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Standard Specification for Automotive Malleable Iron Castings[1]

This standard is issued under the fixed designation A 602; 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 castings of ferritic, pearlitic, tempered pearlitic, and tempered martensitic grades of malleable iron used in the products of the automotive and allied industries. Castings shall be heat treated to meet this specification.

1.2 The values stated in inch-pound units are to be regarded as the standard. The values given in parentheses are for information only.

2. Referenced Documents

2.1 *ASTM Standards:* [2]

E 10 Test Method for Brinell Hardness of Metallic Materials

3. Grades

3.1 The specified grades with required hardness range and final heat treatment are shown in Table 1.

3.2 The foundry may also produce Grades M4504 and M5003 by liquid quenching and tempering or alloying, or both.

4. Hardness

4.1 The foundry shall exercise the necessary controls and inspection procedures to ensure compliance with the specified hardness range. Hardness readings shall be taken in accordance with Test Method E 10 after sufficient material has been removed from the casting surface to ensure representative hardness readings. The area or areas on the casting where hardness is to be checked shall be established by agreement between supplier and purchaser and shown on the drawing.

5. Microstructure Requirements

5.1 *Grade M3210 Ferritic Malleable Iron*:

TABLE 1 Grades of Malleable Iron

Grade	Casting Hardness Range	Heat Treatment
M3210	156 HB max 4.8 BID[A] min	annealed
M4504	163–217 HB 4.7–4.1 BID[A]	air quenched and tempered
M5003	187–241 HB 4.4–3.9 BID[A]	air quenched and tempered
M5503	187–241 HB 4.4–3.9 BID[A]	liquid quenched and tempered
M7002	229–269 HB 4.0–3.7 BID[A]	liquid quenched and tempered
M8501	269–302 HB 3.7–3.5 BID[A]	liquid quenched and tempered

[A] Brinell impression diameter (BID) is the diameter in millimetres of the impression of a 10-mm ball at 3000-kg load.

5.1.1 The microstructure of Grade M3210 malleable iron shall consist of temper-carbon nodules distributed in a matrix of ferrite.

5.1.2 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 can consist of coarse lamellar pearlite underlying a graphite-free ferritic surface layer. If the pearlite layer is excessive, it can result in poor machinability. The rim, therefore, shall not exceed a depth greater than 0.050 in. (1.27 mm) as measured from the casting surface.

5.1.3 The area below the rim can contain some pearlite; however, it shall not exceed the amount shown in Fig. 1.

5.2 *Grades M4504, M5003, M7002, and M8501*:

5.2.1 The microstructure of these other grades of malleable iron shall consist of temper-carbon nodules distributed in a matrix of ferrite and lamellar pearlite or tempered pearlite in air-quenched castings or a matrix of tempered martensite in the case of liquid-quenched castings.

5.2.2 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 can consist of a graphite-free layer sometimes containing more or less combined carbon than the underlying material.

5.3 All grades shall be free of primary graphite.

5.4 All grades shall not exceed 2 % spheroidal primary carbides in the microstructure.

[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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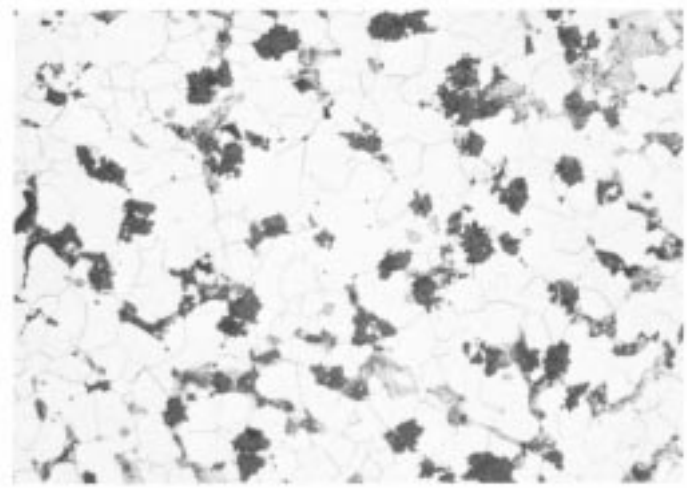


FIG. 1 Reference Photomicrograph Showing Allowable Pearlite in Grade M3210 Iron (100 ×; 2 % Nital Etch)

5.5 The maximum surface ferrite layer and denodularized zone shall be measured after polishing, etching in nital, and viewing at 100×.

