This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.

Designation: A247 – 24

Standard Test Method for Visual Evaluation of Graphite in Iron Castings[1]

This standard is issued under the fixed designation A247; 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 U.S. 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 by visual comparison to reference photomicrographs. 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, compacted graphite irons, and the ductile (nodular) irons.

1.2 The reference photomicrographs 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 concisely define the graphite microstructure required.

1.3 These reference photomicrographs 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 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.5 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.6 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

E3 Guide for Preparation of Metallographic Specimens

3. Summary of Test Method

3.1 The reference micrographs included in this standard form the basis for classification. Characteristic features of graphite particle shape and distribution 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 at a location agreed upon between the manufacturer and purchaser. When this is impractical, a test lug or projection often can be appended to the casting and sawed or broken off to be used as the test sample. If neither of these methods is convenient, microstructural test coupons, such as those recommended by the Cast Iron Research Committee (5R) of the American Foundry Society[3] shall 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 Guide E3, except that

[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] 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.

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

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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 Using Chart

7.1 The graphite form type chart (Fig. 1) 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. 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.

7.2 Type I graphite is nodular in shape and is the normal and usually desirable graphite form in ductile iron.

7.3 Type II graphite consists of slightly irregular nodules and has little or no adverse effect on properties of ductile iron.

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

7.5 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.

7.6 Type V is the spiky graphite form occasionally seen in ductile iron in conjunction with Types I and II.

7.7 Type VI is the exploded nodule graphite form occasionally seen in ductile iron in conjunction with Types I and II.

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

TABLE 1 Graphite Size

Size Class	Actual Dimension (μm)[A]
1	≥640
2	320 to <640
3	160 to <320
4	80 to <160
5	40 to <80
6	20 to <40
7	10 to <20
8	<10

[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).

8. Classification of Graphite Distribution Using Chart

8.1 The graphite distribution chart (Fig. 2) is useful principally in rating flake graphite, Type VII, distributions in gray cast iron. Graphite in malleable 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 This method categorizes the graphite particles by size into eight classes. Figs. 3-5 show size classes for flake graphite and nodular graphite to facilitate comparisons. The maximum dimension of the graphite particles for the various size classes are listed in Table 1.

9.2 For direct comparison with the size classes in Figs. 3-5, the specimen to be evaluated shall be captured at the magnification of exactly 100×. Usually visual comparison with the chart is adequate to define the size class. 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 irons 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. Nodularity

10.1 Nodularity (Figs. 6 and 7) is expressed by counting the nodular particles and reporting the results as a percentage of the total amount of graphite present in the microstructure. Ductile irons typically exhibit a nodularity between 80 to 100 %, gray irons a nodularity of 0 %, and compacted graphite irons a nodularity of 0 to 20 %. Nodularity should be assessed by evaluating more than one field of view. The final report should state the number of fields of view or area of the sample evaluated. The location of the measurement should be agreed upon between the manufacturer and purchaser.

11. Nodule Count

11.1 Nodule count is expressed as the number of graphite nodules/mm^2 and is performed at a magnification of 100×. Generally, high nodule count indicates good metallurgical quality, but there is an optimum range of nodule count for each section size of casting, and nodule counts in excess of this range may result in a degradation of properties. Nodule count should be established between the manufacturer and the purchaser. Figs. 8-10 compare the nodule counts of ductile iron at 100 % nodularity, 90 % nodularity, and 80 % nodularity, respectively.

