



Wheel Radial 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 standard is intended to provide details for determining the fatigue strength of passenger car and light duty truck wheels when subjected to radial fatigue loading.

1.2 Applicability. This test procedure is applicable for steel and light-alloy wheels intended for normal highway use and temporary use for passenger car vehicles, light duty trucks including dual wheel usages, or multipurpose vehicles.

1.3 Remarks.

1.3.1 This standard establishes a uniform testing technique that assesses radial fatigue due to radial forces applied to the wheel for the purpose of evaluating wheel design conformance to specifications. The test is based on:

- ISO 3006 (Road Vehicles – Passengers Car Wheels for Road Use – Test Methods)
- ISO 3894 (Road Vehicles – Wheels/Rims for Commercial Vehicles – Test Methods)
- SAE J267 (Wheels/Rims – Truck and Bus – Performance Requirements and Test Procedures for Radial and Cornering Fatigue)
- SAE J328 (Wheels – Passenger Car and Light Truck Performance Requirements and Test Procedures)
- SAE J1992 (Wheels/Rims – Military Vehicles, – Test Procedures and Performance Requirements)
- TRIAS 09-J002-001, Test Requirements and Instructions for Automobile Standards (Japan)

1.3.2 Fully processed wheels are secured to an appropriate adapter plate using the production intent wheel attachment fasteners. The adapter is allowed to spin freely and is capable of applying a radial load onto a constant speed road wheel. The test equipment shall be designed to enable a constant radial load application to the tire-wheel assembly via the hub mounting system.

1.3.3 The radial load is continuously measured and controlled and when a tire-wheel assembly no longer supports load or holds air pressure, the test is stopped. If a tire pressure (deflection) shutdown does not occur, the test is suspended at a GM-specified number of operational cycles. However, if tire rupture is the cause for the shutdown, replace the tire and continue testing.

2 References

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

2.1 External Standards/Specifications.

ISO 3006	SAE J267	SAE J1992	TRIAS 09-J002-001
ISO 3894	SAE J328		

2.2 GM Standards/Specifications.

GMW16590	GMW17088	GMW17097
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2.3 Additional References.

Opel Drawing 8957388

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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.

3.1.1.1 The radial load calibration shall be verified as a complete assembled system.

Note: Practical limitations may prevent the system being 100% completely assembled.

3.1.1.1.1 The machine radial load calibration shall be calibrated versus a known linear load input (e.g., Load Cell Transducer).

3.1.1.1.2 The calibration load cell shall be placed between the Driven Road Wheel and test spindle.

3.1.1.2 Calibration of the deflection shutdown system shall be sufficient to ensure machine shutdown when the tire loses air, thus avoiding wheel rim contact with the road wheel surface.

3.1.1.3 The range of load and deflection calibrations shall be large enough to encompass all situations during testing.

3.1.1.4 Machine road wheel speed shall be calibrated within 2%.

3.1.1.5 Any additional subsystems that can affect load or cycle life in some manner should be calibrated.

3.1.1.6 Calibration accuracy shall be sufficient to meet the requirements of paragraph 3.2.3, unless stated otherwise.

Note: All load cells and displacement transducers used to calibrate the equipment shall be traceable to the National Institute of Standards and Technology (NIST), or equivalent.

Note: All pressure measuring equipment shall be traceable to the NIST, or equivalent.

3.1.1.7 Equipment calibration shall be performed on a six (6) month cycle.

3.1.1.7.1 A maximum of a one (1) year calibration interval is allowed if there is at least five (5) years of calibration history which shows stable calibration values between calibration events and that operating procedures are in place that ensures machine accuracy during testing. GM test personnel shall review supporting data before allowing annual calibration intervals.

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 Zyglo or equivalent dye penetrant crack inspection media.

3.2.2 Various Hand Tools as Required.

3.2.2.1 Torque wrench capable of applying and measuring requested torque values. Torque measurements shall be accurate within ± 3 Nm (± 2.2 lb ft).

3.2.2.2 Paint pens as needed, refer to paragraph 4.3.9.7 for required colors.

3.2.2.3 Tire pressure gage, accuracy shall be ± 13.79 kPa (± 2 psi) at 448 kPa (65 psi).

3.2.3 Test Machine Requirements.

3.2.3.1 A test machine approved by GM equipped with a means of applying a constant radial load onto a tire-wheel assembly.

