Designation: A 247 – 06

Standard Test Method for Evaluating the Microstructure of Graphite in Iron Castings[1]

This standard is issued under the fixed designation A 247; 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.

This standard has been approved for use by agencies of the Department of Defense.

1. Scope

1.1 This test method covers the classification of graphite in cast irons in terms of type, distribution, and size. This test method is intended to be applicable for all iron-carbon alloys containing graphite particles, and may be applied to gray irons, malleable irons, and the ductile (nodular) irons.

1.2 The reference standards included in this test method are in no way to be construed as specifications. In an appropriate specification for a specific material where graphite microstructure is an important consideration this test method may be used as a reference to define concisely the graphite microstructure required.

1.3 These standards are offered primarily to permit accurate reporting of microstructures of cast irons and to facilitate the comparison of reports by different laboratories or investigators.

1.4 *This standard does not purport to address all of the safety problems associated with its use. It is the responsibility of the user of this standard to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*

E 3 Guide for Preparation of Metallographic Specimens

3. Summary of Test Method

3.1 The reference diagrams included in this standard form the basis for classification. Characteristic features of graphite particles are designated by numerals and letters. Type, distribution, and size of observed graphite are compared with the idealized microstructures in the standard charts and rated accordingly as closely as possible to the equal or similar microstructures in the charts.

4. Significance and Use

4.1 The comparison of observed graphite particles with the structures shown in the charts give only purely descriptive information on the type, distribution, and size of the graphite in the sample being evaluated. It does not indicate except in a very broad way the origin of the graphite, or the suitability of the iron-carbon alloy for a particular service.

5. Test Specimens or Samples

5.1 The preferred sample is a section cut from an actual casting that is being evaluated. When this is impractical, a test lug or projection often can be cast attached to the casting and sawed or broken off to be used as the sample. If neither of these methods is convenient, microscopical test coupons, such as that recommended by the Ductile Iron Research Committee (12K) of the American Foundrymen's Society[2] should be cast from metal representative of the castings poured.

6. Polishing

6.1 Grinding and polishing may follow the usual accepted metallographic procedures as covered in Methods E 3, except that care must be taken that the graphite is retained at the polished surface and not torn or dragged out. Use of diamond powder polishing compound in one of the final stages of polishing is very effective in retaining the graphite at the polished surface.

7. Classification of Graphite Form with Chart

7.1 The graphite form type chart (Plate I)[3] is used as a reference standard by scanning the polished specimen under the microscope and noting the graphite forms in the microstructure that more nearly correspond to type designations on the chart.

7.2 Type I is the normal and usually desirable graphite form in ductile iron, although the presence of Type II graphite forms has little or no adverse effect on properties. Graphite forms represented by Types IV through VI often occur in ductile iron in conjunction with Types I and II. The percentages of each graphite type are estimated by observation, or better, by counting the particles of each type. Types present in a sample are to be reported in percentages to total 100. Any convenient magnification that clearly reveals the graphite form may be used.

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[1] This test method is under the jurisdiction of ASTM Committee A04 on Iron Castings and is the direct responsibility of Subcommittee A04.21 on Testing.

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[2] *Transactions*, American Foundrymen's Society, 1960, p. 655.

[3] Plates I, II, and III may be obtained from ASTM Headquarters. Order ADJA0247.

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7.3 Type III is the graphite form most often seen in malleable iron castings after annealing. Some malleable irons may contain Types I or II graphite particles also.

7.4 Type IV is the predominant graphite form in compacted (vermicular) graphite iron. However, the microstructure is typically evaluated by the percentage of Types I and II that are commonly observed.

7.5 Type VII is the flake graphite form usually seen in gray iron.

8. Classification of Graphite Distribution with Chart

8.1 The graphite distribution chart (Plate II)[3] is useful principally in rating flake graphite, Type VII, distributions in gray cast iron. Occasionally, however, graphite in malleable or ductile iron may occur in a nonrandom distribution pattern which the distributions B to E may be used to describe.

9. Classification of Graphite Size by Chart

9.1 Two series of size charts, one for flake graphite, and one for nodules, are shown in Plate III[3] to facilitate comparisons. At exactly 100 diameters magnification the *maximum* dimension of the graphite particles for the various size classes are shown in Table 1.

TABLE 1 Graphite Size

Size Class	Maximum Dimension at × 100, mm[A]
1	128
2	64
3	32
4	16
5	8
6	4
7	2
8	1

[A]The gradation of sizes shown in each size class from the maximum dimension were computer calculated at the National Bureau of Standards using data obtained from actual micrographs (Wyman, L. L., and Moore, G. A., "Quantitative Metallographic Evaluations of Graphite Microstructures," Modern Castings, Vol 43, No. 1, Jan. 1963, p. 7).

9.2 For direct comparison with the size classes in Plate III, the specimen to be evaluated should be projected on the ground glass screen, or photographed, at a magnification of exactly 100 diameters. Usually visual comparison with the chart is adequate to define the size class. If carefully calibrated, ocular scales may be used to measure the serpentine length dimension of flakes or the diameter of nodules. Where a mixture of one or more sizes occurs in the same sample, the sizes may be reported as percentages of the total graphite area represented by the sizes involved. It is a common practice in malleable iron to use nodule count per unit area instead of a comparison chart as given here. Nodule count, with known free carbon content, is a measure of calculated average nodule area.

10. Report of Graphite Microstructure

10.1 To report the microstructure of graphite in cast iron the headings to be used are as follows: Sample identification; graphite form type or types; graphite distribution; graphite size class.

10.2 Graphite type, or types, is designated by a Roman numeral I through VII. Graphite distribution is designated by a capital letter A through E. Graphite size is designated by an Arabic numeral 1 through 8.

10.3 Graphite distribution is always designated for flake graphite irons, but may be omitted for malleable and ductile iron.

10.3.1 For example, a typical gray iron of normal graphite structure might be designated VII A4. If eutectiform graphite is present, the rating might be VII D7. Mixtures of these two may be described by giving both ratings with appropriate percentages, 70 % VII A4, 30 % VII D7.

10.3.2 A high-quality ductile iron could be designated I6. A slightly inferior ductile iron, with somewhat insufficient nodulizing alloy, might be 70 % I6, 30 % IV5.

10.3.3 Graphite in malleable irons may be similarly designated as Types III, II, or I and the size from the nodular size chart.

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