Automotive Ductile (Nodular) Iron Castings — SAE J434c

SAE STANDARD

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AUTOMOTIVE DUCTILE (NODULAR) IRON CASTINGS - SAE J434c

SAE Standard

Report of Iron and Steel Technical Committee approved September 1956 and last revised January 1975.

1. SCOPE-This SAE Standard applies to ductile iron castings products such as those used in the automotive and allied industries. Castings may be specified in the as-cast or heat treated condition.

NOTE: This document was rewritten in January 1975. The materials described by the grade numbers are different than in the former writing.

2. GRADES-The specified grades, hardness range and metallurgical description are shown in Table 1.

TABLE 1- GRADES OF DUCTILE IRON

Grade	Casting Hardness Range[a]	Description
D4018	170 Bhn, max 4.6 BID, min or as agreed	Ferritic
D4512	156-217 Bhn 4.80 - 4.10 BID or as agreed	Ferritic-pearlitic
D5506	187-255 Bhn 4.4 - 3.8 BID or as agreed	Ferritic-pearlitic
D7003	241-302 Bhn 3.90-3.50 BID or as agreed	Pearlitic
DQ & T	Range specified	Martensitic

3. HARDNESS

3.1. The foundry shall exercise the necessary controls and inspection procedures to insure compliance with the specified hardness range. Brinnell hardness readings shall be determined according to ASTM method E 10 after sufficient material has been removed from the casting surface to insure representative hardness reading. 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.

3.2. Unless otherwise specified, castings may be heat treated to the appropriate hardness range.

4. MICROSTRUCTURE-The graphite component of the microstructure shall consist of at least 80% spheroidal graphite conforming to Types I and II in Fig. 1. The matrix microstructure shall consist of either ferrite, ferrite and pearlite, pearlite, tempered pearlite, or tempered martensite or a combination of these. The microstructure shall be substantially free of primary cementite.

5. 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.

6. GENERAL

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

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

APPENDIX - DUCTILE (NODULAR) IRON

(A material description

not a part of the standard)

7. DEFINITION AND CLASSIFICATION-Ductile (nodular) iron, also known as spheroidal graphite iron, is cast iron in which the graphite is present as spheroids instead of flakes as in gray iron or temper carbon nodules as in malleable iron.

Ductile iron castings may be used in the as-cast condition, or may be heat treated.

8. CHEMICAL COMPOSITION-The typical chemical composition of unallowed iron generally conforms to the following ranges.

Total carbon	3.20 - 4.10%
Silicon	1.80 - 3.00%
Manganese	0.10 - 1.00%
Phosphorus	0.015 - 0.10%
Sulfur	0.005 - 0.035%

Individual foundries will produce to narrower ranges than those shown.

The spheroidal graphite structure is produced by alloying the molten iron with small amounts of one or more elements such as magnesium or cerium.

9. MICROSTRUCTURE

9.1 The microstructure of the various grades of ductile iron consists of spheroidal graphite in a matrix of either ferrite, pearlite, tempered pearlite, tempered martensite, or a combination of these. The relative amounts of each of these constituents is dependent upon the grade of material specified, casting design as it affects cooling rate, and heat treatments, if any.

9.2 The matrix microstructure of as-cast ductile iron depends to a great extent on the solidification rate and cooling rate of the casting, as shown in Fig. 2. If a section solidifies rapidly, especially sections of 0.25 in. or less, an appreciable amount of carbide may be present in the casting. If a section cools slowly, as in a massive, heavy casting, a largely ferrite matrix may result.

9.3 Alloying elements can also alter the microstructure usuallly resulting in increased amounts of pearlite. Large variations in structure can be eliminated or minimized by modifying the casting design or the runner system or both, or by controlled cooling, or any combination of these. Primary carbides, and/or pearlite can be decomposed by appropriate heat treatments.

9.4 A rim may occur on heat treated castings consisting of a graphite-free layer sometimes containing more or less combined carbon than the underlying material.