6. Quality Assurance

6.1 Sampling plans are a matter of agreement between supplier and purchaser. The supplier shall employ adequate equipment and controls to ensure that parts conform to the agreed upon requirements.

7. General

7.1 Castings furnished to this specification 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 allowed by the purchaser and only by approved methods.

7.3 Additional casting requirements may be agreed upon between the purchaser and supplier. These should appear as additional product requirements on the casting drawing.

8. Keywords

8.1 casting; ferrite; malleable iron; mechanical properties; pearlite; temper carbon nodules; tensile strength; yield strength

APPENDIX

(Nonmandatory Information)

X1. MATERIAL DESCRIPTION OF MALLEABLE IRON

X1.1 Definition and Classification

X1.1.1 *malleable iron*—a cast iron in which the graphite is present as temper-carbon nodules instead of flakes, as in gray iron, or small spherulites, as in ductile iron.

X1.1.2 The term malleable iron includes all grades of malleable iron, including those with a ferritic, pearlitic, tempered pearlite, or tempered martensite matrix.

X1.2 Chemical Composition

X1.2.1 The chemical composition of malleable iron generally conforms to the following range:

Element	Composition, %
Total carbon	2.20–2.90
Silicon	0.90–1.90
Manganese	0.15–1.25
Sulfur	0.02–0.20
Phosphorus	0.02–0.15

X1.2.2 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 free of graphite, which is heat treated to specifications.

X1.3 Microstructure

X1.3.1 The microstructure of malleable iron consists of a matrix of ferrite, pearlite, tempered pearlite, or tempered martensite or combinations of these containing temper carbon nodules (see Figs. X1.1-X1.6). The structure of the matrix is controlled by heat treatment or composition, or both.

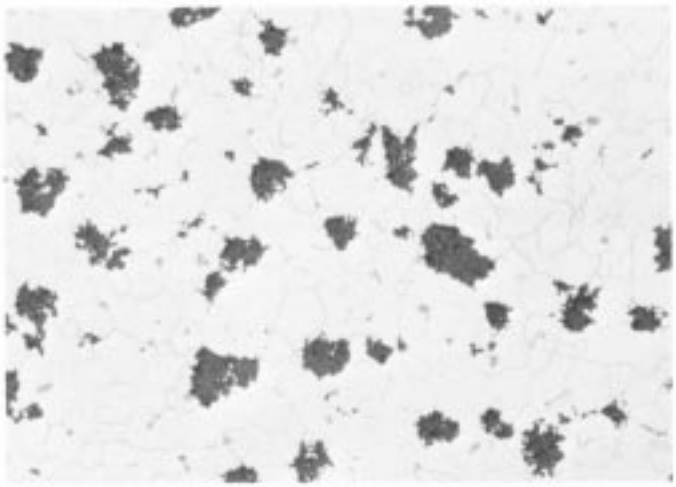


FIG. X1.1 Grade M3210, Approximately HB 143 (100×)

X1.3.2 The matrix of the M3210 grade of malleable iron is essentially free of combined carbon but a small amount of pearlite is permitted.

X1.3.3 The matrices of the other grades of malleable iron contain combined carbon as pearlite, tempered pearlite, or tempered martensite.

X1.3.4 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

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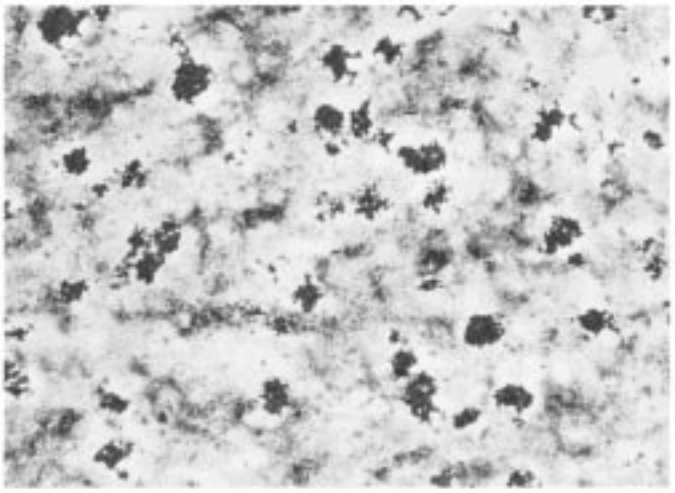


