



Vehicle Level Mechanical Losses

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. To provide a common procedure to measure vehicle level mechanical losses using a single roll, two wheel drive (2WD) chassis dynamometer for:

- Brakes.
- Bearings.
- Transmission and Transfer Case.
- Drive Shafts or Half Shafts.
- Other components as required.

The data from this procedure is used to:

- Confirm estimates of Pre-Vehicle Program Initiation (VPI) system losses.
- Quantify component losses.
- Identify opportunities to reduce spin loss.
- Generate offsets for various components.
- Estimate overall road load (by adding aero).

Note: A four wheel drive (4WD), chassis dynamometer may also be used; however, this is not addressed in this procedure.

1.2 Applicability. This applies to passenger cars and light-duty trucks.

2 References

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

2.1 External Standards/Specifications.

SAE J2264

2.2 GM Standards/Specifications.

None

2.3 Additional References.

- Global Energy and Drive Quality Test Report System Database:
<https://share.gm.com/sites/GlobalEnergyTesting/default.aspx>

3 Resources

3.1 Facilities. Any facility to house required chassis dynamometers.

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.

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3.2 Equipment. See SAE J2264 for dynamometer requirements.

3.3 Test Vehicle/Test Piece. Vehicle prepared per site requirements for restraining vehicles. The following shall be to design or test intent:

- Mass.
- Tires.
- Driveline fluids.
- Wheel alignment.
- Transmission.
- Brake system.

3.4 Test Time.

Calendar time: 1 day
Test hours: 8 hours (Standard Test)
12 hours (Brake Reseat)
Coordination hours: 2 hours

3.5 Test Required Information.

- Target weight for test vehicle.
- Desired test tire pressure.
- Dynamometer parasitic losses.

3.6 Personnel/Skills. Trained technicians to operate dynamometer.

4 Procedure

4.1 Preparation.

4.1.1 Fuel. Fill fuel tank to 100%.

4.1.2 Ballast. The vehicle shall be ballasted to target weights (front and rear axle) as specified by the engineer on the test request. This target weights should be same as the road load test for that region. If the goal is to use the data to estimate vehicle road load, add 45.4 kg (100 lb) ballast to each of the front footwell locations (90.8 kg (200 lb) total). This ballast weight can be adjusted to account for regional differences in certification test weight if required. The 90.8 kg (200 lb) simulates the additional weight of the driver and instrumentation during on-road coast-downs, making the data directly comparable.

4.1.3 Tires. Set the cold tire pressure as specified by the engineer on the test request. If you plan to check multiple vehicles (for comparison), it is recommended that you use a common set of tires. Preferably, these would be measured tires with known 5-term coefficients.

4.1.4 Brake Preparation (Optional in Some Cases). Brakes are normally run "as received". If the "as received" results show brake drag values above Vehicle Technical Specifications (VTS) target (i.e., drag values in the yellow region show in Figure A4, Appendix A), the brake group will want them retested with a known pre-apply. Sections 4.1.4.1 thru 4.1.4.5 illustrate how to reseat and reset the brakes prior to retesting.

4.1.4.1 Remove wheel/tire assemblies. Check drum brake and parking brake clearance and adjust as required. Retract the caliper piston(s) on each corner of the vehicle using a clamp or service tool. Generally, on vehicles equipped with integral parking brake calipers, the rear caliper pistons must be rotated and compressed with an appropriate service tool to retract them.

4.1.4.2 Reinstall tires.

4.1.4.3 For vehicles equipped with a brake pressure transducer (typical of vehicles equipped with Electronic Stability Control (ESC)) that broadcasts on the vehicle Local Area Network (LAN), it is recommended to read the pressure signal directly via the vehicle's diagnostics connection.

If needed, a pedal force transducer may be installed and used to achieve the target system pressure. The following applies to the case of using a pedal force transducer to achieve target system pressure.

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Determine a target brake pedal apply force that provides the following:

- a. Brake Corner (Scorecard) Drag Datasheet value, or
- b. 5000 kPa brake line pressure, or
- c. 90 N brake pedal apply force.

The pedal force corresponding to the preferred 5000 kPa line pressure can be obtained from the brake engineer for the given program. If this is not readily available, use the standard 90 N pedal apply force.

Important: For vehicles equipped with a vacuum brake booster and using the pedal force method of applying the target hydraulic pressure, the brake booster must have enough vacuum to operate correctly. In most cases, this is ensured by starting and running the engine for at least 30 seconds prior to and during the brake apply.

4.1.4.4 Start the engine (brake power assist must be functioning) and pump the brakes lightly, taking care not to exceed the pedal force limits in 4.1.4.3. Pump the brakes until the pedal is firm and consistent. This typically takes 3 to 5 brake applies after the pistons have been fully retracted.

4.1.4.5 Apply the target (4.1.4.3) pedal apply force and hold for 10 seconds, then release. If an overshoot of > 10% of the target apply occurs, retract the pistons again and start the brake preparation procedure over.

4.2 Conditions.

4.2.1 Environmental Conditions. The test cell temperature shall be recorded during the test. A dynamometer test cell temperature of 24 °C is preferred.

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 Mechanical Loss Measurements Tests can be repeated for the following vehicle states:

- No Vehicle Spin/Dynamometer Parasitic Loss Test (to verify torque cells have no offset and dynamometer losses are zeroed out).
- As received.
- Brake pads or shoes removed.
- Parking brake cable disconnected.
- Half Shaft/Drive Shift removed (optional).
- Brakes reset/prepped (see Section 4.1.4). This is typically done if “as received” results show elevated brake drag.

See Section 4.3.3 for a typical test sequence.

