression diameter (BID) is the diameter in millimeters (mm) of the impression of a 10mm ball at 3000 kg load.

1. Liquid quenching and tempering or alloying may be used to produce this grade if agreed upon between supplier and purchaser.

4. ***Hardness***

4.1 The area or areas on the casting where hardness is to be checked shall be established by agreement between supplier and purchaser.

4.2 The foundry shall exercise the necessary controls and inspection techniques to insure compliance with the specified hardness range. Brinell hardness shall be determined according to ASTM E10, Test for Brinell Hardness of Metallic Materials, after sufficient material has been removed from the casting surface to insure representative hardness readings. The 10 mm ball and 3000 kg load shall be used unless otherwise agreed upon.

5. ***Microstructure***

5.1 The microstructure of Grade M3210 malleable iron shall consist of temper carbon nodules distributed in a matrix of ferrite. The rim or surface layer (see A.3.3) shall not exceed 127 mm (0.050 in).

Unless otherwise specified, the material below the rim can contain some pearlite; however, it shall not exceed the amount shown in Figure 1.

5.2 The microstructure of the other grades shall consist of temper carbon nodules distributed in a matrix of ferrite and tempered pearlite in air quenched castings and in a matrix of tempered martensite in liquid quenched castings. All grades shall be substantially free of primary graphite or primary cementite.

6. ***Quality Assurance—***Sampling plans are a matter of agreement between supplier and purchaser. The supplier shall employ adequate equipment and controls to insure that parts conform to the agreed upon requirements.

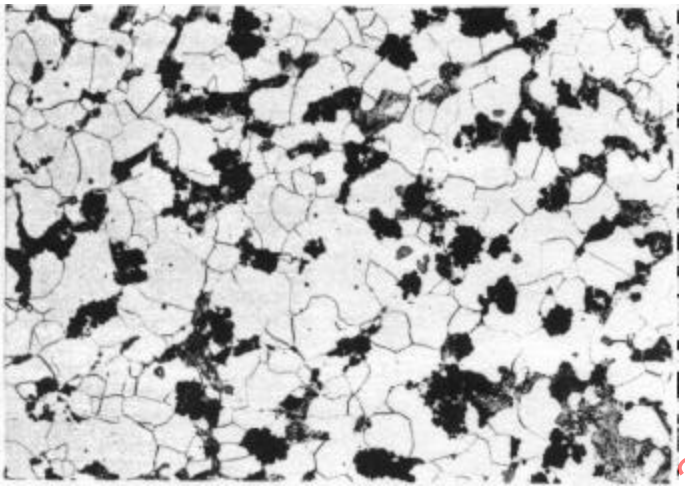

FIGURE 1—REFERENCE PHOTOMICROGRAPH OF ALLOWABLE MAXIMUM PEARLITE IN GRADE M3210 IRON (100X, 2% NITAL ETCH), TYPICAL MICROSTRUCTURE

7. General

7.1 Castings furnished to this standard shall be representative of good foundry practice and shall conform to dimensions and tolerances specified on the casting drawing.

7.2 Minor imperfections usually not associated with the structural function may occur in castings. These imperfections often are repairable; however, repairs shall be made only in areas and by methods approved by the purchaser.

7.3 Additional casting requirements, such as vendor identification, other casting information, and special testing, may be agreed upon by the purchaser and supplier. These should appear as additional product requirements on the casting drawing.

PREPARED BY THE METALS TECHNICAL COMMITTEE DIVISION 9—
AUTOMOTIVE IRON AND STEEL CASTINGS

APPENDIX A

MALLEABLE IRON—

(A material description not a part of the standard)

A.1 ***Definition and Classification—*** Malleable iron is a cast iron in which the graphite is present as temper carbon nodules, instead of flakes as gray iron or spherulites as in ductile iron.

The term malleable iron refers to all grades, including those with a ferritic, pearlitic, tempered pearlitic, or tempered martensitic matrix.

A.2 ***Chemical Composition—*** The chemical composition of malleable iron generally conforms to the following ranges:

a. Total Carbon—2.20 to 2.90%
b. Silicon—0.90 to 1.90%
c. Manganese—0.15 to 1.25%
d. Sulfur—0.02 to 0.20%
e. Phosphorus—0.02 to 0.10%

Individual foundries will produce to narrower ranges than those shown above. The composition is controlled such that the molten iron solidifies with all the carbon in the combined form, producing a "white iron" structure which is heat treated to specifications.