9.5 Typical microstructure of the grades of ductile iron are as follows:

D4018 is annealed ferritic ductile iron. The annealing time and temperature cycle is such that primary carbides, if present in the as-cast structure, are decomposed, and the resulting matrix is ferritic as shown in Fig. 3.

D4512 is ferritic ductile iron supplied either as cast or heat treated. The matrix, shown in Fig. 4, is essentially ferrite but this grade can contain pearlite, depending on the section size.

D5506 is ferritic-pearlite ductile iron supplied either as-cast or heat treated. The matrix, shown in Fig. 5, is essentially pearlite. This grade may contain substantially more ferrite.

D7003 (not shown) is generally air or liquid quenched and tempered to a specified hardness range. The resulting matrix is tempered pearlite or tempered martensite. Time and temperature before hardening can be such that primary carbides are decomposed.

DQ&T is a liquid quenched and tempered grade. The resulting matrix is tempered martensite. The Brinell hardness range is a matter of agreement between supplier and purchaser.

10. MECHANICAL PROPERTIES

10.1 The mechanical properties shown in Table 2 can be used for design purposes but the suitability of a particular grade for an intended use is best determined by by laboratory or service tests.

10.2 The mechanical properties will vary with the microstructure which, especially in the as-cast condition, is depen-

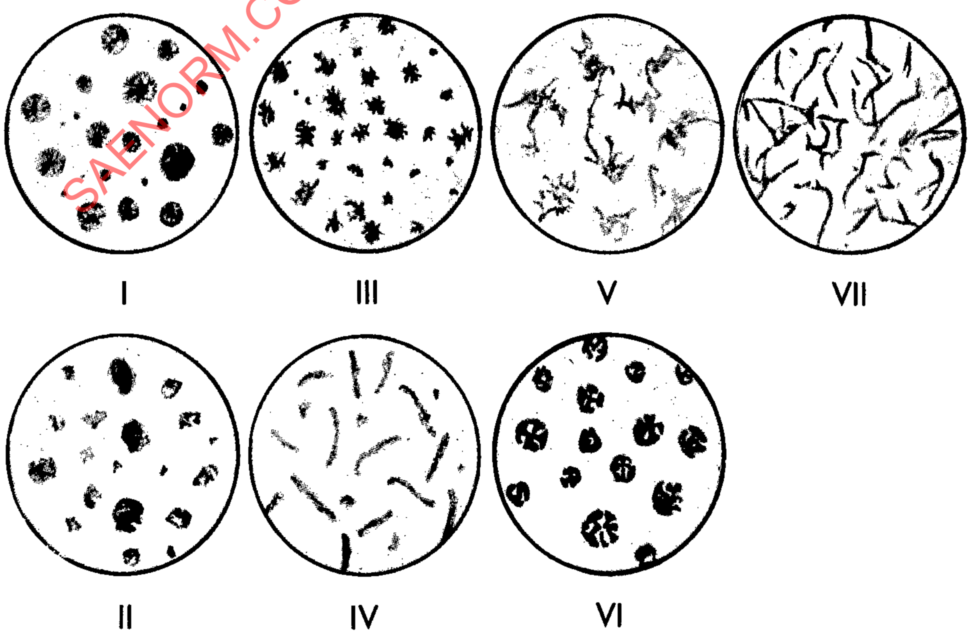

FIG. 1 - CLASSIFICATION OF GRAPHITE SHAPE IN CAST IRONS (FROM ASTM A 247)

dent on section size as well as chemical composition and some foundry processes.

10.3 For optimum mechanical properties in the quenched and tempered grade, section size for unalloyed iron should be limited to approximately 3/4 in to insure a uniform, through hardened structure.

11. TYPICAL APPLICATIONS

11.1 D4018 is used in moderately stressed parts requiring high ductility and good machinability, such as automotive suspension parts.