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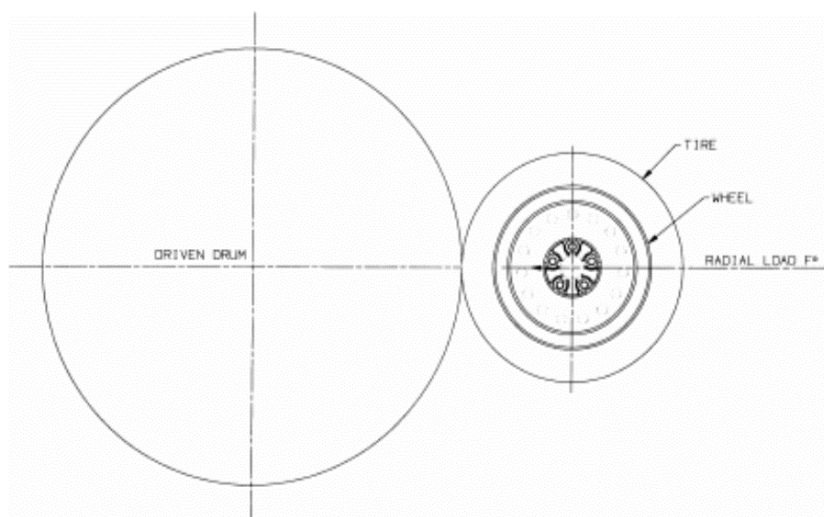
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Figure 1: Radial Fatigue (Typical Setup)



3.2.3.2 Test wheel assembly shall exert a normal radial force to the road wheel surface and that radial force shall be located in line with the spinning centers of both the road wheel and test wheel assembly, as shown in Figure 1. The steer and camber alignment of wheel mounting surface relative to the drum surface must be $0^\circ \pm 0.1^\circ$ when loaded to 15 000 N (66.72 kip).

3.2.3.3 The road wheel shall be at least 1.7 m (67 in) in diameter with a smooth surface wider than the section width of the test tire.

Note: Adhesive backed frictional surface material may be adhered to the road wheel surface (3M 348D Three-M-ite Resin Bond Pressure Sensitive Adhesive (PSA), or equivalent).

3.2.3.4 A system for continuously controlling applied load value accurate within $\pm 2.5\%$ ($\pm 3\%$ for tests on light truck wheels intended to be used as dual wheels).

3.2.3.5 A system for continuously measuring road wheel speed.

3.2.3.6 A system for counting test cycles only when test load is applied.

3.2.3.7 A system for stopping the test if wheel deflects toward road wheel more than 40 mm (1.5 in) from initial loaded radius. Deflection limit value maybe less than 40 mm (1.5 in) as necessary to prevent wheel rim from contacting road wheel surface. Additional systems may be installed to prevent damage to other equipment.

3.2.3.8 Adapters for specified fastener sizes and bolt patterns. An adapter is a removable plate that retains serrated shank wheel bolts or internally threaded hub member and attaches to a load arm shaft. An adapter can have one (1) or more bolt hole patterns. The pattern of adapter bolt-holes centers shall be in true position relative to the wheel mounting surface and the rotational center of the load shaft, regardless of feature size, within 0.06 mm (0.002 in).

3.2.3.9 Wear Plate (Optional for Aluminum Wheels). This is a hardened steel plate that is mounted between the test wheel and the adapter. If a wear plate is not used, then the adapter shall be single bolt pattern with a surface condition matching the wear plate specifications.

Note: The wear plate provides a hard, smooth, clean surface for mounting the test wheel. Typical stock used is 6.35 mm (0.25 in). AISI 4142 Flat Ground Stock that is a modified pre-hardened decarburization free (DCF) alloy steel: 203 mm wide X 914 mm long (8 in wide X 36 in long), SAE 6150 steel or equivalent material with hardness between 28 Hardness Rockwell C (HRC) and 50 HRC - scale, having a thickness of 5 ± 1.5 mm (0.197 ± 0.060 in) with both surfaces parallel within 0.2 mm (0.008 in) with an initial surface finish of 1.6 μ m maximum. The wear plate shall be free of paint, dirt, or foreign matter.

Note: Generally wear plates are initially manufactured at the maximum thickness allowed and may be reused until indentations can be felt with a finger. At that time, they should be resurfaced or discarded.

3.3 Test Vehicle/Test Piece.

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3.3.1 Test Wheels. All wheels shall be fully processed and manufactured to minimum stock thickness conditions, unless otherwise stated by the requester.

3.3.1.1 Aluminum wheels shall not be shot blasted if shot blasting is an optional manufacturing process.

3.3.1.2 Aluminum wheels that are chrome plated shall be tested in the chrome plated condition.

3.3.1.3 Cast, cast flow formed, forged, or forged flow-formed aluminum wheels shall not be clear coated or painted, but shall be fully processed, including any paint curing oven events.

3.3.2 Test Tires. Shown on GM wheel drawings or equivalent maximum size for a given vehicle or wheel design.

3.3.3 Fastener. Production intent wheel attachment fasteners (identified on GM wheel drawings) shall be used, unless otherwise approved by GM.

