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SURFACE VEHICLE STANDARD

SAE J2582

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Automotive Ductile Iron Castings for High Temperature Applications

1. ***Scope—***This SAE Standard covers the hardness, chemical analysis and microstructural requirements for ductile iron castings intended for high temperature service in automotive and allied industries. Commonly known as SiMo ductile iron, typical applications are in piston-engine exhaust manifolds and turbocharger parts. Castings may be specified in the as-cast or heat treated condition.

For design purposes, the Appendix provides general information on the application of high temperature ductile iron castings, their processing conditions, chemical composition, mechanical properties and microstructure.

2. ***References***

2.1 **Applicable Publications—**The following publications form a part of this specification to the extent specified herein. Unless otherwise specified, the latest issue of SAE publications shall apply.

2.1.1 SAE PUBLICATIONS—Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

SAE J417—Hardness Tests and Hardness Number Conversions
SAE J434—Automotive Ductile (Nodular) Iron Castings

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

ASTM A 247—Test Method for Evaluating the Microstructure of Graphite in Iron Castings
ASTM A 439—Austenitic Ductile Iron Castings
ASTM A 536—Standard Specification for Ductile Iron Castings
ASTM E 10—Test Method for Brinell Hardness of Metallic Material
ASTM E 351—Chemical Analysis of Cast Iron - All Types
ASTM E 1999—Analysis of Cast Iron by Optical Emission Spectrometry

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

2.2.1 SAE PUBLICATION—Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

SAE J2515—High Temperature Materials for Exhaust Manifolds [See especially the comprehensive bibliography therein.]

2.2.2 ASM PUBLICATIONS—Available from ATTN: MSC/Book Order, ASM International, PO Box 473, Novelty, OH 44072-9901.

Metals Handbook, Vol. 1 & 15, 10th Ed. 1990 & 1988. ASM International, Materials Park, OH,
J.R. Davis (ed.); ASM Specialty Handbook - Cast Irons, 1996. ASM International, Materials Park, OH

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

STP-455—Gray, Ductile, and Malleable Iron Castings Current Capabilities

2.2.4 IRON CASTING PUBLICATIONS

Iron Castings Handbook, 2nd edition, 1981. Iron Castings Society, Cleveland, OH.

2.2.5 OTHER PUBLICATIONS

H.D. Angus; Cast Iron: Physical and Engineering Properties, 2nd Ed. 1976. BCIRA, Birmingham, UK
R. Eliott; Cast Iron Technology, 1988. Butterworth & Co., London, UK
Data Handbook for Ductile Cast Irons, 1997. Castings Development Centre, Sheffield, UK

3. Grades—The specified grades, chemical analysis requirements and casting hardness ranges are shown in Table 1.

TABLE 1—GRADES OF HIGH TEMPERATURE DUCTILE IRON

GRADE	Casting Hardness, HB	Silicon, %	Molybdenum, %
1	187 - 241	3.50 - 4.50	0.50 maximum
2	187 - 241	3.50 - 4.50	0.51- 0.70
3	196 - 269	3.50 - 4.50	0.71 - 1.00

4. Hardness

4.1 The area or areas on the castings where hardness is to be controlled and the hardness test method or methods to be used shall be established by agreement between the foundry and the purchaser.

4.2 The foundry shall exercise the necessary controls and inspection techniques to insure compliance with the specified casting hardness ranges. Brinell hardness shall be determined in accordance with ASTM E 10 after sufficient material has been removed from the casting surface to insure representative hardness readings. The 10 mm ball and 3000 kgf load for 10 s shall be used unless otherwise specified. Where agreed, other hardness test methods shall be in accordance with both SAE J417 and the applicable ASTM Test Methods.

5. *Chemical composition*

5.1 The concentrations of the elements silicon and molybdenum shall be controlled as specified in Table 1. Non-mandatory ranges typical for some other elements are found in the Appendix on Table A1.

5.2 Chemical composition shall be determined from samples representative of the castings and in accordance with applicable portions of ASTM E 1999, ASTM E 351, or other applicable ASTM Test Methods.

5.3 The chemical composition of high temperature ductile iron is such that the nil-ductility transition temperature is commonly at or above room temperature. Accordingly, and unlike general-purpose ductile iron castings, these castings may exhibit brittle fracture behavior if roughly handled.

6. *Microstructure*

6.1 The graphite component of the microstructure shall consist of at least 80% spheroidal graphite nodules conforming to Types I and II in Figure 1 as determined in accordance with ASTM A 247.

6.2 The matrix component shall consist of a mixture of ferrite and no more than 25% pearlite. Carbides, where present, may not exceed 5%.

