



Acceptance Criteria for Voids in Cast Aluminum Rotors

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 defines the acceptable levels of surface porosity and internal voids in as-cast and fully machined aluminum rotor castings used in vehicles containing electric machines.

This document describes the allowable porosity limits in the cast aluminum regions of high pressure die cast rotors. It also serves as an acceptance standard for internal and surface anomalies and discontinuities.

This standard does not preclude the requirements of any other further refined inspection specification (example: control plan) or engineering drawing requirement as long as the minimum requirements of this standard are met or exceptions approved by General Motors.

1.2 Applicability. As-cast and fully machined aluminum induction rotor castings.

1.3 Remarks.

1.3.1 Retention of Test Measurements. All test measurements shall be recorded and retained per GM record retention policies.

2 References

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

2.1 External Standards/Specifications.

ASTM E505

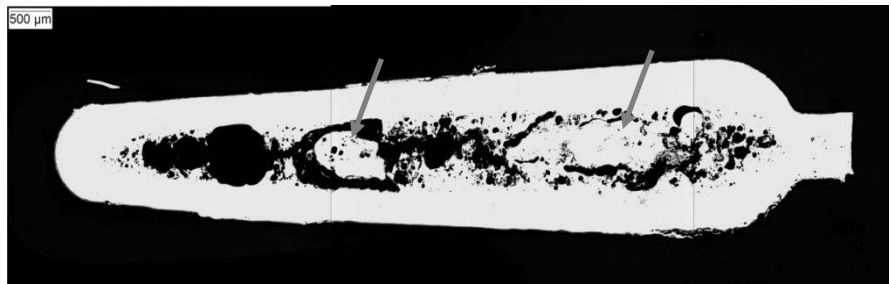
2.2 GM Standards/Specifications.

GMW3059

3 Requirements

3.1 General. Excessive casting defects that reduce the integrity of the casting or adversely affect the structural soundness or the electromagnetic performance of the part are not acceptable.

3.2 Definition of Void. Individual pores, interconnected porosity, shrinkage, hot tears, cracks, oxide films, electrically insulated aluminum inclusions (secondary metal flow), see Figure 1, other inclusions (such as carbon and die lubricant residue) are here referred to as voids.



Note: The inclusions are marked with gray arrows and indicate aluminum that formed during a secondary flow. The surface of the aluminum island is oxidized and therefore the island does not contribute to the electrical conductance of the squirrel cage.

Figure 1: Polished Cross-section of a Single Conducting Bar Showing an Example of Electrically Insulated Aluminum Inclusions That May Sometimes Occur in the Conducting Bars of Die Cast Rotors

3.3 Acceptance Practices. A sound casting with minimal amount of voids is expected. Voids that are acceptable are still subject to continuous improvement requirements. Chronic voids should be reduced or eliminated by process and design improvements, process quality controls, and technology advances.

Final determination of disposition of parts with voids is defined by GM Quality procedures, the same as for any other feature out of print, or in dispute.

3.4 Nondestructive Evaluation.

3.4.1 Radiographic inspection. The cast rotor end rings in their entirety shall be inspected 100% using x-ray procedures approved by GM engineering. The x-ray procedure shall be correlated to actual porosity size and approved by GM Engineering. The maximum (max) allowable level of voids in all regions of the end rings is Level 3 per ASTM E505. Acceptable level of voids at the interface between end rings and conducting bars (see Figure 2) is Level 2 per ASTM E505. Any ultimate acceptance criteria shall be agreed upon between GM engineering and the supplier. For x-ray inspection schedule after capability has been demonstrated refer to the supplier quality control plan.

