



Biaxial Wheel Fatigue Test

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 test simulates wheel road conditions in a laboratory environment by applying a time varying sequence of radial and lateral loads through the tire of a rotating tire and wheel assembly, in order to evaluate the fatigue performance of the wheel. The wheel is secured with fasteners at its mounting surface, and if the appropriate production parts are used between the wheel and the test machine, the fatigue performance of the wheel's fastening system may also be evaluated.

1.2 Applicability. This procedure should be used as a component test and provides uniform laboratory methods for biaxial fatigue testing of wheels intended for normal highway use.

1.3 Remarks. Biaxial testing is intended to subject a wheel to the expected loads and boundary conditions from vehicle operation, with the following differences. Applied driving torque, braking torque, and impact events that occur during vehicle operation are not simulated during the test. (However, damage to the wheel may be introduced prior to the start of the test. This is referred to as pre-damage, and may be used to simulate the effects of some impact events.) Non-damaging events may be omitted, ordering of events may be changed, and substitution of repeats of some events may be made for others as long as the total schedule calculated damage remains the same. This may be done for the purpose of reducing the time the test takes.

Note: For typical biaxial wheel fatigue test machines, the load path through the tire (lateral loading applied primarily through a curb to the tire sidewall) does not match that of vehicle operation (lateral loading at tire patch generated by steer angle). The effect of this difference between load paths is resolved by adjusting assembly tilt (camber) angles. The process by which this adjustment is specified is referred to as Tilt Angle Development.

2 References

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

2.1 External Standards/Specifications.

AK-LH 08 SAE 6150 SAE J2562

2.2 GM Standards/Specifications.

GMW16590

3 Resources

3.1 Facilities. Indoor facility with sufficient Heating, Ventilation, and Air Conditioning (HVAC) capability to meet the temperature and humidity requirements specified in. Facility shall also include:

- Ventilation sufficient to exhaust dust and smoke.
- Conditioned air or chilled water supply to test machine sufficient to allow it to operate as specified.
- Air flow as necessary on the test tire to avoid temperature increases that would adversely affect test tire life.
- Fire suppression capability.
- If hydraulic actuators are used, an enclosure is recommended that is sufficient to protect personnel from associated hazards.

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3.2 Equipment.

3.2.1 Biaxial wheel fatigue test machine. See 7.1 for description.

3.2.2 Adaptors sufficient to secure the test wheel or a production hub to the test machine.

3.2.3 Torque wrench.

3.2.4 Pressure gauge.

3.2.5 Additional equipment as necessary to perform Tilt Angle Determination as described in SAE J2562.

3.3 Test Vehicle/Test Piece.

3.3.1 Items to be Tested. Wheels and fasteners sufficient to fulfill the requirements of the test requestor. Wheels must be new and be at minimum material condition. Typical practice requires a fatigue sample size of three (3) wheels. Fasteners must be new and as specified by the requestor.

3.3.2 Tires. Tires sufficient to fulfill the requirements of the test requestor. Tires should be as specified, or the largest tire intended for use for the vehicle (i.e., with the largest aspect ratio). Based on typical tire wear on test, it is recommended to have on hand at least two (2) tires per wheel tested.

3.3.3 Test Pieces for Tilt Angle Development. Additional test pieces as necessary to perform Tilt Angle Development as described in SAE J2562.

3.3.4 Wheel Adaptation Components, Depending on Test Intent.

Note: For validation testing, the test should be representative in the attachment region of the wheel or as specified by the requestor.

3.3.4.1 Flat Plate Adaptor. If the test is not required to be representative in the attachment region of the wheel, a flat plate adaptor and a wear plate are sufficient.

3.3.4.2 Production Adaptor. If the test is required to be representative in the attachment region of the wheel, production hubs and rotors sufficient to test the wheels are needed. It is recommended that two (2) hubs and one (1) rotor be provided per wheel tested. Adaptation hardware sufficient to adapt production hubs to the biaxial wheel fatigue test machine is necessary. When production hubs and rotors are used, this test may also be used to evaluate the fatigue performance of the wheel fastening system.

3.3.4.3 Silhouette Adaptor. An alternative to a production adaptor is a silhouette adaptor. This kind of adaptor is machined to closely match the dimensions of the production hub from the wheel attachment side inboard to the transition of the spindle into the bearing. It is recommended that one rotor be provided per wheel tested.

3.4 Test Time.

Calendar time: 28 d

Test time: 280 h

Coordination time: 40 h

Note: These values are averages. Depending on the method used for Tilt Angle Development, overall test duration could be less or considerably more.

3.5 Test Required Information.

- Rated wheel load (1/2 of the Maximum vehicle axle load).
- Wheel dimensions, including diameter, width, offset, and fastener circle dimensions.
- Fastener part numbers.
- Tire size.
- Tire usage pressure.
- Wheel fastener torque.
- Pre-damage method, if applicable.
- Adaptor type.
- Test load sequence description.
- Tilt Angle Determination method.
- Hub part number.

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- Rotor part number.