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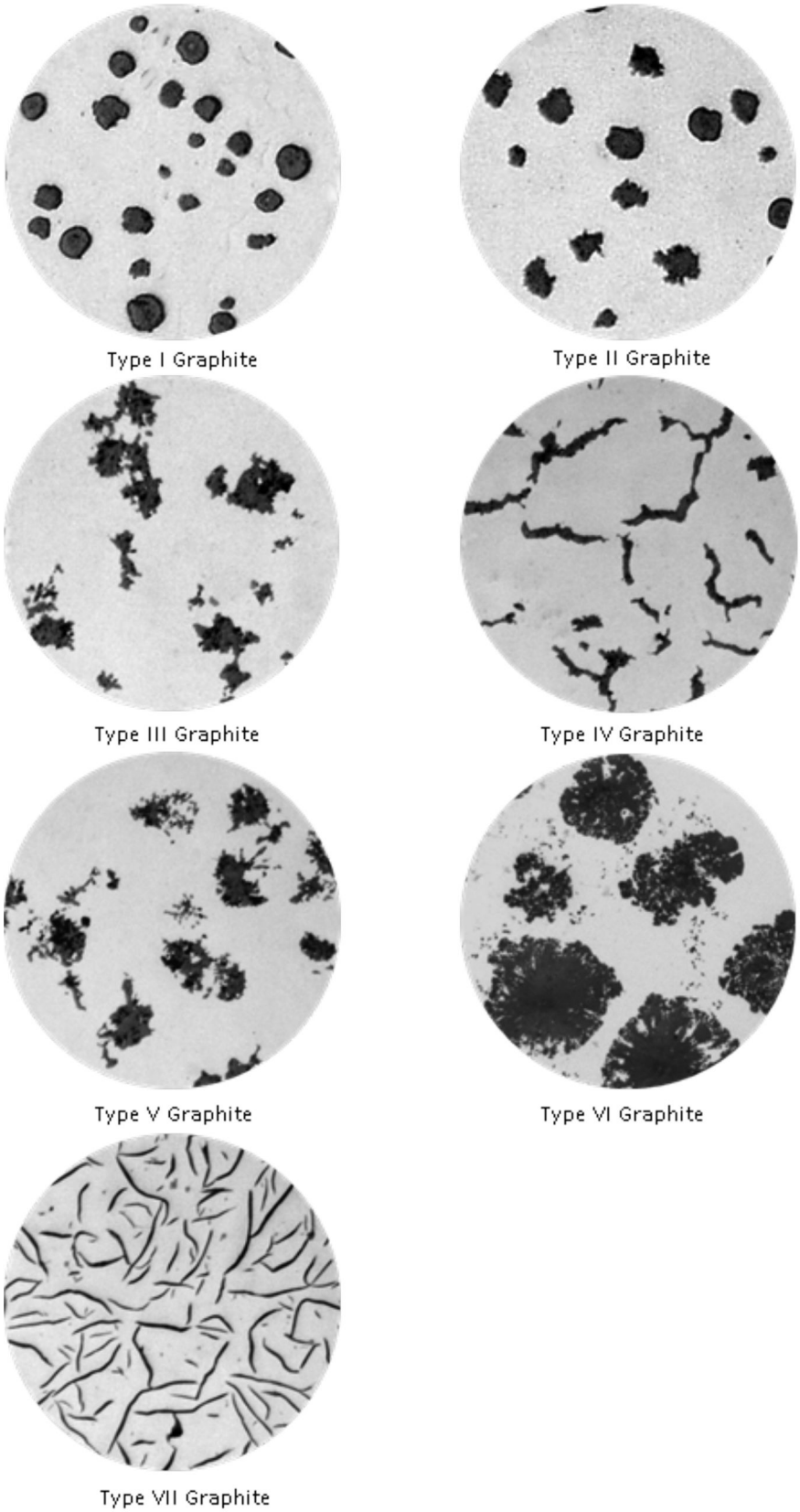

FIG. 1 Graphite Types Found in Iron Castings

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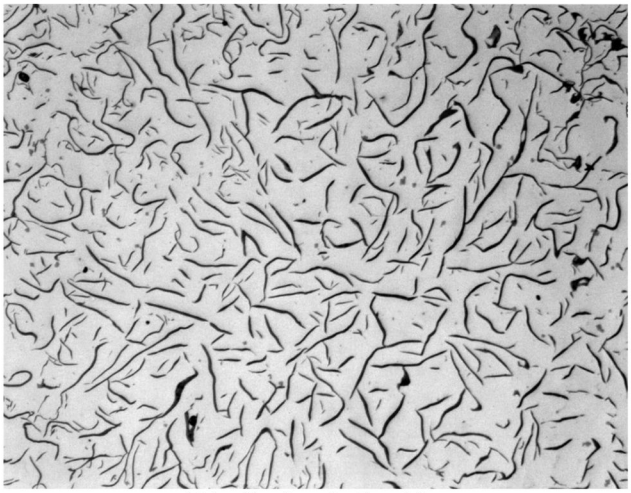
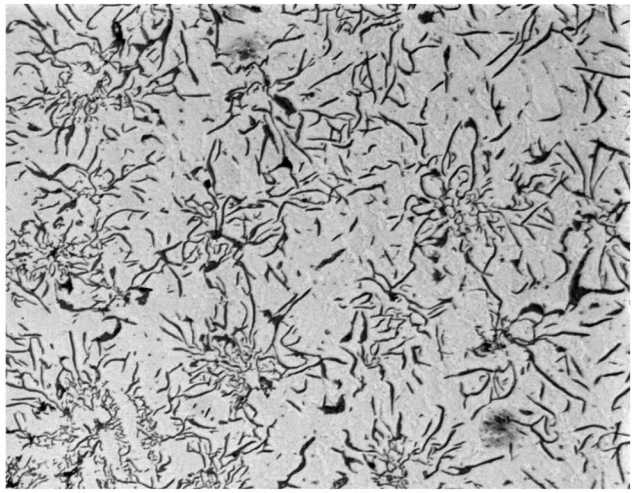


