Score Test for Axle/Rear Drive Module (RDM) Open Differential Bench 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. The purpose of this procedure is to test the robustness and durability of an Axle/Rear Drive Module (RDM) differential assembly and to compare the score resistance characteristics of various differential components, materials, heat treatments, and lubricants under high differential conditions.

1.2 Applicability. Any vehicle equipped with an Axle/RDM that utilizes an open center differential.

Note: This test is not for testing Axle/RDMs that utilize a limited slip differential, an electronically controlled clutch, or testing Axle/RDM differentials in locked modes (such as lockers) where, by design, no differentiation is allowed to occur.

1.3 Remarks. The purpose of a differential in an Axle/RDM is to allow side-to-side driveline speed differences which may occur because of a number of different reasons (i.e., minor differences in tire size, one wheel traveling faster than the other wheel while turning, wheel slip on split mu surfaces, etc.) Many GM vehicles utilize a brake based traction control which minimizes speed differences across an Axle/RDM differential through brake intervention. This is done in order to prevent potential damage from overspeed conditions. This test procedure ensures that a differential is robust enough to withstand limited overspeed in the event of a traction control malfunction, or intentional disabling of traction control by the customer.

2 References

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

2.1 External Standards/Specifications.

None

2.2 GM Standards/Specifications.

None

2.3 Additional References.

- Backlash Measurement Procedure (to be provided by GM Lead Engineer)
- CG4546 Data Sheet for Score Test for Axle/RDM Open Differential
- Component Technical Specification (CTS)
- Drag Torque Measurement Procedure (to be provided by GM Lead Engineer)
- Drive Torque Measurement Procedure (to be provided by GM Lead Engineer)
- GM1829 Analysis/Development/Validation Plan and Report (ADVP&R)
- Statement of Requirements (SOR)
- Subsystem Technical Specification (SSTS) (for Axle/RDM or Rear Drive Module)
- Validation Cross Reference Index (VCRI)

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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.

3.1.2 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.

3.1.3 This test requires a lab/test cell for component testing.

3.1.3.1 The lab must be equipped with a dynamometer (power source) capable of delivering required pinion torque (within 1.0% of target) under varying speed conditions (± 5 rpm).

3.1.3.2 Two (2) energy absorption devices capable of absorbing the output of the input source and regulating the output speed; ± 5 rpm under the varying conditions of this procedure. See Appendix A, Figures A1 and A2.

3.1.3.3 Control equipment capable of accelerating and decelerating one (1) axle shaft on a linear function from base speed to test speed ± 5 rpm, while maintaining constant speed conditions on the opposite shaft and constant load on the input.

3.2 Equipment.

3.2.1 Fixtures, reaction members and adapters to mount the Axle/RDM.

3.2.2 Input adapter (provide for connection to dynamometer and sealing of input flange).

3.2.3 Two (2) output adapters (provided for connection to dynamometer and sealing of output shafts; i.e., dummy joints).

3.2.4 Temperature monitoring in sump with resolution within 1 °C (2 °F).

3.2.5 Vibration monitoring, or similar device, connected with drive absorption device controls to provide automatic shutdown in the event of failure of either test parts or equipment.

Note: Preferred method of detecting part problems is to use a delta analyzer for early warning.

3.3 Test Vehicle/Test Piece.

3.3.1 A minimum of six (6) differential assemblies are required for each design configuration to be evaluated. If the test is to evaluate a potential change, baseline differential assemblies should also be tested for comparison purposes. Note special treatment, lubricants and/or material of test components. Record on CG4546 Data Sheet.

3.3.2 The test Axle/RDM must be an open differential of the highest numerical ratio available for that model in order to test the worst case condition for differential overspeed.

3.3.3 Sample Preparation. The inspections listed in 3.3.3.1 to 3.3.3.4 are to be performed and recorded for each differential assembly being tested. See table titled Inspection Rating in CG4546 and table titled Inspection Dimensional Measurement in CG4546.

