SAE International™

SURFACE VEHICLE STANDARD

SAE J434

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(R) Automotive Ductile (Nodular) Iron Castings

1. Scope

This SAE standard covers the minimum mechanical properties measured on separately cast test pieces of varying thickness and microstructural requirements for ductile iron castings used in automotive and allied industries. Castings may be specified in the as-cast or heat-treated condition. If castings are heat-treated, prior approval from the customer is required.

The appendix provides general information on chemical composition, microstructure and casting mechanical properties, as well as other information for particular service conditions.

In this standard SI units are primary and in-lb units are derived.

2. References

2.1 Applicable Publications

The following publications form a part of the specification to the extent specified herein. Unless otherwise indicated, the latest revision of SAE publications shall apply

2.1.1 ASTM INTERNATIONAL PUBLICATIONS

Available from ASTM INTERNATIONAL, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959

ASTM E10 –-Standard Test Method for Brinell Hardness of Metallic Materials
ASTM E23—Standard Test Methods for Notched Bar Impact Testing of Metallic Materials
ASTM E111—Standard Test Method for Young's Modulus, Tangent Modulus and Chord Modulus
ASTM A247—Standard Test Method for Evaluation the Microstructure of Graphite in Iron Castings
ASTM A536—Standard Specification for Ductile Iron Castings
STP-455—Gray, Ductile, and Malleable Iron Castings Current Capabilities (out-of-print)

2.1.2 OTHER PUBLICATION

Metals Handbook, Vol. 1, 2, and 5, 8th Edition, American Society for Metals, Metals Park, OH
Gray and Ductile Iron Castings Handbook, Gray and Ductile Iron Founder Society, Cleveland, OH
H. D. Angus, Physical Engineering Properties of Cast Iron, British Cast Iron Research Association, Birmingham, England

3. Grades

The grades, mechanical properties and metallurgical description are shown in Table 1.

TABLE 1—GRADES OF DUCTILE IRON

Grade	Typical Hardness Range (MPa)	Description	Relative Wall Thickness	Tensile Strength		Yield Strength		% Elongation
				MPa	ksi	MPa	ksi	
D400 (D4018)	143-170 HBW (1402-1667) or as agreed	Ferrite	<=20mm >20mm-<=40mm >40mm-<=60mm	400	58	275 260 250	40	18
D450 (D4512)	156-217 HBW (1530-2128) or as agreed	Ferrite-Pearlite	<=20mm >20mm-<=40mm >40mm-<=60mm	450	65	310 295 285	45	12
D500 (D5006)	187-229 HBW (1834-2246) or as agreed	Ferrite-Pearlite	<=20mm >20mm-<=40mm >40mm-<=60mm	500	73	345 330 320	50	6
D550 (D5504)	217-269 HBW (2128-2638) or as agreed	Pearlite-Ferrite	<=20mm >20mm-<=40mm >40mm-<=60mm	550	80	380 365 350	55	4
D700 (D7003)	241-302 HBW (2363-2961) or as agreed	Pearlite	<=20mm >20mm-<=40mm >40mm-<=60mm	700	102	450 435 425	65	3
D800	255- 311 HBW (2501 – 3050) or as agreed	Pearlite or Tempered Martensite	<=20mm >20mm-<=40mm >40mm-<=60mm	800	116	480 465 455	70	2
DQ&T	Range Specified By Agreement	Tempered Martensite	A wide variety of properties are possible. Minimum properties are specified by agreement Between manufacturer and purchaser.					

NOTE—Please refer to ISO 6506 /ASTM E 10 for Brinell Hardness of Metallic Materials Casting properties and microstructure may vary due to chemistry, section size/cooling rate and other parameters. It is desired that separately cast test bars reflect properties of the castings they represent. Casting process for separately cast test pieces shall be agreed upon between manufacturer and purchaser. Refer to ASTM A 536.

4. Hardness

The hardness ranges shown in Table 1 are for guidelines only.

4.1 The area or areas on the castings where hardness is to be checked should be established by agreement between manufacturer and purchaser.

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

5. Heat Treatment

5.1 The heat treatment of castings and test specimens produced to this standard in order to meet hardness or other mechanical property requirements, for thermal stress relief or for other purposes is permissible only with the express approval of the casting purchaser.

