



Measurement of Primary Silicon Characteristics for High Pressure Die Cast Hypereutectic Aluminum Alloy Components

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 specification covers microstructural requirements for hypereutectic aluminum silicon alloy GMW5-AL-C-D-Si17Cu4Zn1Fe1-F (B390), A390/B390 specified by ASTM B85 or ADC14 specified by JIS H5302 for high pressure die casting. The intended usage for this alloy is where high wear resistance is required. The wear resistance of this alloy is strongly dependent on primary silicon particle size and distribution.

1.2 Applicability. Automotive component applications include, cylinder liners, pistons, engine blocks, hydraulic pumps, clutch housings and air conditioner compressor cylinders.

1.3 Remarks. Aluminum GMW5M-AL-C-D-Si17Cu4Zn1Fe1 (B390) alloy contains 16% to 18% silicon, 4.0% to 5.0% copper, up to 1.3% iron and 0.45% to 0.65% magnesium. These alloying elements produce a cast structure composed of hard primary and eutectic silicon particles along with copper and iron intermetallic particles. This combination of alloying elements provide high wear resistance, strength, and low thermal expansion coefficient.

2 References

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

2.1 External Standards/Specifications.

ADC14

ASTM B85

ASTM E3

JIS H5302

2.2 GM Standards/Specifications.

GMW5

3 Resources

3.1 Facilities. Metallographic preparation laboratory.

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.

3.2.1 Cut-off saw, sample mounting and 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 grinding and polishing operations.

3.2.3 A metallurgical microscope capable of 50x and 100x magnification minimum is required.

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

3.3 Test Vehicle/Test Piece. Not applicable.

3.4 Test Time. Not applicable.

3.5 Test Required Information. Not applicable.

3.6 Personnel/Skills. Technician skilled in metallographic samples preparation and use of metallurgical microscope.

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Documents

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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.

4.2 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.

4.2.4 Microstructure Comparison Images. Appendix A provides microstructural comparison images for acceptable, marginal, unacceptable primary silicon distribution and depth of silicon depletion zone adjacent to as-cast surface.

4.2.5 Examination Area. A microstructural test specimen shall be excised through designed regions, mounted and polished for evaluation of primary silicon size and distribution described in Appendix A. Selection of designated regions and examination frequency for each casting shall be agreed upon between GM Materials Engineering and supplier and be documented in supplier's control plan. Examination areas or regions considered critical are surfaces that require high wear resistance in the finished part. Regions selected for examination will include as-cast surfaces to be examined for silicon particle depletion and regions considered wear surfaces and used for determination of primary silicon particle size and distribution.

4.2.6 Primary Silicon Particle Size. In a field of view at 100x magnification, the primary silicon particle size (maximum particle length) shall be in a range of 0.005 mm to 0.075 mm. Desired average primary silicon particle size is 0.025 mm. Individual silicon particle size shall not exceed a maximum of 0.13 mm.

4.2.7 Silicon Particle Distribution. Primary silicon particles shall be uniformly distributed throughout the cast structure. Comparison images of preferred, minimal and unacceptable primary silicon distributions are shown in Appendix A, Figures A2 through A4. Minimum acceptable criterion for the silicon particle distribution in a casting shall be established and mutually agreed upon by GM Materials Engineering and the supplier during process development. The requirements shall be documented in Production Part Approval Process (PPAP) documents and supplier's control plan.

4.2.8 Silicon Particle Depletion Zone. The depletion zone is defined as a layer adjacent to an as-cast surface that exhibits sparse distribution or absence of primary silicon particles as shown in Appendix A, Figure A1. A depletion zone is allowable adjacent to any as-cast surface. Depth of the depletion zone varies with different locations in a casting. It should be measured at critical locations defined by the part's function.

The depletion zone depth should be measured as a distance between as-cast surface and a defined line that is parallel to the surface at a field of view at 50x magnification under non-etched condition. The defined line shall be drawn where uniform primary silicon distribution starts. The criteria of uniform distribution shall be agreed mutually by supplier and General Motors Powertrain (GMPT), and shall be document in supplier's lab inspection procedure. An example of the defined line and the measured depth of primary silicon depletion zone is shown in Appendix A, Figure A5.

The silicon depletion zone depth shall not exceed 0.6 mm or an applicable drawing specification, whichever is smaller. Casting supplier shall work with part manufacturer to ensure the depths of depletion zones are smaller than machining stock at those areas in the part where high wear resistance is required.

4.3 Instructions. Not applicable.

5 Data

5.1 Calculations. Not applicable.

5.2 Interpretation of Results. Not applicable.

5.3 Test Documentation. Not applicable.