3.3.3.1 Micro finish of cross shaft, differential pinion bores, back face of all gears, case internal sphere diameter, and case bores for half shafts**.**

3.3.3.2 Cross shaft diameter at each pinion location.

3.3.3.3 Pinion gear inside diameters (at bore ends and mid bore).

3.3.3.4 Case bore inside diameters (for half shaft interface).

3.3.4 Test samples must be built per the processes in 3.3.4.1 through 3.3.4.6. Record all results on table titled Pre-Test Inspection Results in CG4546.

3.3.4.1 Inspect and thoroughly clean all Axle/RDM components with a suitable solvent to insure no chips or foreign materials are present in the assembly.

3.3.4.2 Lubricate with the test lubricant and assemble the following components in the differential case: Side gears and thrust washers, pinions and thrust washers, and cross shaft and pin.

3.3.4.3 Install differential side bearings and differential case assembly into Axle/RDM.

3.3.4.4 Adjust side bearing preload, per Drag Torque Measurement. Record results on table titled Pre-Test Inspection Results in CG4546**.**

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3.3.4.5 Adjust ring gear backlash, per Backlash Measurement. Record results on table titled Pre-Test Inspection Results in CG4546.

3.3.4.6 Adjust drive gear set contact pattern to nominal pattern at production test load or equivalent pattern at no load. Take photos of contact patterns for each unit or record on table titled Contact Pattern in CG4546.

3.3.5 The test Axle/RDM must be equipped with a means of monitoring and recording oil sump temperature.

3.3.5.1 Install a thermocouple in the lower sump drain plug. See Appendix C, Figure C2**.**

3.3.6 Run an analysis of a lubricant test sample (obtained from the same container from which the Axle/RDM fill is obtained) to ensure that it meets specifications.

Note: Balance of differential to be manufactured within production specifications.

Note: All new Axle/RDMs require break-in. See 4.3.1 for procedure details.

3.4 Test Time.

Calendar time:	1 day (each unit)
Test hours:	4 hours (each unit)
Coordination hours:	4 hours (each unit)

3.5 Test Required Information. Possible sources are:

- Statement of Requirements (SOR)
- Subsystem Technical Specification (SSTS)
- GM1829 Analysis/Development/Validation Plan and Report (ADVP&R)
- Validation Cross Reference Index (VCRI)

3.5.1 Gear ratio of axle being tested. Record on CG4546.

3.5.2 Axle/RDM allowable oil temperature range. Record on CG4546.

3.5.3 Determine the number of cycles to be tested based on requirements in 3.5, or as required by requesting engineer. Record the required test bogey cycles on the CG4546.

Note: Development Testing: It is recommended that new materials/new technology type components be inspected at five (5) cycle intervals (to capture buds of problems, such as gear and pin scoring).

Note: Validation Testing: For established components, recommended inspection intervals are every 50 cycles, as required by requesting engineer.

3.5.4 Obtain appropriate value for Axle Torque Capacity (ATC) from program team Design Release Engineer (DRE). If ATC is not readily available from technical specification, select ATC from Appendix D, Table D1 (also referenced in table titled Axle Torque Capacity in CG4546). Acquire concurrence from DRE.

3.5.5 Calculate Input Torque required for Break-in and Score Test. Record on CG4546.

- Input Torque $_{\text{Break-in}}$ (calculated) = _____ (ATC) × 0.20 (20%) ÷ Gear Ratio
- Input Torque $_{\text{ScoreTest}}$ (calculated) = _____ (ATC) × 0.50 (50%) ÷ Gear Ratio

3.6 Personnel/Skills. Test Technician should be proficient in operation of the facilities listed in 3.1, proper selection and operation of the equipment listed in 3.2, and familiar with the general operation of gearboxes with differential assemblies. See Appendix B, Figure B1 titled Examples of Differential Components. See Appendix C, Figure C1 titled Operation of Differential Components.