A.3 ***Microstructure***

A.3.1 The microstructure of malleable irons covered in this standard consist of temper carbon nodules in a matrix of ferrite, pearlite, tempered pearlite, or tempered martensite or certain combinations of these. The structure of the matrix is controlled by heat treatment and/or composition.

A.3.2 The matrix of the M3210 grade of malleable iron is essentially ferritic but a small amount of pearlite is permitted. The matrices of the other grades of malleable iron contain combined carbon as pearlite, tempered pearlite, or tempered martensite.

A.3.3 Because of reaction with the annealing furnace atmosphere, some depletion of carbon and silicon occurs at the surface of the castings. This usually results in a rim which, if excessive, can result in poor machinability. The rim on M3210 malleable iron can consist of coarse pearlite underlying a graphite-free layer sometimes containing more or less combined carbon than the underlying material.

A.3.4 Typical microstructure of the various grades of malleable iron are shown in Figures A1 to A6.

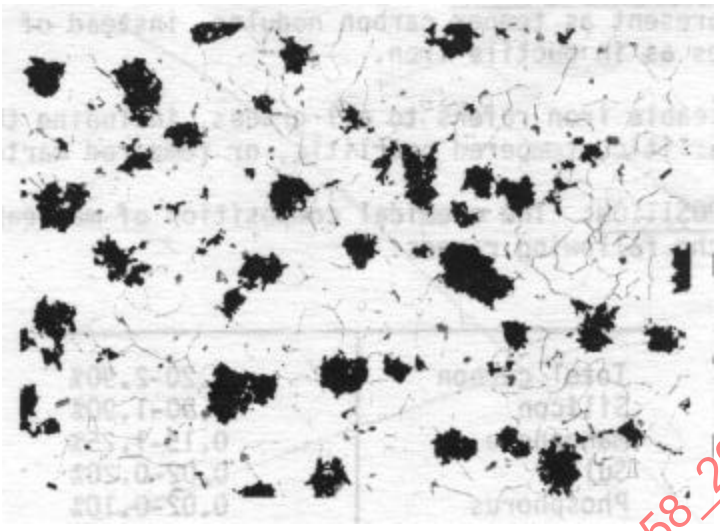