3.6 Personnel/Skills. Personnel trained to operate a biaxial fatigue wheel test machine.

4 Procedure

4.1 Preparation.

4.1.1 Perform Pre-damage. Perform pre-damage as specified by the test requestor. See Appendix A, Table A1. Recommended pre-damage methods and test load sequences in Appendix A to be used as a reference indicating when pre-damage is recommended.

4.1.2 Inspect the Test Wheels. Check the uniformity of the wheels. It is recommended that wheels not meeting uniformity specifications not be used as test wheels. Inspect the wheels for cracks. In general, if a wheel is already cracked, it should not be used as a test specimen, unless the test is intended to assess the performance of a cracked wheel.

4.1.3 Mount Test Tires on Test Wheels.

4.1.4 Configure the Test Machine. Secure wheel adaptation equipment to the test machine. Modify the test machine configuration as necessary. For example, the overall length of the adaptation stack up or the assembly size may require that test program parameters be changed.

4.1.5 Secure the Assembly to the Test Machine. Install the assembly on the adaptor and tighten the fasteners to the torque specified by the requestor using a star pattern until the torques stabilize. If not specified, use the minimum dynamic torque specification from the appropriate assembly documentation or part usage details. For example, in North America, M12 fasteners typically have a dynamic torque specification of $125 \text{ N}\cdot\text{m} \pm 15 \text{ N}\cdot\text{m}$, and M14 fasteners typically have a dynamic torque specification of either $150 \text{ N}\cdot\text{m} \pm 15 \text{ N}\cdot\text{m}$ or $170 \text{ N}\cdot\text{m} \pm 20 \text{ N}\cdot\text{m}$, depending on nut coating, so the minimum specifications would be $110 \text{ N}\cdot\text{m}$ and $135 \text{ N}\cdot\text{m}$ or $150 \text{ N}\cdot\text{m}$, respectively.

4.1.6 Set the Cold Tire Pressure. Adjust the tire pressure to the value specified by the requestor. If not specified, the pressure should be set to the following:

- For tires with usage pressure of 310 kPa (45 psi) or less: Set to $448 \text{ kPa} \pm 7 \text{ kPa}$ ($65 \text{ psi} \pm 1 \text{ psi}$).
- For tires intended for use at higher pressure: Use 1.2 times the usage pressure $\pm 7 \text{ kPa}$ ($\pm 1 \text{ psi}$).

4.1.7 Modify the Test Machine Configuration as Necessary. Make any required modifications to the test machine configuration that cannot be done prior to the previous step. For example, adjustments may need to be made based on tire centerline to wheel mounting surface offset.

4.1.8 Prepare the Test Load Sequence. See Appendix A, Table A1 for a listing of categories for biaxial tests and their associated test load sequences. If the test requestor does not specify the test load sequence, the test load sequence described in SAE J2562 is typically used. Under some circumstances, the Figure 8 test load sequence may be requested. It is described in Appendix E. The test requestor may specify a special test load sequence. Under this circumstance, the test requestor will provide the test load sequence.

4.1.9 Prepare Tilt (Camber) Angles (Tilt Angle Development). Tilt angles typically must be developed for Type B and C biaxial test machines. Refer to SAE J2562 for descriptions of these types of test machines. The methods SAE J2562 described for Tilt Angle Development should be used to develop the necessary tilt angles.

4.2 Conditions.

4.2.1 Environmental Conditions.

- Temperature range: 10°C to 26.7°C (50°F to 80°F).
- Humidity range: Sufficient to prevent condensation on test equipment.

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 Test Load Sequence File. A test load sequence, as discussed in 4.1, should be used for testing.

4.2.2.2 Ensure Correct Wheel Loads. The test machine loading should closely match target load values unless the test machine is going through a transition from one load pair to the next. Minimize the difference between target loads and actual loads. Also, minimize transition times. Fatigue life will be affected by differences between target and actual loads and by transition times.

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4.3 Instructions.

4.3.1 Input the test load sequence file into the test machine controller.

4.3.2 Document Test Settings. Record all information having to do with the test machine configuration and required test settings. This includes the following:

- Test machine type.
- Drum diameter.
- Curb type and spacing.
- Test machine pivot location.
- Deflection limits.
- Adaptor description.
- Vibration sensor settings.

4.3.3 Start the test.

4.3.4 Perform Routine Inspections. Pause the test to inspect at intervals specified by the requestor. If not specified, it is recommended to inspect at least twice a day if practical, or more often. The following guidelines are established for inspections.

4.3.4.1 Check the Pressure. Check and record the tire pressure. See Appendix F, Data Sheet F1. Do not change the pressure.

4.3.4.2 Check the Torque. Check and record the wheel fastener torques to tighten using a torque wrench that can indicate torque. Do not adjust torque more than once after the assembly has been secured to the test machine. The single torque adjustment is only to be used as an optional restoration to initial torque requirements at the first inspection in order to correct torque values that have not stabilized.