3.4 Test Time.

Calendar time: 14 days

Test hours: 259 hours

Coordination hours: ½ hour

Note: Based on 2 500 000 cycles and 7 samples.

3.5 Test Required Information. Test load, fastener torque, inspection and end of test parameters, per GM wheel drawing or as stated by the requester.

3.6 Personnel/Skills. Test operator shall be qualified on the basis of appropriate education, training, experience, and/or demonstrated skills.

4 Procedure

4.1 Preparation.

4.1.1 Pre-Test Inspection.

4.1.1.1 Inspect all wheels for cracks prior to test. Refer to paragraph 4.3.9 for inspection process.

4.1.1.2 Steel or wrought (fabricated) aluminum wheels with apparent cracks are unacceptable for testing unless approved by the requester.

4.1.1.3 Cast, cast flow formed, forged, or forged flow-formed aluminum wheels with apparent cracks are acceptable for testing.

4.2 Conditions.

4.2.1 Environmental Conditions. Room temperature: 24 °C ± 14 °C (75 °F ± 57 °F).

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. Refer also to Appendix B and Appendix C.

4.3 Instructions. Mount a tire-wheel assembly to an adapter attached to a free-spinning axle shaft. Radial load is applied to the tire-wheel assembly and is continuously controlled while spinning under the influence of a driven road wheel. If a non-tire related deflection shutdown occurs, the test is stopped. If a deflection shutdown does not occur, the test is continued to a specified number of cycles and suspended (Refer to Appendix B and Appendix C). In some wheel designs, new and propagating cracks may also end the test.

4.3.1 Select the appropriate wheel adapter, and press or otherwise secure the wheel attachment fasteners into the wheel adapter.

Note: Wheel attachment fasteners shall be fully seated and perpendicular to adapter surface.

4.3.2 Mount and secure the wheel adapter to the test machine's loading spindle.

4.3.3 Install appropriate wear plate, as needed.

Note: Either adapter or wear plate, if utilized, shall have an outside diameter that is greater than or equal to the vehicle hub assembly that contacts the inboard side of the wheel disc for the given design.

4.3.4 Mount a tire onto a test wheel.

4.3.5 Inflate tire. Record the tire inflation pressure.

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4.3.5.1 Inflate the tire to 448 kPa $\pm$ 14 kPa (65 psi $\pm$ 2 psi) for tires with usage pressure of 310 kPa (45 psi) or less.

4.3.5.2 For wheels and tires intended for use at higher pressures, use 1.2 times the usage pressure, but not less than 448 $\pm$ 14 kPa (65 $\pm$ 2 psi).

4.3.6 Mount the tire-wheel assembly onto the wheel adapter and install the wheel attachment fasteners.

4.3.6.1 Using a star pattern, tighten wheel fasteners to torque value specified by the requester or wheel drawing. If not specified, tighten to assembly plant minimum dynamic torque specification. Record observations on the Appendix A, Test Data Sheet A1.

Note: Refer to Opel Drawing 8957388 for tightening torque, as needed.

4.3.6.2 Using a star pattern, recheck fastener torque until requested torque values stabilize.

4.3.7 If performing TRIAS 09-J002-001, record picture of test setup showing the wheel and machine in test configuration.

Note: This may be done at any convenient time. Only one (1) picture is required even when multiple wheels samples are being tested, per each test request.

4.3.8 Begin Testing. Enter the load value into the control system, if applicable.

Note: Loading value is stated on the wheel drawing, or otherwise stated by the requester. If the load value is not provided, the calculation is shown in Appendix B.

4.3.8.1 Apply load onto the tire-wheel assembly.

4.3.8.2 Set dynamometer road wheel surface speed (recommended 80 km/h (50 mph)) to avoid tire temperature increases that adversely affect test tire life.

Note: Tire pressure will increase slightly during testing; do not regulate in order to maintain initial cold pressure value.

Note: If test is evaluating light truck wheels that incorporate use of large profile tires, decrease speed as needed to promote tire life.

Note: External cooling is permissible (e.g., fans, compressed air, vortex tubs, etc.)

4.3.8.3 Set deflection limit within 40 mm (1.5 in) or less of initial loaded radius to stop test and prevent test wheel from contacting dynamometer road wheel when the tire or wheel cannot sustain test load. Adjust any additional protective devices to prevent damage to equipment, as needed.

4.3.8.4 When testing light truck wheels which are intended to be used as duals, per SAE International (SAE), stop fixture at 50 000 cycles and re-torque fasteners per paragraph 4.3.6.

4.3.8.5 Perform test until end of test criteria (e.g., deflection shutdown, inspection cycle or required number of cycles). Refer to paragraph 4.3.10 for end of test criteria.

Note: Refer to Appendix B, Tables B1 thru B3, and Appendix C for inspection cycle values, if not stated by the requester.

