



Police Vehicle Brake 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 defines the evaluation of brake performance of vehicles to be marketed as Police vehicles.

1.2 Applicability. Passenger cars and light-duty trucks with police package options.

1.3 Remarks. This procedure has three separate tests to evaluate braking performance for vehicles intended to be sold as Police vehicles. The request engineer should specify which tests are to be performed. This procedure may be used as a development tool to predict brake stopping performance as will be measure during official police department evaluations.

Typical police vehicle evaluations cover brakes, handling, acceleration, top speed, ergonomics, and fuel economy. This procedure addressed only the straight-line braking performance testing.

1.3.1 Simulated Michigan State Police Braking Test: The Michigan State Police (MSP) tests vehicles at the DaimlerChrysler Proving Ground, Chelsea, Michigan, and/or at the Michigan International Speedway, Brooklyn, Michigan. To simulate the straight-line braking tests at the GM Milford Proving Ground on the North-South Straightaway, the MSP test brake intervals of 0.38 km were changed to 0.32 km to eliminate the need to setup marker cones.

1.3.2 Simulated Pomona Police Braking Test. The Los Angeles County Sheriff Department tests vehicles at their driver training facility at the Pomona Fairgrounds, Pomona, California.

1.3.3 London Metropolitan Police Test. The London Metropolitan Police Test measures service brakes and parking brakes performance before and after a brake fade sequence. Brake performance is also monitored during the fade sequence.

2 References

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

2.1 External Standards/Specifications.

FMVSS 135

2.2 GM Standards/Specifications.

None

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 North-South Straightaway at GM Milford Proving Ground or Equivalent. Track should have marked lanes $\approx$ 3.5 m wide.

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September 2014

Page 1 of 17

3.1.4 Circular Track at GM Milford Proving Ground or equivalent. Track should have marked lanes ≈ 3.5 m wide.

3.2 Equipment.

3.2.1 Fifth wheel or equivalent to measure stopping distance and initial velocity.

3.2.2 Decelerometer.

3.2.3 Driver readable decelerometer.

3.2.4 Service brake pedal force transducer.

3.2.5 Service brake pedal travel transducer.

3.2.6 Park brake apply force transducer.

3.2.7 Brake pad/lining thermocouples.

3.2.8 Brake fluid thermocouples.

3.2.9 Ambient temperature thermocouple.

3.2.10 Brake line pressure transducers (optional).

3.2.11 Digital data acquisition system.

3.2.12 Appropriate signal conditioning equipment and cables.

3.2.13 Stopwatch.

3.2.14 Instrumentation shall be calibrated as required. Store calibration dates and instrument identification in the test record.

3.3 Test Vehicle/Test Piece.

3.3.1 Vehicle should be design or test intent with respect to the brake system, suspension system, wheels, tires, engine, axle, transmission, mass, and mass distribution.

3.3.2 All vehicles to be tested with a clean roof (i.e., no overhead light or light bar) and without spotlights.

3.4 Test Time.

Calendar time: (1 to 2) days

Test hours: (4 to 10) h

Coordination hours: 4 h

3.5 Test Required Information. Not applicable.

3.6 Personnel/Skills. A brake technician or engineer trained to perform the instructions in paragraph 4.

4 Procedure

4.1 Preparation.

4.1.1 Install embedded thermocouples in brake linings, unless otherwise specified. Use the instructions in FMVSS135 for lining thermocouple installation.

4.1.2 Build vehicle with brake system per test request.

4.1.2.1 For the simulated Michigan State Police test, new brake linings and rotors/drums are suggested.

4.1.2.2 For the simulated Pomona test, brake linings and rotors/drums from a vehicle test at Grattan Raceway or Pomona are suggested. The actual Pomona brake evaluation is done after the brakes have been used in a series of handling laps at the facility, creating lining wear, thermal conditioning and, possibly, lining taper. Grattan Raceway, Belding, Michigan creates a similar brake wear/temperature cycle. Other courses should be evaluated for comparison to the brake wear/temperature cycle.

4.1.2.3 For the London Metropolitan Police test, new brake linings and rotor/drums are suggested. Measure the initial thickness of the usable friction material of all brake linings. Measure each quadrant of the pad/lining as shown in Figure 1. Average the measurements and document in the test record.

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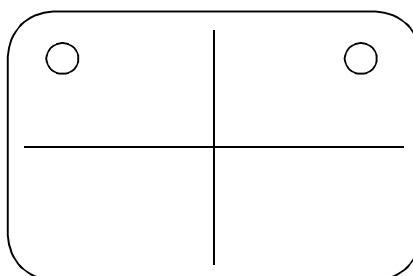
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September 2014

Page 2 of 17

Documents
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Figure 1: Brake Lining Measurement Template



4.1.3 Install instrumentation, per test request, and calibrate as needed. The parking brake apply transducer is only required for the London Metropolitan Police test.