4.3.4.3 Check for Cracks. Examine the wheel for visible cracks. Photograph any cracks.

4.3.4.4 Examine the Tire. Inspect the tire for wear. If the tire is worn to cords, it may be either “flipped” (the inboard side swapped for the outboard side) if the wear patterns indicate that this would result in it lasting longer, or it may be replaced.

4.3.5 Test Completion Criteria. Test the wheel to the test load schedule as specified by the test requestor. If the requestor does not specify a test completion criterion with respect to the schedule, typical practice is to end the test if the schedule has been completed once. The test requestor may also specify certain events that would signal that the test is complete. If not specified, the criteria of SAE J2562 may be used, with a slight modification as denoted with brackets:

- Loss of tire pressure resulting from a fatigue crack.
- The inability of the test assembly to sustain load.
- Development of a propagating fatigue crack of at least 5 mm in length through a section observable from both sides of the wheel.

The following criterion may also be added:

- Vibration of the assembly due to fatigue cracks results in shut down of the test machine.

4.3.6 Posttest Inspection. Check and record the tire pressure. See Appendix F, Data Sheet F1. Check and record the wheel fastener torques to tighten. Inspect the wheel for cracks. Photograph any cracks.

5 Data

5.1 Calculations. It is recommended to determine the ratio of cycles at load as compared to total cycles. This provides a measure of how many revolutions the wheel spent during transitions between schedule load pairs, and therefore, an idea of how much damage was generated due to transition cycles.

5.2 Interpretation of Results. See sourcing documents.

5.3 Test Documentation. The test results documentation should include the following:

- Test results report.
- Completed data sheets.

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- Photos as appropriate.

Note: A sample data sheet for the biaxial test is given in Appendix F, Data Sheet F1 and a sample report for the biaxial test is given in Appendix G, Figure G1.

Note: For data being loaded into the Global Tire-Wheel Test System (GTWTS), submit electronically the test results data files (Extensible Markup Language (XML) format) and other supporting files. GMW16590 defines the electronic file details (e.g., file types, file naming convention, and detailed file formats) for the GTWTS.

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.

Biaxial: Combined radial and lateral loads applied to a rotating tire-wheel assembly through the tire.

Biaxial Wheel Fatigue Test Machine: Any test machine that is capable of the following:

- A tire and wheel assembly must be secured to the test machine by fasteners and the wheel's mounting surface.
- The part of the test machine to which the wheel is secured must allow free (low friction) rotation on the wheel axis.
- Rotation of the assembly must be driven by the test machine through the tire.
- Radial and lateral load paths between the test machine and the assembly must go through the tire.
- The test machine must be capable of controlling the tilt (camber) angle in order to ensure that wheel strains on test will match to vehicle operation wheel strains.

Refer to SAE J2562 for descriptions of Type A, B, and C biaxial wheel fatigue test machines.

Pre-damage: Testing that introduces damage into the wheel prior to the start of the biaxial test. See Appendix A, Table A1 for recommended types of pre-damage tests.

Test Load Schedule: Multiple repeats of a test load sequence that make up an entire wheel test.

Test Load Sequence: A defined sequence of sets of radial and lateral loads, tilt angles, cycle counts, and drum rotation speeds that is repeated multiple times to form an entire wheel test.

Tilt Angle Development: The process by which assembly tilt (camber) angles are set. See SAE J2562 for a description of methods.

Wear Plate: This is a hardened steel plate that is mounted between the test wheel and a flat plate adapter, in a similar fashion as a brake rotor or brake drum. The wear plate provides a hard, smooth, clean surface for mounting the test wheel. Wear plates should be made of steel (SAE 6150), or similar material, hardened to Rockwell C, 45 to 50, 6 mm to 4 mm thick, both surfaces parallel within 0.02 mm with an initial surface finish of 1.6 μm maximum, free of paint, dirt, or foreign matter.

7.2 Acronyms, Abbreviations, and Symbols.

#	Number
CMM	Coordinate Measuring Machine
GSSLT	Global Subsystem Leadership Team
GTWTS	Global Tire-Wheel Test System
HVAC	Heating, Ventilation, and Air Conditioning
ID	Identification
P/N	Part Number

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PQMS	Performance and Quality Management System
TR	Test Request
TTN	Torque Tension New
TWS	Tire and Wheel System
XML	Extensible Markup Language

8 Coding System

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

Test to GMW14340

9 Release and Revisions

This standard was originated in September 2005. It was first approved by the Tire and Wheel Global Subsystem Leadership Team in October 2006. It was first published in March 2007.

Issue	Publication Date	Description (Organization)
1	MAR 2007	Initial publication.
2	AUG 2013	Revised to current template. Made the following significant changes: Appendix A lists the biaxial tests included in the current Global Wheel Validation Guidelines and identifies the recommended Pre-damage method (if applicable) and Test Load Sequence for each. Appendices B, C, and D describe the referenced wheel Pre-damage methods. Appendix E describes the Figure 8 Test Load Schedule. (Tire and Wheel Global Subsystem Leadership Team)
3	JUL 2018	Revised to current template. (Chassis - Tire and Wheel Global Subsystem Leadership Team (GSSLT))

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