11.2 D4512 is used for moderately stressed parts where machinability is less important such as differential cases and carriers.

11.3 D5506 is used for more highly stressed parts, such as automotive crankshafts.

11.4 D7003 is used where high strength or improved wear resistance is required and where selective hardening is to be employed.

11.5 DQ&T is used where the uniformity of a heat treated material is required to control the range of mechanical properties or machinability.

12. ADDITIONAL INFORMATION

1. Metals Handbook, Vol 1, 2, and 5, 8th Edition. American Society for Metals, Metals Park, Ohio.

2. Gray and Ductile Iron Castings Handbook, Gray and Ductile Iron Founders Society, Cleveland, Ohio.

3. H.D. Angus, *Physical Engineering Properties of Cast Iron*. British Cast Iron Research Association, Birmingham, England.

4. *Gray, Ductile, and Malleable Iron Castings Current Capabilities*, STP-455, American Society for Testing and Materials, 1916 Race Street, Philadelphia, Pennsylvania 19103.

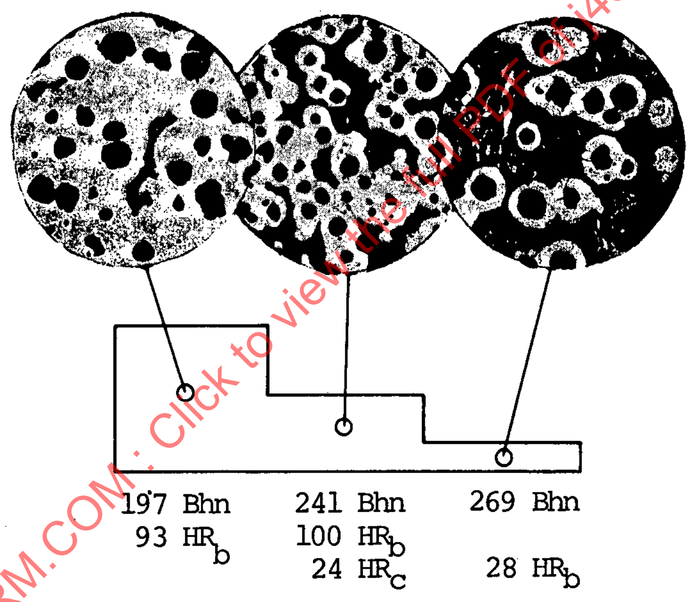

FIG. 2 - EXAMPLE OF MICROSTRUCTURAL VARIATION WHICH MAY OCCUR IN AS—CAST CONDITION AS FUNCTION OF METAL THICKNESS (THAT IS, SOLIDIFICATION RATE)

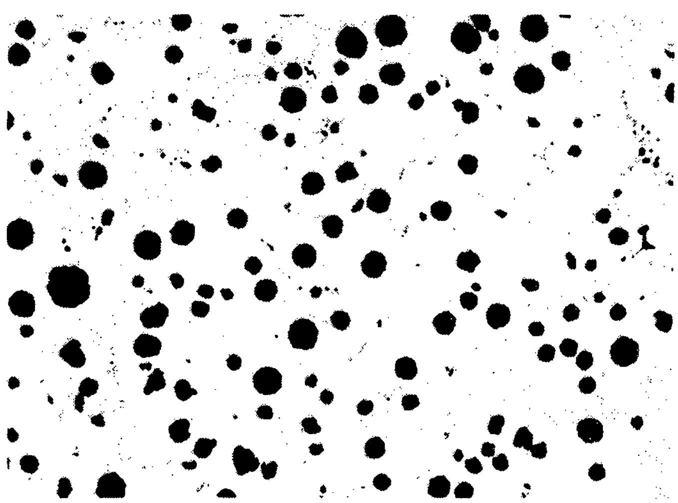

FIG. 3 - D4018, APPROXIMATE 156 BHN (100X)
TYPICAL MICROSTRUCTURES