5.2 Purchaser approval may be blanket or may be issued on a case-by-case basis, as agreed.

5.3 Unless otherwise agreed, the heat treat cycles employed; times, temperatures, rates, quenchants, etc. shall be at the option of the manufacturer.

5.4 Unless otherwise agreed, any separately cast test specimens or any removed from the castings, must accompany the castings they represent as part of the same heat treatment lot(s) or be subjected to the same thermal cycle as the castings they represent, in all respects.

6. Microstructure

The graphite component of the microstructure shall consist of at least 80% spheroidal graphite conforming to Types I and II (per ASTM A247) in Fig. 1 (nodularity rating chart developed by the Ductile Iron Society may be used as a guide). The matrix microstructure shall consist of ferrite, ferrite and pearlite, pearlite, tempered pearlite, or tempered martensite, or a combination of these. The microstructure shall be substantially free of primary cementite. The microstructure shall be substantially free of undesirable carbides, the details of which are agreed upon between the casting manufacturer and the purchaser. Examples of matrix microstructures for each grade are shown in Fig. 2.

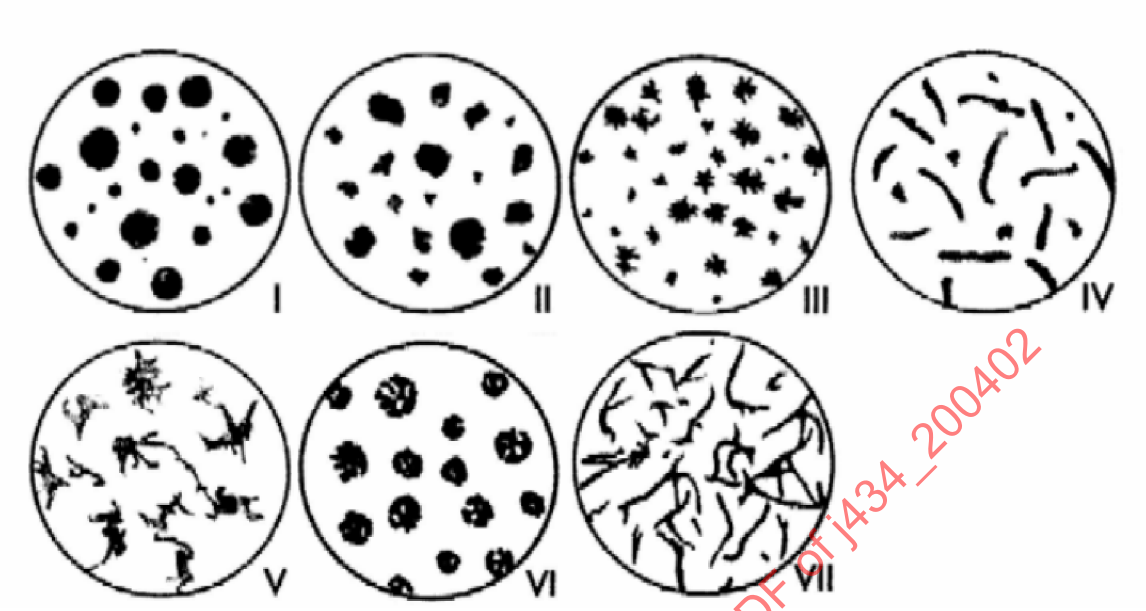
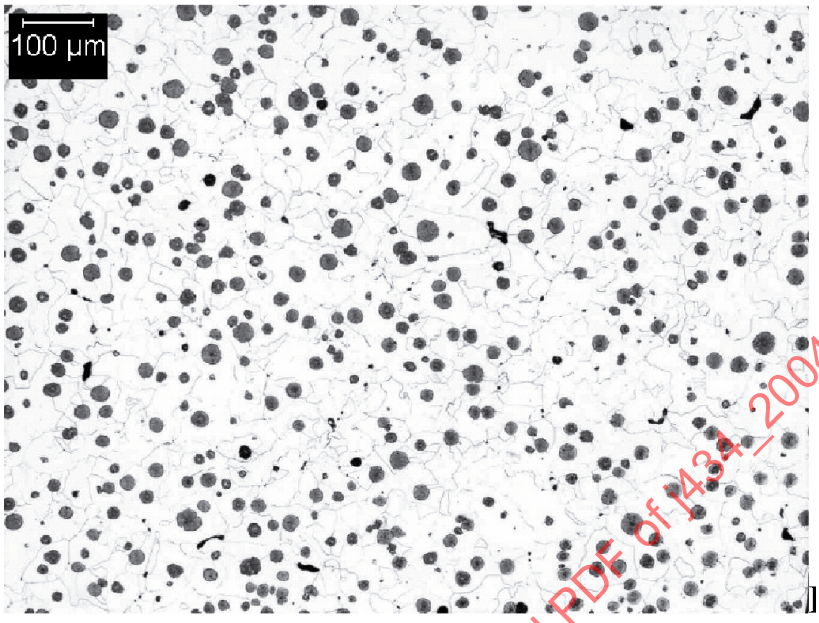
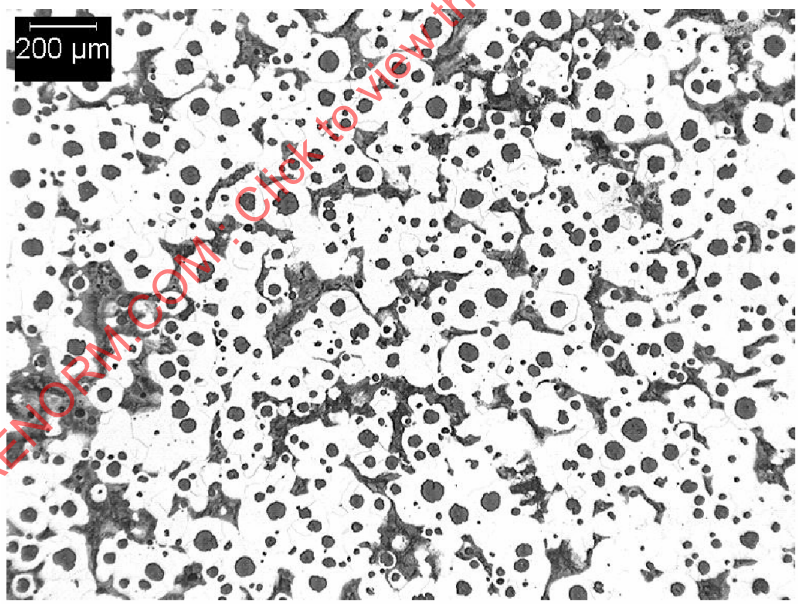


