GM	WORLDWIDE ENGINEERING STANDARDS	Test Procedure	GMW16436

Dendrite Arm Spacing Measurement of Aluminum 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. This standard covers the process for determining and reporting the microstructural fineness of aluminum castings. Two (2) methods are presented in this standard:

- **Method A (Appendix A)**. Secondary Dendrite Arm Spacing (SDAS) as measured via the linear intercept method.
- **Method B (Appendix B)**. Mean Linear Dendrite Spacing (MLDS) as measured via an image analysis routine.

1.2 Applicability. This standard applies only to aluminum castings which have well defined dendrite arms evident in the microstructure. It is not suitable for characterization of near eutectic, eutectic or hypereutectic aluminum alloys.

1.3 Remarks. These methods provide a quantitative representation of the two dimensional (2-D) microstructure of hypoeutectic aluminum castings. It is important to note that these two (2) methods will not produce identical results.

2 References

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

2.1 External Standards/Specifications.

ASTM E3	ASTM E407	ASTM E1951	ISO 17025

2.2 GM Standards/Specifications.

None

2.3 Additional References.

- Automatic Assessment of Dendrite Cell Spacing in Cast Aluminum Microstructures", P.N. Crepeau, W.T. Whited, M.E. Hoover, AFS Transactions 97-50, pp 775-781
- Part Print
- Product Engineering Quality Document
- Supplier Process Control Plan

3 Resources

3.1 Facilities. Fume hood for preparation of any etchants that may be necessary.

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.

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3.2 Equipment.

3.2.1 Grinding/polishing equipment is required for preparation of the metallographic samples.

3.2.2 An ultrasonic cleaning unit may be used for cleaning the samples between operations.

3.2.3 A metallurgical microscope with a 10x objective lens and 10x multiplier (100x magnification) minimum is required. The use of other multipliers must be discussed with/and approved by GM Materials Engineering.

3.2.4 A digital camera connected to the metallurgical microscope for capturing images.

3.2.5 Image analysis software with a maximum pixel resolution or calibration factor of 1 µm (micron) per pixel at 100x and capability of object, field, and relative measurement is required.

3.2.6 A certified stage micrometer that has been calibrated by an ISO 17025 accredited laboratory is required for calibration and verification at each magnification of the system.

3.3 Test Vehicle/Test Piece. Metallographic specimens shall be taken from castings. Locations and frequency for measurement shall be agreed upon between the supplier and purchaser (Design Release Engineer or delegate). These locations shall be identified on the part print and/or in the Product Engineering Quality Document and shall be included in the supplier Process Control Plan.

3.4 Test Time. Not applicable.

3.5 Test Required Information. Not applicable.

3.6 Personnel/Skills. The requirements set forth in ISO 17025 shall be complied with.

4 Procedure

4.1 Preparation. Metallographic samples shall be prepared in either a compression or castable mount in accordance with ASTM E3.

4.1.1 Metallographic samples shall be final polished to obtain a flat, near mirror image surface finish.

4.1.2 Chemical etching may be used to enhance the contrast of the dendrite structure. Chemical etching should be in accordance to ASTM E407.

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. The agreement is between the supplier and purchaser (Design Release Engineer or delegate) and shall be noted in the results.

4.2.3 Polishing Acceptability Standards. Samples must be clean and dry. Polishing artifacts such as comet tailing, pitting, scratching, pullout, and staining should be kept to a minimum. See Appendix C for examples.

4.3 Instructions. See Appendix A, A2, Appendix B, B2, and Appendix C, C2, for specific test instructions.

4.3.1 Verification and Calibration of Microscope. ASTM E1951 describes the procedures for calibrating eyepiece reticles and light microscope magnifications. The remainder of this section will discuss specific items related to the use of image analysis software and cameras.

4.3.1.1 Determine the size of the test area or magnification bar using a stage micrometer scale for each objection and projection eyepiece/camera multiplying factor combination (consult the manufacturer's instruction book for the calibration procedure specific to the instrument used). The relationship between the number of pixels per micron and the inverse of the magnification must be linear.

4.3.1.2 The verification measurements should be recorded to three (3) decimal places and three (3) measurements per magnification are required.

5 Data

5.1 Calculations. See Appendix A, A3 and Appendix B, B3 for specific test calculations.

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5.2 Interpretation of Results. Not applicable.

5.3 Test Documentation. The test results shall include:

5.3.1 A representative image showing the microstructure. A micrometer marker shall be superimposed on the image at the time of capture. Each image should include a figure caption to ensure traceability to the part being analyzed.

5.3.1.1 For Method A, the representative image shall include the lines used to measure the dendrites along with the resulting length measurements indicated.

5.3.2 Table showing the individual dendrite length measurements, number of dendrite arms counted corresponding to each length measurement, and the resulting dendrite arm value.

5.3.3 The resolution of the system as indicated by the number of microns per pixel.

5.3.4 The size of the field of view as indicated by the length and height of the image in number of pixels.

5.3.5 The magnification of the image analyzed.

5.3.6 The number of fields of view analyzed.

6 Safety

This standard may involve hazardous materials, operations, and equipment. This standard does not propose to address all the safety problems associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

7 Notes

7.1 Glossary.

Dendrite: A crystal with a tree-like branching pattern.

Field of View: Portion of a sample that can be viewed at one time in a photomicrograph, in an image analysis system, or through the eye piece of the microscope.

Secondary Dendrite Arm Spacing: The distance, (d), between concurrent points on adjacent branches growing from the main dendritic arm.

7.2 Acronyms, Abbreviations, and Symbols.

2-D	Two Dimensional
ASTM	ASTM International
d	Distance
DCS	Dendrite Cell Spacing
ISO	International Organization for Standardization
MLDS	Mean Linear Dendrite Spacing
SDAS	Secondary Dendrite Arm Spacing

8 Coding System

This standard shall be referenced in other documents, drawings, etc., as follows:

Test to GMW16436

Note: If no method is referenced in part documents or drawings, the default test method shall be Method A.

Or, as example:

Microstructure per GMW16436 Method X

- XX µm (microns) maximum in combustion chambers
- YY µm (microns) maximum in other areas

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