FIGURE A1—M3210, APPROXIMATE 143 HB (100X), TYPICAL MICROSTRUCTURE

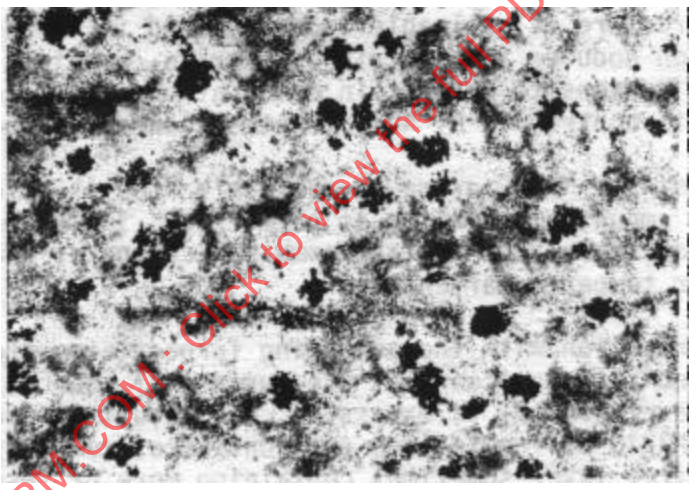

FIGURE A2—M4504, APPROXIMATE 207 HB (100X), TYPICAL MICROSTRUCTURE

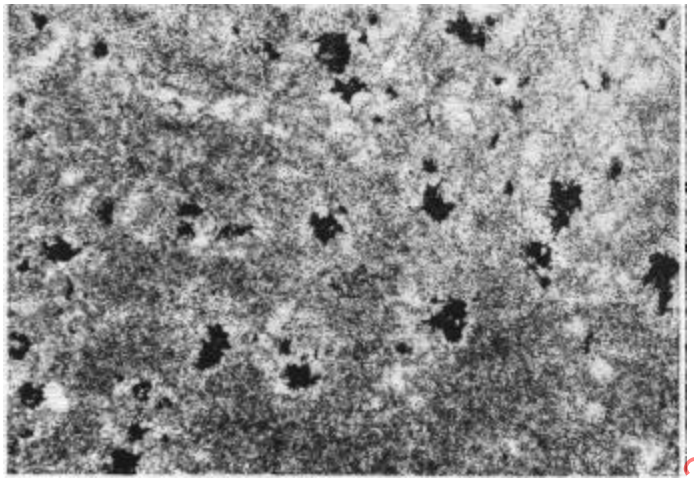

FIGURE A3—M5003, APPROXIMATE 229 HB (100X), TYPICAL MICROSTRUCTURE

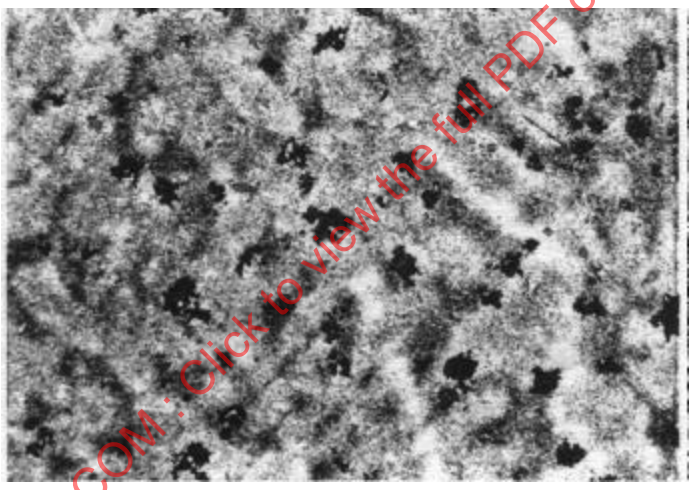

FIGURE A4—M5503, APPROXIMATE 229 HB (100X), TYPICAL MICROSTRUCTURE

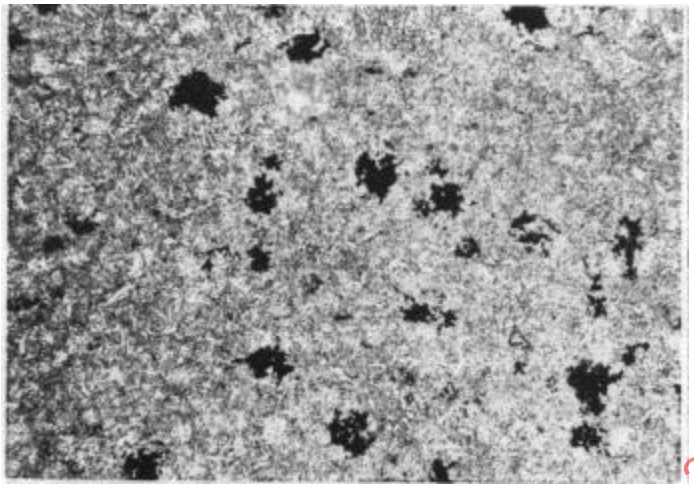

FIGURE A5—M7002, APPROXIMATE 262 HB (100X), TYPICAL MICROSTRUCTURE

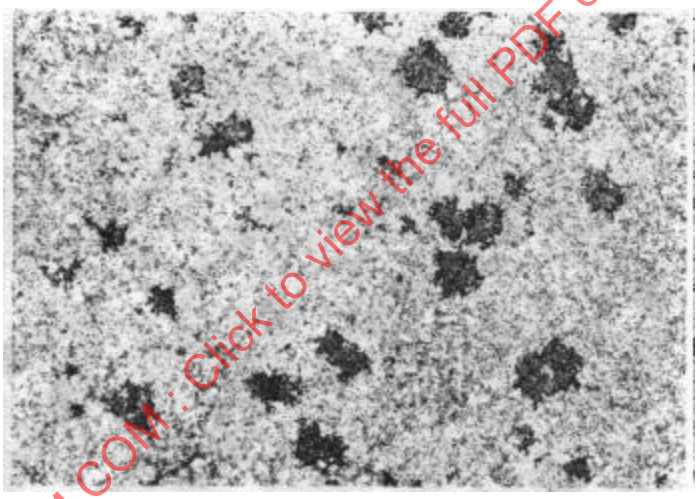

FIGURE A6—M8501, APPROXIMATE 285 HB (100X), TYPICAL MICROSTRUCTURE

A.4 ***Mechanical Properties—*** The mechanical properties listed in Table A1 are intended as guidelines; but, since properties may vary with location in a given casting, the suitability of a particular metal for an intended use is best determined by laboratory or service tests.

The mechanical properties with microstructure and hardness. For optimum mechanical properties, especially in the liquid quenched and tempered grade, section size should generally not exceed 19 mm (3/4 in) to insure a uniform structure.