



Laboratory Test Procedure for Wheel Bearing Fretting Wear

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 is used to ensure acceptable resistance to fretting wear of passenger vehicle wheel bearings. Fretting wear may occur due to repeated alternating loading during vehicle shipment, when there is no redistribution of grease. In bearings, fretting wear is sometimes referred to as false Brinelling, because the wear results in marks similar to those caused by impact Brinelling.

1.2 Applicability. This standard applies to wheel bearings used on General Motors passenger vehicles. This standard may be used for both development and validation.

1.3 Remarks. This standard uses alternating vertical and lateral loading of non-rotating wheel bearings to induce fretting wear. The bearing's ability to maintain a grease film between the rolling elements and the raceways is a major contributor to fretting wear resistance. This ability may be affected by temperature.

The applicable Wheel Bearing Statement of Requirements (SOR) or Component Technical Specification (CTS) provides program specific information and acceptance criteria for bearings tested according to this procedure. In the event there is disagreement between this procedure and the SOR or CTS, the SOR or CTS has precedence.

2 References

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

2.1 External Standards/Specifications.

ISO 1101

2.2 GM Standards/Specifications.

GMW15760

2.3 Additional References.

- Component Technical Specification (CTS)
- Statement of Requirements (SOR)

3 Resources

3.1 Facilities. Facility with Test Improvement Process (TIP) approved test machine shall be used.

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.

3.1.2.1 Test facilities must be certified per the GM TIP.

3.2 Equipment.

3.2.1 Rigid fixturing to hold the bearing(s) in the same orientation as on a vehicle.

3.2.2 Actuators, load cells, and controllers to apply and monitor the specified loading at the specified frequencies.

3.2.3 A chamber for holding the temperature at the specified values, per 4.2.1 and the SOR.

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3.2.4 If required, a chamber for preconditioning the bearings at the specified temperature and relative humidity, per 4.1. Preconditioning and testing may be in the same chamber.

3.2.5 A timer or cycle counter to shut off the test after the required number of vertical load cycles.

3.2.6 A vehicle or bench setup for measuring noise and/or vibration is recommended.

3.2.7 Equipment for measuring the roundness and/or flatness, capable of measuring the depth of any resulting wear marks to within 0.5 μm precision.

3.3 Test Vehicle/Test Piece.

3.3.1 Test parts used for Design Validation (DV) are to be from production tooling and processes to the extent possible. Production Validation (PV) requires parts to be from production tooling and processes unless an exception is approved in writing by the General Motors contact specified in the SOR document.

3.3.2 Test bearings may be rotated up to 400 revolutions prior to test. A pretest vibration measurement may be taken, provided this usage condition is not violated.

3.3.3 Selection of parts undergoing PV shall be made according to GMW15760 Multi-Vari Sample Selection Procedure for Product Validation.

3.3.4 The GM design engineer and validation engineer will determine quantity of parts to test with and without constant velocity joint (half shaft).

3.4 Test Time.

Calendar time: Depends on test length, sample size, and the number of bearings tested at a time.

Test hours: 60 h/bearing/648 000 vertical load cycles, if applied at 3 Hz. Test length must be adjusted if the loading frequency is changed. (See 4.2.2.)

3.5 Test Required Information. Not applicable.

3.6 Personnel/Skills. Person trained for test set up, machine operation, and measurements is required.

4 Procedure

4.1 Preparation. Any bearings that are to be tested at any temperature above the freezing point of water are to be preconditioned for a minimum of 48 h at room temperature and 95% to 99% relative humidity. Testing is to begin within 2 h after preconditioning.

4.2 Conditions.

4.2.1 Environmental Conditions. Each individual bearing is tested at only one (1) temperature. Unless otherwise specified in the SOR document; separate bearings are to be tested at each of the following temperatures: $-20\text{ }^{\circ}\text{C} \pm 3\text{ }^{\circ}\text{C}$; normal room temperature $20\text{ }^{\circ}\text{C} \pm 3\text{ }^{\circ}\text{C}$.

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.

4.2.2.1 Loading. In the following, 1G bearing force equals one-half ($\frac{1}{2}$) the Gross Axle Weight Rating (GAWR) for the vehicle. Loading is to be applied at the center of the tire patch, through a rigid plate.

- Rotational Loading: No bearing rotation is allowed.
- Vertical Loading: +0.5G to +1.5G at 3.0 Hz. Positive is upward.
- Lateral Loading: -0.3G to +0.5G at 3.1 Hz. Positive is inboard.