FIGURE 1—CLASSIFICATION OF GRAPHITE SHAPE IN CAST IRONS (FROM ASTM A 247)

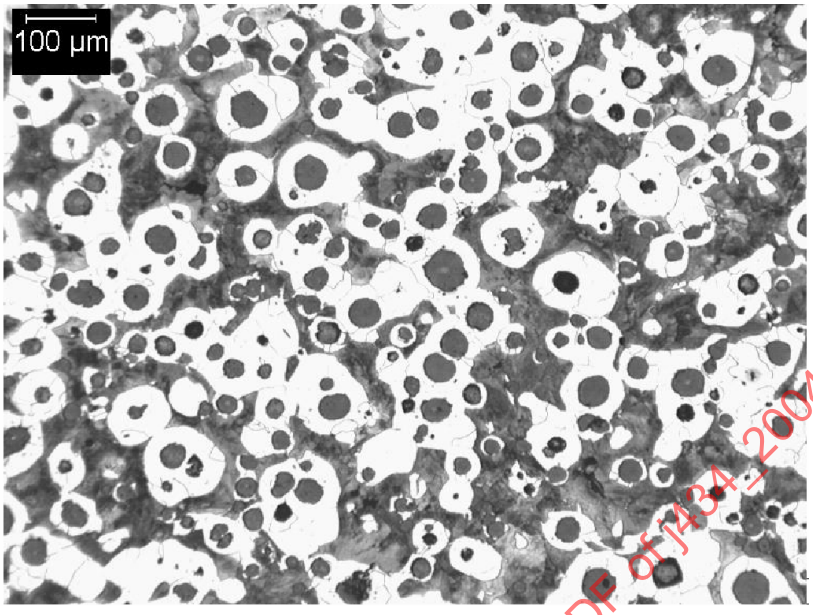


D400

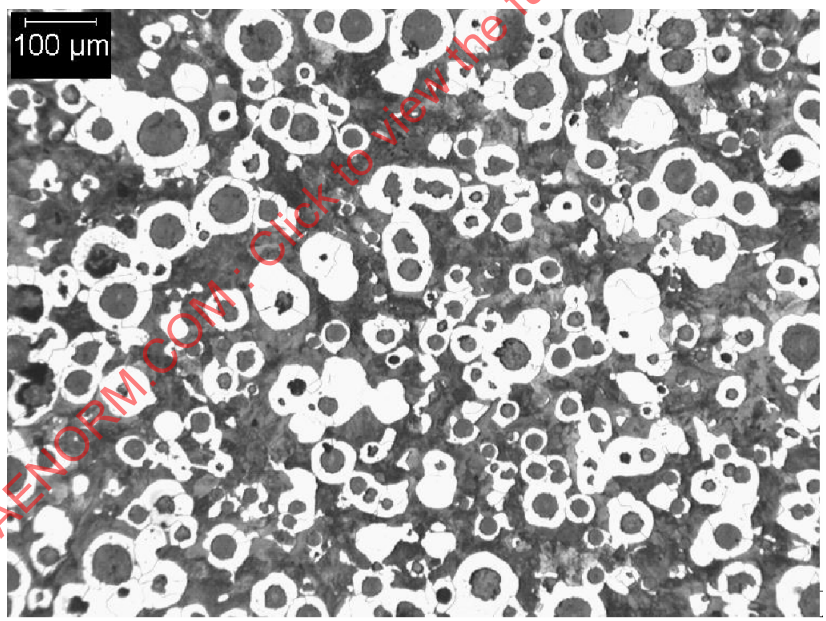


D450

FIGURE 2—TYPICAL MATRIX MICROSTRUCTURES
(PHOTOS COURTESY OF CLIMAX RESEARCH SERVICES)