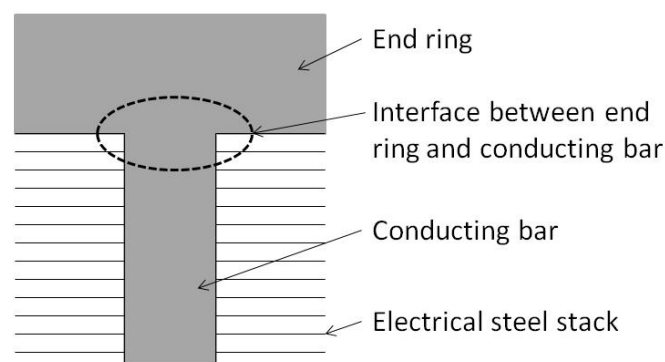


Figure 2: Illustration of the Interface between the Conductive Bar and the End Ring in Cross-section

3.4.2 Visual Inspection of As Cast Rotors. 100% inspection is required. Surface porosity, cracks, hot tears, inclusions, cold flow lines, blisters, handling damage, indications of die lubricant are not acceptable on as-cast surfaces including conducting bars and end rings. The acceptance criteria for breakout due to the removal of gates and overflows shall be agreed upon between GM Engineering and the supplier.

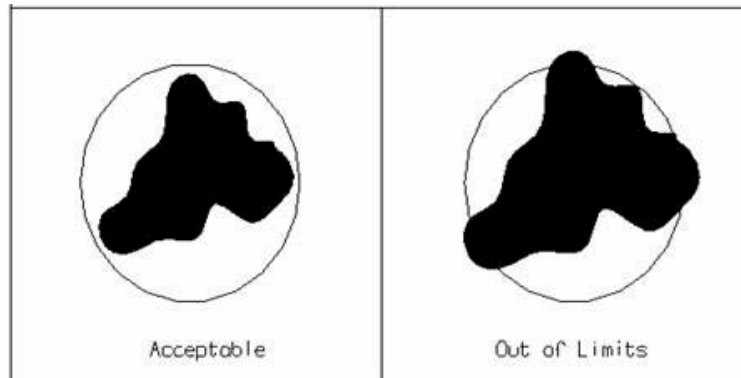
3.4.3 Visual Inspection of Rotors after Machining. All machined surfaces of the rotors shall meet the surface porosity requirements defined in this standard and the cast rotor engineering drawings. The following definitions and standard surface porosity limits (see Table 1) apply to die cast aluminum rotors after machining.

3.4.3.1 Definition of Porosity Size. Porosity size is determined by the diameter of the minimum circle that completely circumscribes the pore. See Figure 3.

3.4.3.2 Definition of Maximum (Max) Size. Porosity is within acceptance limits for “Max Size” when a circle of the diameter of the specification limit can completely circumscribe any pore on the surface. See Figure 3.

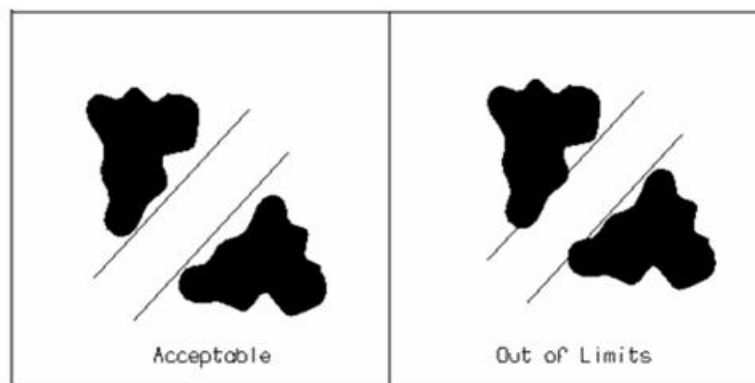
3.4.3.3. Definition of Indication Size. “Indication Size” is used to count pore for “Min Spacing” “Max Density”, and “Total Indications” requirements. A pore is counted as an indication when the porosity size is larger than the “Indication Size” limit specified for that category. See Figure 3.

3.4.3.4 Definition of Minimum (Min) Spacing. Porosity is within acceptable limits for “Min Spacing” when the shortest line between the edges of two indications is greater than the spacing specification limit. See Figure 4.



Note: Circle has diameter of 1.5 mm (no scale).

Figure 3: Example of Porosity Size Limit (per Category C) or Determination of Indication (per Category F)



Note: Lines are 2.0 mm apart, porosity is greater than 0.5 mm size (to rate as indication) (no scale).

Figure 4: Example of Porosity Spacing Limit (per Category C)

3.4.3.5 Definition of Max Density. Porosity is within acceptable limits for “Max Density” when a square of the area of the specification limit can cover (partially or fully) no more than the number of indications in the density specification limit. See Figure 5.