4.3.8.6 Inspect Wheel. Refer to 4.3.9 for inspection instructions.

4.3.8.6.1 Tire and wheel removal is necessary for crack inspection.

4.3.8.7 If not at end of test conditions, per 4.3.10, reinstall tire onto wheel and continue testing per 4.3.5 to 4.3.8.6.

4.3.8.8 If testing has reached end of test conditions, per 4.3.10, repeat testing for additional samples. Refer to Appendix C for sample size requirements, if not stated by the requester.

4.3.9 Inspection Instructions. All wheels shall be inspected for cracks at required inspection intervals and at end of test. Observations shall be documented on the test data sheet (refer to Appendix A) and on the wheel.

- Verify machine is not operating
- Verify load value is set at zero

4.3.9.1 Record test cycles, test hours, tire inflation pressure, and wheel fastener audit torque values, for each attachment fastener on data sheets (refer to Appendix A).

4.3.9.2 Crack detection media shall be used (e.g., Zyglo or other equivalent dye penetrants).

4.3.9.3 Refer to 4.3.9.7 for marking wheel cracks on the wheel.

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4.3.9.4 Identify wheel cracks on the data sheet per crack location codes stated in Appendix E, Data Sheet E1.

4.3.9.5 If a chrome-plated wheel exhibits cracking, the chrome-plating shall be removed to determine if the crack(s) penetrates base metal.

Note: Care shall be taken when removing chrome plating, such that, the base metal is not affected.

4.3.9.6 Requester shall review all cracks found during wheel inspection.

4.3.9.7 Marking Wheel Cracks.

4.3.9.7.1 Use a fine point marker (paint pen) that will not be removed by materials used during subsequent crack inspections.

4.3.9.7.2 Mark ends of crack with small lines.

4.3.9.7.3 Color code crack marks as follows:

4.3.9.7.3.1 Black for pre-test inspection of light colored wheels.

4.3.9.7.3.2 Yellow for pre-test inspection of dark colored wheels.

4.3.9.7.3.3 White for bogie inspection.

4.3.9.7.3.4 Red for end of test inspection.

Note: To describe crack location use the valve stem hole as the zero point, and inspect the wheel in a clockwise direction (looking at the curbside of the wheel). Each spoke and wheel bolt hole position is identified by number with the number one (1) nearest or just clockwise of the valve stem hole and counting upward while traveling in a clockwise direction around the wheel.

Note: Describe crack direction (radial, circumferential, axial, diagonal, etc.), and length.

Note: Describe crack area (window, spoke, support rib, weld, drop well, pocket, curb side, backside, etc.)

4.3.10 Sample-End of Test.

4.3.10.1 When wheel cannot sustain test load.

4.3.10.2 When deflection shutdown occurs.

4.3.10.2.1 If a tire air leak caused the deflection shutdown and the wheel passes crack inspection per paragraph 4.3.9, then record tire change information, on Data Sheet A1 in Appendix A. Then mount new tire on test wheel and continue testing per paragraph 4.3.5.

4.3.10.2.2 If a tire air leak caused the deflection shutdown and one or more cracks are found in the wheel crack inspection per paragraph 4.3.9, then record tire change information on the data sheet (refer to Appendix A). Then mount a new tire on the test wheel and determine if the wheel is able to maintain air pressure (no loss of pressure greater than 2 psi over a 30 minute period). If the wheel can maintain air pressure, continue testing per paragraph 4.3.5.

4.3.10.2.3 If deflection limit shutdown is due to a wheel fastener fracture, replace all wheel fasteners then continue test per paragraph 4.3.1.

4.3.10.3 When chrome plated wheel has documented crack(s) in the base metal.

4.3.10.4 Steel or wrought (fabricated) aluminum wheels:

4.3.10.4.1 When a new crack is found at or before B₁₀ bogie.

4.3.10.4.2 When test cycles reach 2.5 times B₁₀ bogie.

4.3.10.4.3 Review Appendix C for crack location requirements.

Note: Refer to Appendix B for B₁₀ bogie value.

4.3.10.4.3.1 For full face wheels only. No full face weld cracks through 2.5 times B₁₀ Bogie cycles (2 500 000 cycles for Light Trucks and 1 250 000 cycles for Passenger Cars). Contact requesting engineer in the event of deflection shutdown prior to 2.5 times B₁₀ Bogie cycles.

4.3.10.5 Cast, cast flow formed, forged, or forged flow-formed aluminum wheels, end of test.

4.3.10.5.1 When a documented, pretest crack propagates when inspected at minimum life bogie inspection (B₁₀ bogie).

4.3.10.5.2 When a new crack identified during minimum life bogie inspection propagates before or at 2.5 times minimum life bogie (B₁₀ bogie).

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