4.2.2.2 Paragraph 4.2.2.3 gives the preferred load phasing. Using two different frequencies ensures that all possible phase angles occur between the two input directions. See Figure A1, Appendix A.

4.2.2.3 Alternative Phasing Methodology. If equipment is not available to run the two (2) channels at different frequencies, then there must be the ability to manually change the phasing of the channels. In this case, do the following:

- Run both channels at 3.0 Hz.
- Divide the specified test length into four (4) equal segments.
- At the beginning of each segment, manually set the phasing between the two (2) channels so that the vertical signal is, in order, 0 degrees, 90 degrees, 180 degrees, and 270 degrees ahead of the lateral signal. See Figure A2, Appendix A.

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4.2.2.4 Verify that the test equipment can generate the required loads at the given frequencies. If necessary, the frequencies may be reduced and the test time increased to obtain the full number of cycles in each direction. The frequencies may not be increased.

4.3 Instructions.

4.3.1 Recommended: Perform a pretest vibration measurement, ensuring that the number of pretest revolutions does not violate 3.3.3.

Note: Pretest and posttest vibration measurements shall be completed on a vibration test rig that is capable of applying the correct lateral and radial loads and has been TIP certified for vibration as defined by Brake Component Development (BCD) bearing engineer.

4.3.2 Precondition the bearings per 4.1.

4.3.3 Set up and run the test to the specified number of vertical cycles. Unless otherwise specified in the SOR document, test length is 648 000 vertical load cycles (60 h at 3 Hz).

4.3.4 Posttest Evaluations.

4.3.4.1 Vibration Measurements. Perform posttest vibration testing per instructions from 4.3.1.

4.3.4.2 Brinell Measurements. Clean the tested bearings, and measure the location, shape and maximum depth of each wear depression utilizing the recommended Brinell measurement detailed in 4.3.4.2.1 and 4.3.4.2.2.

Note: Brinell measurements shall be completed on a measurement machine that has been TIP certified and correlated to the GM Brinell measurement process as defined by BCD bearing engineer.

4.3.4.2.1 Ball Bearings. Provide geometry and coordinates coinciding with ball contact positions on all wheel bearing races relative to Gross Vehicle Weight (GVW) and 0.5G lateral load at GVW, and halfway up the raceway from the contact angle position, and 0.5 mm from edge of race. Descriptions and x-y positions of traces to be provided for each race from a key feature position on the bearing as well as the diameters from the center of the bearing. Perform fourteen (14) measurements at 0.3 mm axial increments, starting 0.5 mm from edge of shoulder. Refer to Figures A3, A4, and A5, Appendix A.

4.3.4.2.2 Roller Bearings. Establish the span length and initial contact position of roller bearings inboard edge of the roller relative to the centerline of the bearing and provide x and y dimensions to a key feature in the bearing. Measure eleven (11) traces along the length of the roller. Refer to Figures A6 and A7, Appendix A.

4.3.5 Posttest Roundness and Brinell Depth Measurement. Make a polar trace of the surface, to determine Brinell mark depth at the specified location(s). See Figure A8, Appendix A, for example linear plot of the polar trace. Apply a filter to the depth trace to establish the sectional roundness/flatness to determine the Brinell depth. Preferred filtering on the surface measurements for the Brinell depth should be Gaussian with a band pass filter 5 undulations per revolution (upr) to 150 upr. The stylus size used for the trace must also be specified and recommended to be 1 mm diameter or smaller. It is also recommended to use the sectional roundness and/or flatness specification to determine the maximum depth of an individual trace. The data must be recorded at a minimum sample rate of 0.1 degree. Unfiltered is not preferred. The filter must be set higher than eight (8) times the number of balls or rollers present in a race (150 upr in most cases). The sectional degrees should be 360 degrees divided by two (2) times the number of balls or rollers per raceway.

4.3.6 Inspections, Measurements and Analyses. The supplier is required to conduct failure analyses on all posttest parts, and investigate and understand all indicators of degradation on both failed and non-failed parts, per Table A1, Appendix A. The goal of the analyses is to reduce the rate of degradation through design and/or processes improvements.

Comparison parts are to be obtained at the same time as the parts that will be tested. They should be held in reserve in case they are needed for comparisons with tested parts. If that need does not arise, they may be used for other purposes.