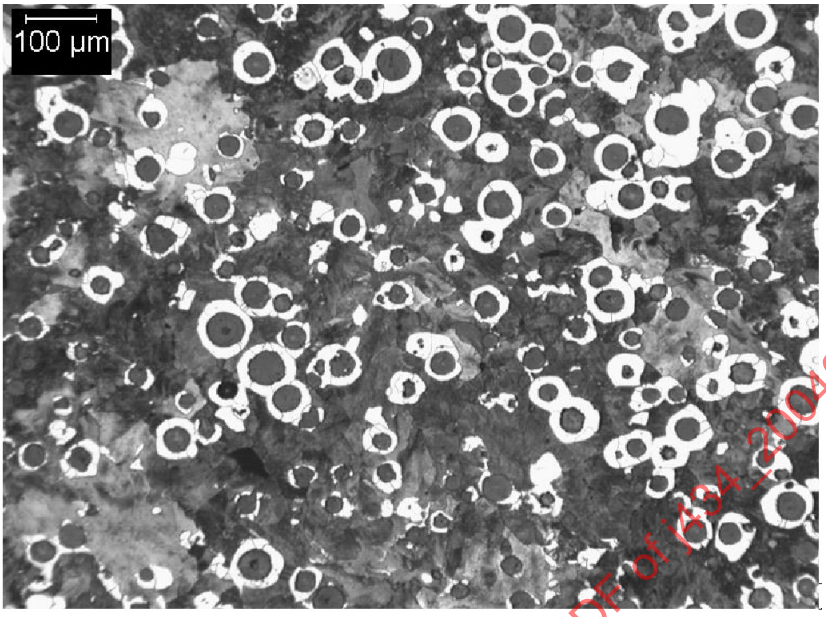


D500

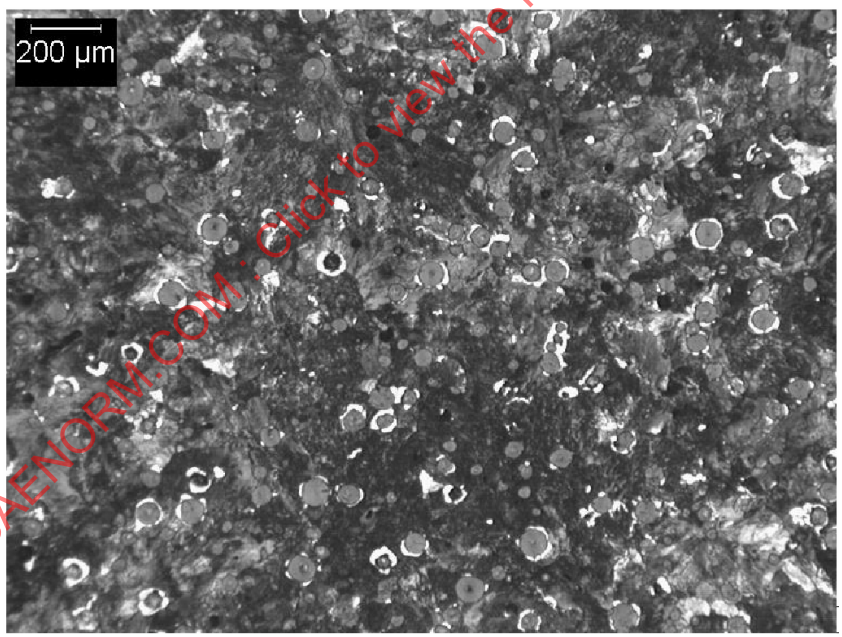


D550

FIGURE 2—TYPICAL MATRIX MICROSTRUCTURES (CONTINUED)
(PHOTOS COURTESY OF CLIMAX RESEARCH SERVICES)



D700



D800

FIGURE 2—TYPICAL MATRIX MICROSTRUCTURES (CONTINUED)
(PHOTOS COURTESY OF CLIMAX RESEARCH SERVICES)

7. Quality Assurance

It is the responsibility of the manufacturer to demonstrate process capability. The specimen(s) used to do so shall be of a configuration and from a location agreed upon between the manufacturer and the purchaser. Sampling plans shall be agreed upon between the manufacturer and purchaser. The manufacturer shall employ adequate controls to ensure that the parts conform to the agreed upon requirements.

8. General

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

8.2 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 and by methods approved by the purchaser**.**

8.3 Purchaser and manufacturer may agree to additional casting requirements, such as manufacturer identification, other casting information, and special testing. These should appear as additional product requirements on the casting drawing**.**

9. Notes

9.1 Marginal Indicia

The change bar (l) located in the left margin is for the convenience of the user in locating areas where technical revisions have been made to the previous issue of the report. An (R) symbol to the left of the document title indicates a complete revision of the report.

PREPARED BY THE SAE AUTOMOTIVE IRON & STEEL CASTINGS COMMITTEE

APPENDIX A
APPENDIX—DUCTILE (NODULAR) IRON
(FOR INFORMATION ONLY)

A.1 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.

A.2 Chemical Composition

The typical chemical composition of unalloyed iron generally conforms to the following ranges:

TABLE A1

Carbon	3.20 – 4.10%
Silicon	1.80 – 3.00%
Manganese	0.10 – 1.00%
Phosphorus	0.050% max.
Sulfur	0.035% max.
Magnesium	0.025 – 0.060%

Individual foundries will produce to narrower ranges than those shown above.

The spheroidal graphite structure is produced by alloying the molten iron with small amounts of one or more elements such as magnesium or cerium. The matrix microstructure may be controlled by addition of other alloying elements, such as: copper, tin, nickel, chromium and molybdenum.

A.3 Microstructure

A.3.1 The microstructure of the various grades of ductile iron consists of spheroidal graphite in a matrix of ferrite, pearlite, tempered pearlite, tempered martensite, or certain combinations 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.

A.3.2 The matrix microstructure of as-cast ductile iron depends to a great extent on the solidification rate and cooling rate of the casting. If a section solidifies rapidly, especially sections of 0.25 in. (6mm) or less, some amount of carbide may be present in the casting. If a section cools slowly, as in a massive, heavy casting, a largely ferritic matrix may result.

A.3.3 Alloying elements also can alter the microstructure, usually 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, by controlled cooling, or any combination of these. Primary carbides, and/or pearlite can be decomposed by appropriate heat treatments.

A.3.4 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.