Distribution A Graphite



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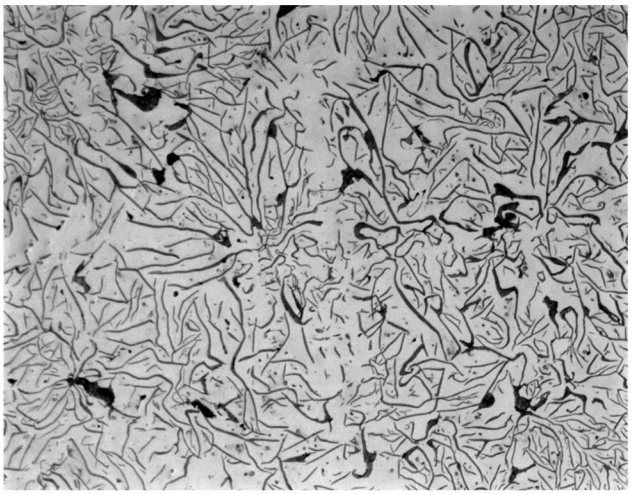

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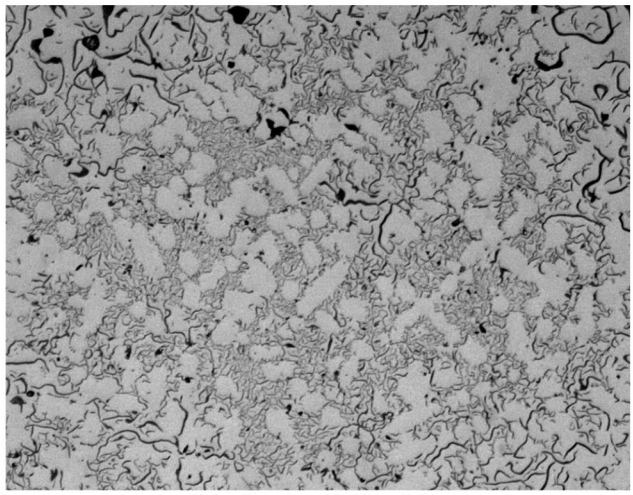
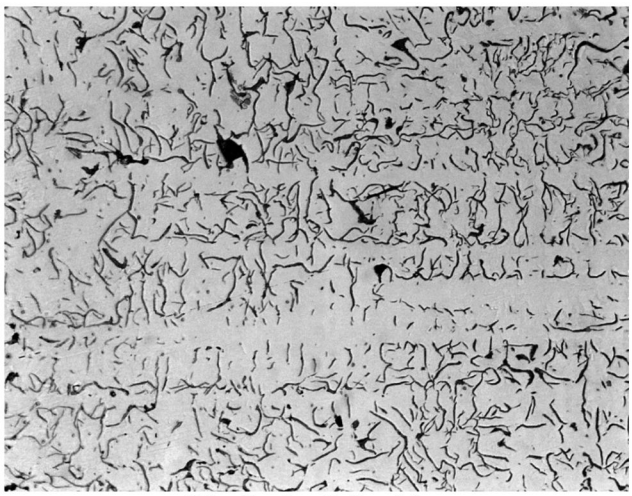


Distribution D Graphite



Distribution E Graphite

FIG. 2 Graphite Distribution Typically Used to Rate Type VII Flake Graphite in Gray Iron (100×)

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