4 Procedure

4.1 Preparation.

4.1.1 New test samples shall be used. For Product Validation (PV) testing, off tool parts is mandatory. For Design Validation (DV) testing, prototype parts may be used.

Note: Test samples that complete this test are not to be reused for other testing, unless approved by the DRE due to the accrued damage which may be introduced in the parts.

4.1.2 Check the Axle/RDM lubricant level and ensure it is set to the appropriate level.

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4.1.3 Install Axle/RDM in test cell. The Axle/RDM shall be mounted on a test stand that consists of an electric motor input and two (2) electric motors at the outputs. See Appendix A, Figures A1 and A2.

4.1.4 Connect torque cells and speed sensors at each input/output interface.

4.1.5 Connect thermocouple from the lower sump drain plug.

4.1.6 Attach a vent tube (clear tube recommended) to the Axle/RDM vent fitting and position it at least 457 mm (18 in) above the vent outlet.

4.1.7 Record the sump temperature, torque (input, Left Hand (LH) and Right Hand (RH) output), and speed (input, LH and RH output), with frequency 10 Hz.

4.1.8 Test Stand Review. The test setup and methodology must be reviewed with the GM System Validation Engineer (SVE). The GM SVE may request for a review by the DRE and/or the Bill of Material (BOM) Family Owner (BFO). Photographs and/or computer aided design images of the test must be provided.

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.

4.2.3 Any fluid that enters the clear vent tube should be noted. Any leakage from the vent pipe should be noted.

4.2.4 Ensure the Axle/RDM fluid is filled to the proper level. Sump temperature shall be held below 120 °C (250 °F) throughout the test.

4.2.5 The test sample orientation on the test bench shall be the same as within the vehicle. Any deviations need to be approved by the GM SVE and/or the DRE.

4.2.6 Test shall be controlled and monitored by a computer program. Load, displacement, and cycles of the specimen shall be monitored through entire test until failure.

4.2.7 Adjust vibration sensing device to affect shutdown when vibration level increases by approximately 20%.

Note: Preferred method of detecting imminent parts problem is to use delta analyzer for early warning.

4.2.8 Failure mode is to be recorded and failure location shall be identified for each test specimen. Pictures shall be taken for typical failure modes and any anomalous failures documented and photographed.

4.3 Instructions.

4.3.1 Perform break-in (only if not previously performed).

4.3.1.1 Run at 20% ATC load for 20 minutes**.**

4.3.1.1.1 Set shaft speed (rpm) counters to zero (0).

4.3.1.1.2 Adjust absorbing devices to obtain a 20 rpm delta speed between the two (2) axle shafts.

4.3.1.1.3 Run 10 minutes with LH axle shaft at speed = 90 rpm, and RH axle shaft at speed = 70 rpm.

4.3.1.1.4 Run 10 minutes with RH axle shaft at speed = 90 rpm, and LH axle shaft at speed = 70 rpm.

4.3.1.1.5 Apply test load and set ring gear speed to 100 rpm.

4.3.1.1.6 Adjust vibration sensing device to affect shutdown when vibration level increases by approximately 20%.

Note: Preferred method of detecting imminent parts problem is to use delta analyzer for early warning.

4.3.2 Open Differential Score Procedure.

Note: The differential gear sets should be tested in five (5) cycle intervals (see Table 1).

4.3.2.1 Obtain input torque necessary for score test (see 3.5.5). Record in Table 1. Record on table titled Run Sheet in CG4546.

4.3.2.2 Set output speed (final drive ring gear) to 40 rpm. Adjust absorbing devices to 40 rpm on each side.

4.3.2.3 Apply input load with power source, per Table 1.

4.3.2.4 Run warmup until sump > 43 °C (110 °F).

Note: In the event that a break-in run has just been performed and the sump temperature is over 43 °C (110 °F), skip the previously mentioned warmup run, and perform a cool down run until the sump temperature falls below 43 °C before starting test.

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