4.3.1 No-Vehicle Spin.

4.3.1.1 Dynamometer Warm-up/Parasitic Loss Compensation.

4.3.1.1.1 Without the vehicle installed, verify that the torque/force load cell reads zero. Adjust if needed. Also verify that the losses for the chassis rolls themselves have been zeroed out within the system. Most dynamometers have an automated process for doing this. It is sometimes referred to as parasitic loss compensation or test stand losses. (See Figures A1 and A2, Appendix A).

4.3.1.1.2 Bring dynamometer roll speed to 80 km/h for 45 minutes minimum. Monitor the dynamometer surface force during this process. Due to the nature of torque readings on rotating components, it is easier (recommended) to monitor a filtered version of the signal. It will typically start at some non-zero level for a cold vehicle, and then gradually decrease as the bearings, fluids, etc., begin to warm. If after 45 minutes, the surface force is still decreasing, extend the warm-up.

4.3.1.1.3 Bring dynamometer to a stop.

4.3.1.2 No-Vehicle Spin Loss Test.

The “no-vehicle spin” test is performed to ensure that the dynamometers are properly compensating out their own losses and no drifting of the torque/force load cells has occurred.

4.3.1.2.1 Immediately following 4.3.1.1.3, bring dynamometer roll speed to 120 km/h (75 mph).

4.3.1.2.2 After dynamometer roll speed has stabilized (approximately 30 s), record dynamometer surface force for 30 seconds. A minimum data acquisition rate of 1 Hz is recommended to get at least 30 sample data points at each speed.

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4.3.1.2.3 Repeat step 4.3.1.2.2 for the following speed points in order: 113, 105, 97, 90, 80, 72, 65, 55, 48, 40, 32, 25, 16 km/h (70, 65, 60, 55, 50, 45, 40, 35, 30, 25, 20, 15, and 10 mph).

It is permissible to modify the speed points listed above, as the objective is to generate points along a curve. However, a minimum of 10 speed points are required.

4.3.1.2.4 Repeat no-vehicle spin test (sections 4.3.1.2.2 through 4.3.1.2.3) 3 times.

4.3.1.3 Analyze the data. Verify that the average no-vehicle spin data at each speed is below 4.5 N (1 lbf). If not, run a new dynamometer mechanical loss test and then repeat the no-vehicle spin test. Do not start the actual spin loss measurements on the vehicle until it is verified that the dynamometer no-vehicle spin results in losses between ± 4.5 N (1 lbf).

Note: Many dynamometers have a Parasitic/Test Stand Loss feature built into the software that may be used to automate this procedure.

4.3.2 Vehicle Non-drive Axle Loss Measurement.

4.3.2.1 Vehicle Warm-up.

4.3.2.1.1 Check and reset the load cell to zero if needed.

4.3.2.1.2 Load the vehicle on the dynamometer placing the non-drive axle of the vehicle on the rolls.

4.3.2.1.3 Start the engine.

Note: If the proximity of the engine/trans/exhaust does not affect the temperature of the non-driven components, the test can be run with the engine off. Otherwise, start the engine. For example, the front axle of a 4WD/Rear Wheel Drive (RWD) truck is affected by heat radiating from the engine, so it would be tested with the engine on. The rear axle of a front wheel drive car is typically not affected by engine heat radiation, so it would be tested with the engine off.

4.3.2.1.4 With the transmission in Drive, bring dynamometer roll speed to 80 km/h (50 mph). Shift to neutral any time after the speed is above 16 km/h (10 mph), and let the dynamometer continue to motor the vehicle up to speed. (This eliminates potential clutch-to-clutch engagement issues.) Hold 80 km/h for 45 minutes minimum. Monitor the dynamometer surface force during this process. It will typically start at some non-zero level (cold) and then gradually decrease as the bearings, fluids, etc., begin to warm. If the surface force is still decreasing after 45 minutes, extend the warm-up. Figure A1 in Appendix A is included as an example warm-up trace for dynamometer torque.

Note: As a guideline, a minimum allowable variance of 0.7 kg (1.5 lb) over a 140 s window is recommended. If the force is still decreasing at a faster rate than this, extend the warm-up.

4.3.2.1.5 Bring dynamometer to a stop.

4.3.2.2 Mechanical Losses Test.

4.3.2.2.1 Bring dynamometer roll speed to 120 km/h (75 mph).

4.3.2.2.2 After dynamometer roll speed has stabilized (approximately 30 s), record dynamometer surface force and speed for 30 s. Sample rate should be a minimum of 1 Hz.

Note: Stabilization time and torque measurement may vary depending on dynamometer type.

4.3.2.2.3 Repeat step 4.3.2.2.2 for the following speed points in order: 113, 105, 97, 90, 80, 72, 65, 55, 48, 40, 32, 25 and 16 km/h (70, 65, 60, 55, 50, 45, 40, 35, 30, 25, 20, 15, and 10 mph).

4.3.2.2.4 Repeat the measurement from 120 km/h to 16 km/h (75 mph to 10 mph) 3 times (i.e., record 3 ramps).

4.3.2.2.5 Repeat steps 4.3.2.1.4 through 4.3.2.2.4 for any additional configurations. When testing the driven axle, make sure the engine is running in order to warm-up engine and transmission fluids. See the following section for typical test sequences.

Notes: Speed points may vary depending on the dynamometer type. A minimum of 10 speed points are required.

Also, there is a known issue with clutch to clutch engagements at low speeds (even in neutral) for many 6 speed transmissions applications. The clutches engage after the vehicle has been placed in neutral below a threshold speed (typically 4 km/h to 7 km/h). They do this in anticipation of a shift to D. The clutches will stay engaged up to about 32 km/h (20 mph) before they release. This would cause spin loss at low speeds to be unrealistically high. In order to avoid this:

- Drive the vehicle up to a speed above 16 km/h (10 mph) before shifting to neutral.

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