



Nodularity Determination in Iron Castings

1 Introduction

Note: Nothing in this standard supercedes applicable laws and regulations.

Note: In the event of conflict between the English and domestic language, the English language shall take precedence.

1.1 Purpose. Test method to qualify a nodule, determine the degree of nodularity, nodule counts for graphite particles using a light microscope image of graphite in nodular cast iron.

1.2 Applicability. Nodular cast iron components used in automotive Chassis, Powertrain and other applications.

1.3 Remarks. For cast iron to be qualified as a nodular iron, a number of specifications including ISO 1083 stipulate that the metal shall contain 80% of graphite of certain form according to ASTM A247 or ISO 945. The descriptions of the graphite shapes are in a pictorial form in these standards and are used as a guide in rating the percentage nodularity. A repeatable test procedure that the casting suppliers and GM materials laboratories can use will greatly aid in accurate cast product evaluation.

This standard supercedes the currently used manual point-count method, which is labor intensive and requires many areas to be counted for a precise determination.

2 References

Note: Only the latest approved standards are applicable unless otherwise specified.

2.1 External Standards/Specifications.

ASTM A247	ASTM E3	ISO 945
ASTM A644	ASTM E1245	ISO 1083

2.2 GM Standards/Specifications.

None

3 Resources

3.1 Facilities.

3.1.1 Calibration. The test facilities and equipment shall be in good working order and shall have a valid calibration label.

3.1.2 Alternatives. Alternative test facilities and equipment may also be used. However, all measuring variables as specified in this standard shall be determined correctly with respect to their physical definition.

3.2 Equipment. Image analysis equipment consisting of:

3.2.1 Reflected light microscope.

3.2.2 Video camera detecting the magnified image.

3.2.3 Image analysis software.

3.3 Test Vehicle/Test Piece. The test piece should have a surface area large enough to provide a number of fields-of-view at the required magnification. In general, a 10 mm × 10 mm surface area test sample is sufficient. A user may need to determine variation within a given sample, at a designated location in a casting, or between different locations in a casting, or from casting to casting over time. Near surface samples may exhibit a large variation in graphite structure and shall be reported accordingly.

3.4 Test Time.

Calendar time: 8 h

Test hours: 8 h

3.5 Test Required Information. Nodularity, particles/mm², and nodule size distribution are typically required to be reported.

3.6 Personnel/Skills. Personnel trained in metallographic specimen preparation per ASTM E3 and image analysis procedures shall be used.

4 Procedure

4.1 Preparation. Specimen preparation:

4.1.1 Metallographic specimen preparation must be carefully controlled to produce an acceptable quality surface for image analysis. Guide lines are per ASTM E3.

4.1.2 The polishing procedure must remove all deformation and damage induced by the cutting and grinding procedure. Scratches and smeared graphite must be removed by polishing with a fine abrasive, about 1 µm or less is recommended. Scratches must be small enough so as not be detected as part of the thresholding step in the image analysis procedure.

4.2 Conditions.

4.2.1 Environmental Conditions. Not applicable.

4.2.2 Test Conditions. Deviations from the requirements of this standard shall have been agreed upon. Such requirements shall be specified on component drawings, test certificates, reports, etc.

4.2.3 Test Procedure.

4.2.3.1 The sample image shall be captured in the unetched condition for nodularity measurements. Etching the sample will cause gray level overlap between the graphite and other matrix constituents and must be avoided.

4.2.3.2 The image to be analyzed is expected to be of sufficient quality to reflect the truest possible shape of particles on a random plane of polish. The graphite particle should appear dark grey compared to the surrounding unetched surface.

4.2.3.3 The light should be checked for correct illumination intensity and focus should be adjusted to provide the sharpest image achievable.

4.2.3.4 Capture the image to be analyzed. A magnification setting of 100x (minimum objective of 10x) and a maximum resolution of 0.9 µm/pixel is recommended. The captured image should be free from scratches and other marks that would be detected when establishing the threshold level.

4.2.3.5 The image on the monitor should show well defined particles. The routine may have steps to enhance the appearance of the particles, but the shape of the particles must be maintained.

4.2.3.6 Although threshold settings are established so that the graphite particles are detected, sometimes small features, such as voids, inclusions, or other features are also evident. The operator must adjust the threshold setting so that, as near as possible, the gray level setting selected detects only the graphite shapes for the intended measurement.

4.2.3.7 It is important only to measure whole particles. The Image analysis equipment usually has a routine to eliminate particles touching the edge of the field-of-view.

4.3 Instructions. Test measurement.

4.3.1 A single field of view is approximately 1 mm². It is recommended to use a minimum of 16 fields-of-view for measurement.

4.3.2 Particle Count. Only graphite particles that exceed the required minimum size of 25 µm² are counted.

4.3.3 Nodule Qualification. To determine if a graphite particle above the minimum size qualifies as a nodule its shape factor is measured. This standard uses the roundness as shape factor based on the measured area and the measured average feret diameter of the graphite particle. A roundness shape factor ≥ 0.70 qualifies a particle as a nodule.

4.3.4 Roundness is the ratio of the area of the particle over the area of a circle with the diameter equal to the average feret diameter and is given by the following formula: