



Determine Permanent Growth Potential in Aluminum Due to Metallurgical Instability

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. The standard described herein measures the potential for aluminum to experience permanent growth due to metallurgical instability. Aluminum parts often operate at temperatures that facilitate phase transformation and precipitation of supersaturated alloying elements. These metallurgical changes may be accompanied by permanent volumetric expansion. Background on this phenomenon is given in Appendix A. Results of a benchmark study are presented in Appendix B.

1.2 Applicability. Aluminum alloys.

1.3 Remarks. Summary of test method: Ten right-circular cylinders with premeasured end-to-end lengths are heated at 250 °C for 100 h. After cooling to ambient temperature, each sample is remeasured with the change in length converted into percent (%) growth. Average and standard deviation(s) growth are calculated. Mean + 3s growth is defined herein as "Maximum Permanent Growth Potential" for the material and rated per Section 5.4 against a maximum allowance.

2 References

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

2.1 External Standards/Specifications.

ISO 10360-2

2.2 GM Standards/Specifications.

None

2.3 Additional References.

- Boileau, J.M., C.A. Cloutier, L.A. Godlewski, P.A. Reeber-Symanksi, C. Wolverton, J.E. Allison, "The Dimensional Stability of Cast 319 Aluminum," SAE paper 2003-01-0822.
- Hunsicker, H.Y. "Dimensional Changes in Heat Treating Aluminum Alloys," Met. Trans. A, v. 11A, p. 759 (1980).
- Li, M., R. Vijayaraghavan, C. Wolverton, J.E. Allison, "Simulation of Local Microstructures and Thermal Growth of a Cast 319 Aluminum Alloy component," Proceedings 1st International Symposium on Metallurgical Modeling for Aluminum Alloys, ASM International, 2003.

3 Resources

3.1 Facilities. A temperature-controlled room where measurements will be made.

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 Coordinate Measuring Machine (CMM) with temperature compensation and 3-dimensional length-measurement uncertainty $\leq 2.50 \mu\text{m}$ calibrated per ISO 10360-2 or its successor.

© Copyright 2017 General Motors Company All Rights Reserved

August 2017

Page 1 of 7

3.2.2 Convection oven with temperature control capability of $250\text{ }^{\circ}\text{C} \pm 5\text{ }^{\circ}\text{C}$.

3.2.2.1 Capability may be established by measuring and recording the furnace temperature with a thermocouple co-located with the samples.

3.3 Test Vehicle/Test Piece. Material for test shall be taken from parts made by a documented process in a defined level of development or production.

3.4 Test Time.

Specimen machining:	1 h
Specimen pre-measurement:	1 h
Thermal conditioning:	100 h
Specimen final measurement:	1 h
Coordination, set up, report:	8 h

3.5 Test Required Information. Not applicable.

3.6 Personnel/Skills. Proficiency in programming and operating CMM equipment.

4 Procedure

4.1 Preparation. Machine 10 test samples into right-circular cylinders per Figure 1. If sufficient material is unavailable, alternate geometries are acceptable per agreement by GM. Place a permanent reference mark on each specimen surface for use in orienting the specimen during length measurement. Number each specimen.

4.2 Conditions.

4.2.1 Environmental Conditions. Laboratory air.

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.

4.3 Instructions.

4.3.1 Dimensional Measurements. Program a CMM conforming to paragraph 3.2.1 to measure temperature-compensated end-to-end length of the test specimens. Measurements are made before and after the thermal conditioning in paragraph 4.3.1.5.

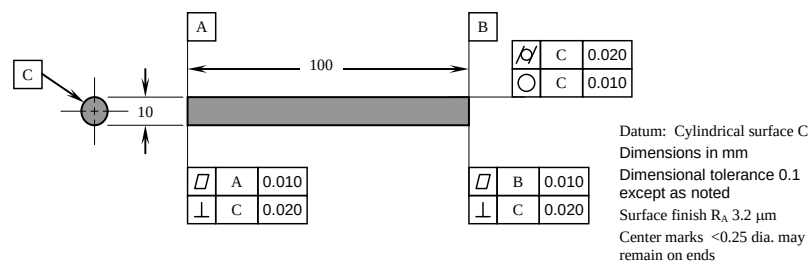


Figure 1: Specimen Dimensions and Tolerances

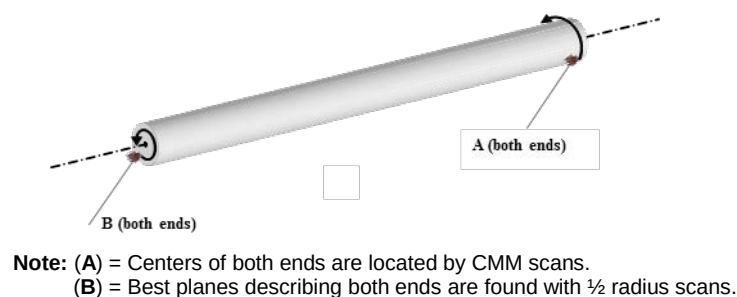


Figure 2: CMM Programming Detail

4.3.1.1 Use the same CMM and probe for all measurements, and locate specimens in the same position on the bed. Use the reference marks on each specimen to establish a common orientation.

4.3.1.2 Stabilize specimens at the CMM ambient temperature. Attach the CMM temperature probe to each sample and compensate for workpiece temperature. Use a Coefficient of Thermal Expansion (CTE) value of $21 \times 10^{-6}/^{\circ}\text{C}$ (or other appropriate value).

4.3.1.3 End-to-End Length. Locate the centers of the specimen ends and determine their best planes by scanning them at $\frac{1}{2}$ radius, A and B in Figure 2. Determine end-to-end length as the distance between the best planes at the centers of the ends.

4.3.1.4 Thermal Conditioning. Place samples into a preheated furnace and hold at $250^{\circ}\text{C} \pm 5^{\circ}\text{C}$ for 100 h (± 2 h). Cool samples with forced air (e.g., a fan).

4.3.1.5 Post-Treatment Measurement. Recondition samples at ambient temperature and repeat measurements in paragraphs 4.3.1.3 and 4.3.1.4.

5 Data

5.1 Calculations. Growth calculation: Determine mean and standard deviation of growth calculated by:

$$\% \text{Growth} = \left(\frac{l_{\text{final}} - l_{\text{initial}}}{l_{\text{initial}}} \right) \cdot 100\%$$

5.2 Interpretation of Results. The *Maximum Permanent Growth Potential* is defined herein as the result of mean + 3s for the 10 samples tested.

5.3 Test Documentation. The process and development/production level shall be documented for the origin of samples tested. Include all initial and final sample lengths, initial and final measurement temperature, percent (%) Growth for each sample, and the Maximum Permanent Growth Potential per paragraph 5.2.

5.4 Evaluation and Rating.

5.4.1 Acceptance. The material may be reported as substantially free from potential permanent growth if the Maximum Permanent Growth Potential defined in paragraph 5.2 is less than 0.030%.

5.4.2 Other criteria for acceptability may be dictated by GM.

6 Safety

This Engineering Standard may involve safety requirements for hazardous materials, the method of operations and equipment. This standard does not propose to address all the safety issues associated with its use. It is the responsibility of the user of this standard to ensure compliance with all appropriate safety and health practices. This would include any specific training that may be required. The safety and health standards include site specific rules and procedures, company rules and procedures, and Government Standards. Contact shall be made with the appropriate site Safety and Health personnel for further direction and guidance in these matters.

7 Notes

7.1 Glossary.

Maximum Permanent Growth Potential. Defined herein as the largest value of mean+3s of the sample groups tested per this standard.

7.2 Acronyms, Abbreviations, and Symbols.

CMM	Coordinate Measuring Machine
CTE	Coefficient of Thermal Expansion
DC	Die Casting
FEA	Finite Element Analysis
GSSLT	Global Subsystem Leadership Team
s	Standard Deviation