FIG. X1.2 Grade M4504, Approximately HB 207 (100×)

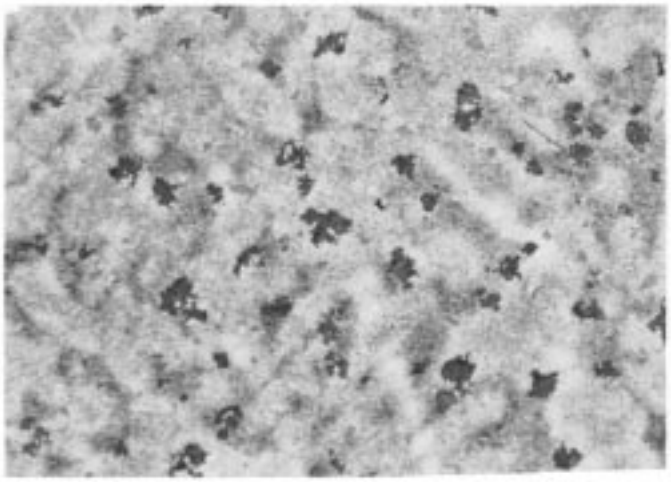


FIG. X1.4 Grade M5503, Approximately HB 229 (100×)

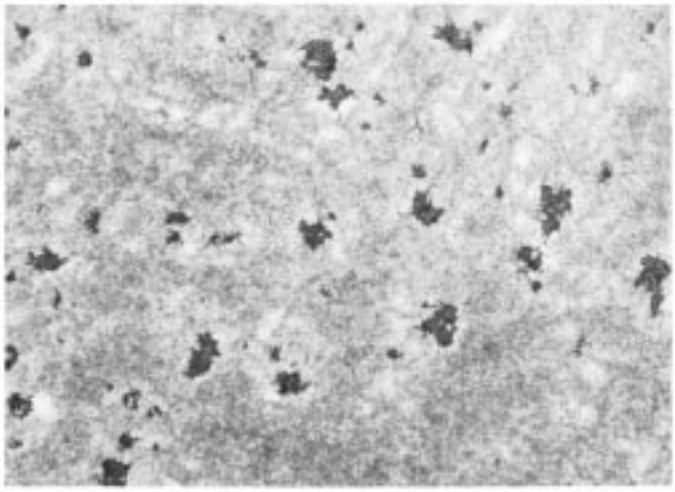


FIG. X1.3 Grade M5003, Approximately HB 229 (100×)

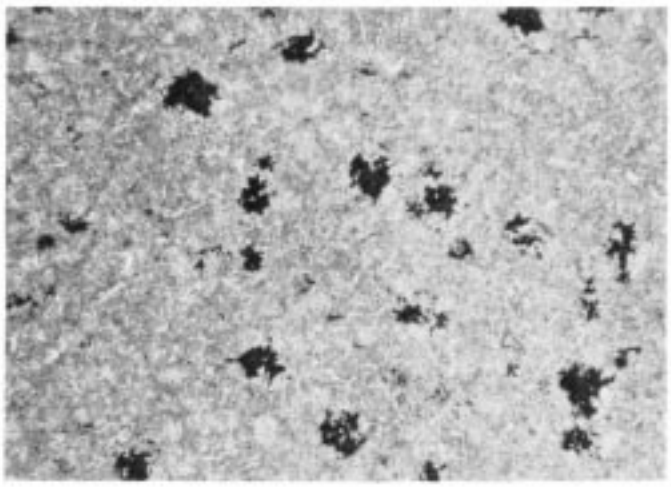


FIG. X1.5 Grade M7002, Approximately HB 262 (100×)

excessive, can result in poor machinability. The rim on M3210 malleable iron can consist of coarse pearlite underlying a graphite-free ferritic surface layer. The rim on the other grades can consist of a graphite-free layer sometimes containing more or less combined carbon than the underlying material.

X1.4 Mechanical Properties

X1.4.1 The mechanical properties listed in Table X1.1 can be used for design purposes but the suitability of a particular grade for an intended use is best determined by laboratory or service tests.

X1.4.2 The mechanical properties vary with microstructure and hardness. For optimum mechanical properties, especially in the liquid-quenched and tempered grades, section size should be limited to ¾ in. (19.05 mm) to ensure a uniform structure.

