



Retained Austenite Reference Photomicrographs and Test Method for Nodular Cast Iron Camshafts

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 procedure is for determining and rating the level of retained austenite present in the hardened case of nodular (ductile) cast iron camshafts. The camshaft material grade is specified from GMW10.

Retained austenite is a microstructural phase resulting from an incomplete transformation to martensite after a quenching operation. It has a lower hardness, is unstable and is often undesirable in high-precision machine components such as camshafts.

A series of 4 photomicrographs of nodular cast iron with progressive levels of retained austenite are used for evaluation. This visual reference method is preferred over quantitative measurement methods such as x-ray diffraction and image analysis due to the high investment costs and sample size requirements.

1.2 Applicability. This document describes the specific procedures for sectioning hardened nodular iron camshaft lobes for analysis of retained austenite. However, the basic principle and analysis can be applied to any case hardened cast iron material with similar microstructures.

1.3 Remarks. The intent of this document is to provide a standardized method of preparing and evaluating metallographic samples for determining the amount of retained austenite in the microstructure, and to rate it on a scale of 0 to 4.

2 References

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

2.1 External Standards/Specifications.

ASTM 6-8 ASTM E3

2.2 GM Standards/Specifications.

GMW10 GMW16547

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.

3.2.1 Test Equipment.

3.2.1.1 A cutting machine that will section nodular cast iron without producing excessive heat that would cause microstructural changes in the material.

3.2.1.2 Metallographic preparation equipment (mounting press, polishing wheels, etc.)

3.2.1.3 Nital etchant (2% nitric acid, remainder methanol or ethanol).

3.2.1.4 Metallograph capable of 200x total magnification.

3.3 Test Vehicle/Test Piece.

3.3.1 Test Material. Nodular cast iron with a nodularity of at least 80% (per GMW16547), nodule size between ASTM 6-8, minimum nodule count of 250/mm², and hardened to produce a microstructure of martensite (80% or higher) can be evaluated by this procedure.

3.4 Test Time.

Calendar time: 0 d

Test time: 1 h

Coordination time: 1 h

3.5 Test Required Information. Not applicable.

3.6 Personnel/Skills. Not applicable.

4 Procedure

4.1 Preparation.

4.1.1 Summary of Test Method. A polished and etched section of the hardened zone is produced showing contrast between retained austenite and the surrounding martensite.

4.1.2 Test Sample Preparation. A section should be taken from the area of the hardened lobe with the highest tendency for retained austenite. In most cases, this would be at the nose of the lobe. The cutting should be performed carefully as to prevent tempering of the part, which can lower the amount of retained austenite.

Standard metallurgical sample preparation procedures should be followed. Reference ASTM E3 for more details. The etching time should be controlled to produce a good contrast between the martensite matrix and the retained austenite. A higher amount of untempered martensite will require a slightly longer etch time.

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.

4.3 Instructions. The test samples can be examined either in-situ using a metallograph, or micrographs can be produced electronically or on physical media.

The microstructure shall be examined at 200x, which is the same magnification as the comparison photomicrographs (Figure A1 thru Figure A4) in Appendix A. The photomicrographs in Appendix A are at 200x scale when printed full size on standard 8.5 in x 11 in paper.

High resolution photomicrographs of the 4 retained austenite levels used by this document are available from the GM Global Propulsion Systems (GPS) camshaft materials engineer.

A total area of 1 mm² is to be compared. This generally translates to 10 different fields of view when evaluated at a magnification of 200x. The area examined shall be within 0.5 mm of the outside surface of the lobe in the roller track. If the sample is from an unground camshaft lobe, compensate for the extra grind stock of 1.5 mm to 2 mm from the outside edge of the sample.

5 Data

5.1 Calculations. Not applicable.

5.2 Interpretation of Results. Not applicable.

5.3 Test Documentation.

5.3.1 Evaluation and Rating. The comparison rating of all examined areas shall be averaged and rounded up to the next highest level.

5.3.2 Report. A rating level between 0 and 4 is used to define the amount of retained austenite in the microstructure of the sample. Level 0 defines a microstructure with no visible retained austenite at 200x magnification. There shall be no mid-point levels such as 3.5, etc. All fractional values shall be rounded up to the next integer. The only defined levels are: 0, 1, 2, 3, and 4. The retained austenite acceptance level criteria is defined on the part print.

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. Not applicable.

7.2 Acronyms, Abbreviations, and Symbols.

GPS Global Propulsion Systems

GSSLT Global Subsystem Leadership Team

8 Coding System

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

Test to GMW16844

9 Release and Revisions

This standard was originated in July 2012. It was first approved by the Non Ferrous Metals and Castings GSSLT in September 2012. It was first published in September 2012.

Issue	Publication Date	Description (Organization)
1	SEP 2012	Initial publication.
2	JUN 2017	Document refresh with grammatical corrections. (Materials – Nonferrous and Castings Global Subsystem Leadership Team (GSSLT))