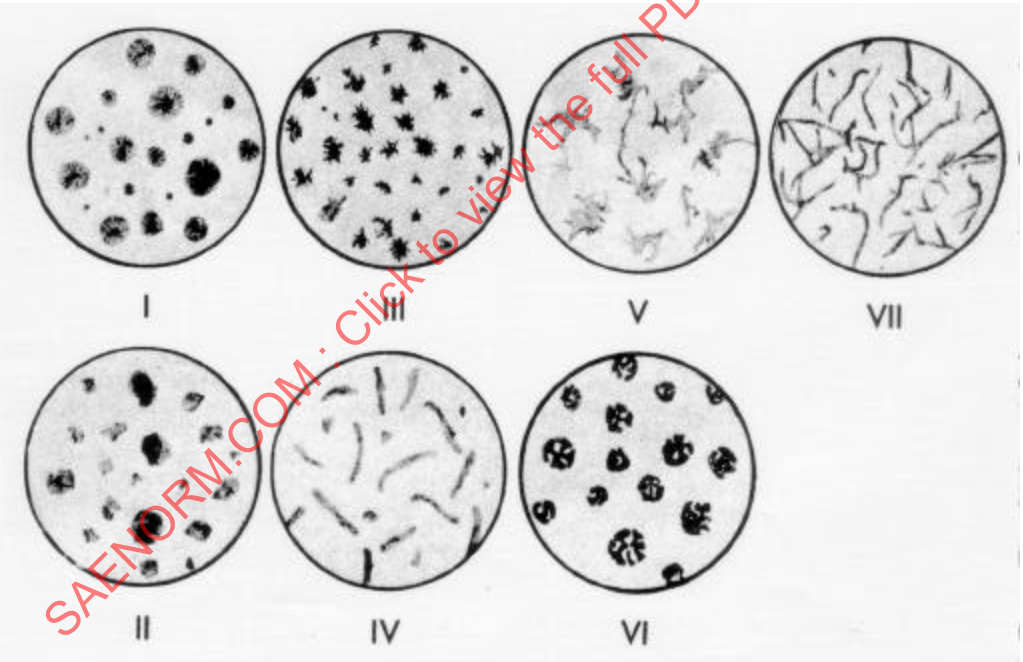

FIGURE 1—CLASSIFICATION OF GRAPHITE SHAPE IN CAST IRONS (FROM ASTM A 247)

7. ***Heat treatment*—**By documented agreement between the foundry and the purchaser, heat treatment of high temperature ductile iron castings is permitted provided the requirements for the grade are met.

8. ***Quality Assurance*—**Sampling plans are a matter of agreement between foundry and purchaser. The foundry shall employ adequate equipment and controls to ensure that the castings conform to the mandatory requirements of this standard and to any other agreements made by the parties.

9. General

9.1 Castings furnished to this standard shall be representative of good foundry practice and shall conform to dimensions and tolerances specified on the applicable drawing or engineering data base.

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

9.3 Additional casting requirements, such as foundry identification, other casting information and special testing, may be agreed upon by the foundry and the purchaser.

PREPARED BY THE SAE IRON AND STEEL DIVISION 9—AUTOMOTIVE IRON AND STEEL CASTINGS

APPENDIX A

HIGH TEMPERATURE DUCTILE IRON
(A MATERIAL DESCRIPTION NOT A PART OF THIS DOCUMENT)

A.1 ***Definition and Classification—***High temperature ductile iron is a ductile (or nodular or spheroidal graphite) iron alloyed for applications where resistance to elevated temperature effects is an important material property.

High temperature ductile iron castings may be used in the as-cast condition or, as agreed between the foundry and the purchaser, it may be heat treated.

A.2 ***Hardness—***Many applications of high temperature ductile iron are in predominantly thin section (<6 mm) castings for which the standard 10 mm ball/3000 kgf Brinell Hardness Test is inappropriate. Users of this document should consider carefully which alternative hardness test methods will be employed and at which point or points on the casting the hardness measurement will be made.

A.3 ***Chemical Composition—***Other chemical elements of interest, not covered in Table 1 are shown in Table A1. The ranges are illustrative only and individual foundries will typically hold ranges significantly narrower than those indicated in Table A1. Other elements, notably copper, nickel, cerium and other rare earth metals, may also be present.

TABLE A1—TYPICAL COMPOSITION

Element	Typical ranges, %
Carbon	3.30 - 3.80
Manganese	0.10 - 0.50
Phosphorus	0.050 max
Sulfur	0.035 max
Magnesium[1]	0.025 - 0.060

1. Cerium and other rare earth elements may be substituted for a portion of the magnesium.

A more extensive discussion of ductile iron composition can be found in the Appendix to SAE J434.

A.4 ***Microstructure***

A.4.1 The microstructure of high temperature ductile iron consists of spheroidal graphite nodules in a matrix composed of ferrite and, in substantially lesser amounts, pearlite. The actual amount of pearlite present in a given casting section will depend upon the grade of material specified, the effective cooling rate experienced by that section, the details of the chemical composition and heat treatments, if any.

A.4.2 Depending on the grade of material chosen and other influences as described above in A.4.1, minor amounts of carbide may be present at eutectic cell boundaries. These are often a complex mix of iron and molybdenum carbides which can be decomposed, completely or partially, by appropriate heat treatment.

A.4.3 Where employed, other alloying elements may influence the relative amounts of ferrite, pearlite and carbide present in the microstructure.

A.4.4 Iron castings, especially those that have been heat treated, commonly exhibit a shallow (approximately 1 mm thick) surface zone or rim that differs in composition and microstructure from the underlying material. This zone may be depleted in carbon content and may contain, depending on specific conditions, more (or less) pearlite than the bulk of the material.