X1.5 Typical Applications

X1.5.1 Grade M3210 is used in less highly stressed parts where good machinability is important such as steering gear housings, carriers, and mounting brackets.

X1.5.2 Grade M4504 is used where slightly higher strength and hardness is required such as certain compressor crankshafts and hubs.

X1.5.3 Grade M5003 is used where moderate strength or selective hardening, or both, are required for parts such as planet carriers, certain transmission gears, and differential cases.

X1.5.4 Grade M5503 is used where better machinability or improved response to induction hardening, or both, are necessary for parts requiring moderate strength.

X1.5.5 Grade M7002 is used for parts where high strength is required such as connecting rods and universal joint yokes.

X1.5.6 Grade M8501 is used where high strength and wear resistance are required, such as certain gears.

X1.6 Additional Information

X1.6.1 Additional information on malleable iron may be found in Refs. **1-6**.[3]

[3] The boldface numbers refer to the list of references at the end of this standard.

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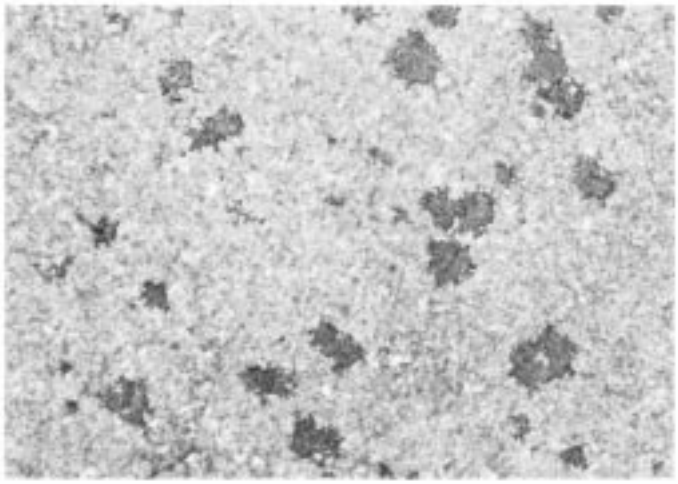


FIG. X1.6 Grade M8501 Approximately HB 285 (100×)

TABLE X1.1 Typical Mechanical Properties for Design Purposes

Grade	Hardness Range	Heat Treatment	Tensile Strength, psi (MPa)	Yield Strength, psi (0.2 percent offset) (MPa)	Percent Elongation in 2 in. or 50 mm	Modulus of Elasticity, Million psi (GPa)
M3210	156 HB max 4.8 BID[A] min	annealed	50 000 (345)	32 000 (221)	10	25 (172)
M4504	163–217 HB 4.7–4.1 BID[A]	air or liquid quenched and tempered	65 000 (448)	45 000 (310)	4	26 (179)
M5003	187–241 HB 4.4–3.9 BID[A]	air or liquid quenched and tempered	75 000 (517)	50 000 (345)	3	26 (179)
M5503	187–241 HB 4.4–3.9 BID[A]	liquid quenched and tempered	75 000 (517)	55 000 (379)	3	26 (179)
M7002	229–269 HB 4.0–3.7 BID[A]	liquid quenched and tempered	90 000 (621)	70 000 (483)	2	26 (179)
M8501	269–302 HB 3.7–3.5 BID[A]	liquid quenched and tempered	10 000 (724)	85 000 (586)	1	26 (179)

[A] Brinell impression diameter (BID) is the diameter in millimetres of the impression of a 10-mm ball at 3000-kg load.

REFERENCES

(**1**) *Cast Metals Handbook*, American Foundrymen's Society, Des Plaines, IL.

(**2**) *Malleable Iron Castings*, Malleable Founders Society, Cleveland, OH.

(**3**) *Metals Handbook*, Vol 1, 2, and 5, 8th Edition, American Society for Metals, Metals Park, OH.

(**4**) *Modern Pearlitic Malleable Castings Handbook*, Malleable Research and Development Foundation, Dayton, OH.

(**5**) Angus, H. D., *Physical and Engineering Properties of Cast Iron*, British Cast Iron Research Association, Alvechurch, Birmingham, Eng., 1960.

(**6**) Gilbert, G. N. J., *Engineering Data on Cast Irons*, British Cast Iron Research Assoc., 1968.

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