Note: All inspections, measurements and analyses that might be performed on new bearings are described as either Destructive (D) or Non-Destructive (ND) to the wheel bearing assembly. Use comparison parts for all destructive measurements and analyses that are to be performed on new parts.

4.3.6.1 Dimensional Measurements (ND for parts prior to assembly, D for parts already assembled). Measure and document all dimensions critical to performance of the bearings during the tests. This could include the geometry profiles of the balls/rollers and races, dimensions affecting wheel bearing preload, seal dimensions,

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etc. Record dimensions prior to and after the durability testing. Document changes and unusual findings during teardown analyses.

4.3.6.2 Surface Roughness (ND for parts prior to assembly, D for parts already assembled). Measure the surface roughness of rolling contact surfaces prior to and after testing (including all damaged surfaces). Measurement may be Root Mean Square Roughness (Rq), Arithmetic Roughness (Ra) or Total Peak-to-Valley Roughness (Rt).

4.3.6.3 Microstructure (D). Examine and document the microstructure of all critical areas of the wheel bearing to ensure proper heat treatment processes and material cleanliness prior to testing. Examine the microstructure of the same areas after testing. Determine the extent, and causes, of all microstructure changes (e.g., the amount of retained austenite before and after testing), and determine the effect of such changes on any failures or degradation that was observed.

4.3.6.4 Case Depth, Hardness Traverse (D). Measure case depth at the rolling contact areas and measure hardness traverse (hardness vs. depth) prior to testing on comparable parts and on at least two (2) posttest parts for each force evaluated once all vibration and Brinell depths have been collected.

4.3.6.5 (Posttest) (D) Roundness and Brinell Depth Measurements. Make a polar trace of the surface, to determine Brinell mark depth (sectional roundness/flatness, reference Figure A8, Appendix A) at the specified location(s).

4.3.6.5.1 Brinell Depth Measurement. Make a polar trace of the surface, to determine Brinell mark depth at the specified location(s). Apply a filter to the depth trace to establish the sectional roundness/flatness to determine the Brinell depth. Preferred filtering on the surface measurements for the Brinell depth should be Gaussian with a band pass filter 5 upr to 150 upr. The stylus size used for the trace must also be specified and recommended to be 1 mm diameter or smaller. It is also recommended to use the sectional roundness and/or flatness specification to determine the maximum depth of an individual trace. The data must be recorded at a minimum sample rate of 0.1 degrees. Unfiltered is not preferred. The filter must be set higher than eight (8) times the number of balls or rollers present in a race (150 upr in most cases). The sectional degrees should be the value of 360 degrees divided by two (2) times the number of balls or rollers per raceway.

4.3.6.5.2 Roundness Measurement. Make a polar trace of the surface and apply a filter to smooth the curve to establish the 1st through 5th order effects on roundness. The preferred filtering on the roundness measurements for posttest should be Gaussian with a band pass filter 0 upr to 15 upr. For initial roundness comparisons the trace should be evaluated with a 0 upr to 15 upr filter to look for the 1st through 5th order roundness and a 0 upr to 150 upr filter to look for higher order roundness issues.

5 Data

5.1 Calculations. Not applicable.

5.2 Interpretation of Results. The maximum depth of each wear mark is to be determined, and the results compared with the specified requirement(s). A spreadsheet is to be created, similar to Figure A9, Appendix A, which lists the maximum Brinell depth for each trace. Requirements for the maximum Brinell depth shall be called out in the CTS. For a ball bearing, the area of concern is typically from the contact angle position to one-half ($\frac{1}{2}$) way to the edge of the raceway. For a roller bearing, the concern area is the complete roller length.

5.3 Test Documentation. The supplier shall maintain records of 5.3.1 through 5.3.9.7.

5.3.1 Written test procedures, including all versions ever used for testing.

5.3.2 A report documenting significant aspects of the initial test development. This would include, as an example, information on any studies conducted to set up details of the test.

5.3.3 All pertinent information about the manufacture and assembly of the wheel bearing assemblies used, including both comparison parts and test parts. This may include, as examples only, the source of all critical parts of each wheel bearing assembly, assembly line and shift information, material specifications, etc.

5.3.4 The results of all inspections, measurements, and analyses.

5.3.5 The results of all tests, including all degradation and failure analyses and data analyses (including the times or cycles to failure, as well as times or cycles at which un-failed parts were suspended).

5.3.6 Actions taken to address issues found on test.

5.3.7 Equipment calibration records.

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