4.1.4 Set tire pressures to manufacturer's specification.

4.1.5 Perform a brake burnish (conditioning) per test request. Suggested conditioning:

4.1.5.1 For Michigan State Police test, use of either an FMVSS 135 200 stop burnish or the Police burnish from Appendix A, Figure A1 is suggested.

4.1.5.2 For Pomona, at a minimum, use of either an FMVSS 135 200 stop burnish or the Police burnish from Appendix A, Figure A1 is suggested. See 4.1.1.2.

4.1.5.3 For the London Metropolitan Police test, follow the instructions in 4.3.4 unless otherwise specified.

4.1.6 Load vehicle to test weight per test request. Suggested weight is vehicle curb weight plus driver, instrumentation and full tank of gas. All instrumentation and ballast must be properly secured due to the high rate of deceleration achieved during test.

4.2 Conditions.

4.2.1 Environmental Conditions.

4.2.1.1 Ambient temperature shall be (0 to +40) °C. However, for higher correlation, try to keep temperature in a range of (+10 to +27) °C.

4.2.1.2 Road surfaces must be dry and clear of any salt residue.

4.2.1.3 Wind velocity should be 24 km/h or less, unless otherwise specified by test engineer.

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.

4.3.1 General Instructions.

4.3.1.1 All safety requirements for the test track and facility shall be followed. Consult facility safety department for requirements.

4.3.1.2 Stops must be started with the vehicle in the center of the lane. During the testing, note any stops that result in the vehicle leaving the lane.

4.3.1.3 Test vehicles with automatic transmissions are to be tested in "overdrive" if available or highest forward gear.

4.3.1.4 Four-wheel-drive vehicles are to be tested in 4-wheel-drive mode.

4.3.2 Simulated Michigan State Police Braking Test.

4.3.2.1 Phase I Evaluation. These instructions are specific to the MPG N-S straightaway. At other facilities, space stops between 0.32 km and 0.38 km apart. See 1.2. See Appendix B, Figure B1 for an example test data sheet.

4.3.2.1.1 Start at the 0.0 km (0.0 miles) marker heading North. Brake temperatures should be < +100 °C.

4.3.2.1.2 From a stop, go WOT to 145 km/h. Maintain speed to the 1.0 km (0.60 miles) marker.

4.3.2.1.3 At the marker, decelerate at 6.7 m/s² to a stop using a fast ramp apply to deceleration level (7.1).

4.3.2.1.4 Immediately, go WOT to 145 km/h and maintain speed to the 1.8 km (1.1 miles) marker.

GM Confidential

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September 2014

Page 3 of 17

4.3.2.1.5 At the marker, decelerate at 6.7 m/s^2 to a stop using a fast ramp apply to deceleration level.

4.3.2.1.6 Immediately accelerate to 72 km/h and drive around the turn-around.

4.3.2.1.7 After the turn-around, accelerate to 100 km/h and maintain speed to the 0.32 km (0.20 miles) marker.

4.3.2.1.8 At the 0.32 km (0.20 miles) marker, make a spike brake apply stop (7.1).

4.3.2.1.9 After the stop, immediately accelerate to 100 km/h and maintain speed to the 0.64 km (0.40 miles) marker.

4.3.2.1.10 At the 0.64 km (0.40 miles) marker, make a spike brake apply stop.

4.3.2.1.11 Repeat 4.3.2.9 and 4.3.2.10 at the 1.0, 1.3, 1.6 and 1.9 km (0.60, 0.80, 1.0, and 1.2 miles) markers for a total of six 100 km/h to 0 km/h stops.

4.3.2.1.12. After the 1.9 km (1.2 miles) marker stop, immediately start stopwatch and drive to 0 km (0.00 miles) marker heading north using the traffic circle. Soak vehicle until stopwatch reaches 4 minutes. End of Phase I.

4.3.2.2 Phase II Evaluation. Repeat section 4.3.2.1 Phase I. This second set of maneuvers is called Phase II.

4.3.3 Simulated Pomona Police Braking Test. Use test road suitable for a continuous series of stops with wide open throttle accelerations between stops. See Appendix C, Figure C1 for an example test data sheet.

4.3.3.1 Perform four successive 145 km/h to 0 km/h stops at 6.7 m/s^2 using a fast ramp brake apply up to the deceleration level. Modulate pedal to maintain deceleration. Accelerate at Wide Open Throttle (WOT) between stops.

4.3.3.2 Perform four successive 100 km/h to 0 km/h stops at maximum deceleration using a fast ramp brake apply. Modulate pedal to maintain maximum deceleration without wheel lock or ABS activation. Accelerate at WOT between stops.

4.3.3.3 Soak vehicle for 5 minutes. Record brake fluid temperatures during soak.

4.3.3.4 Repeat 4.3.3.1 and 4.3.3.2.

4.3.3.5 Accelerate WOT to 100 km/h. Conduct a spike brake apply stop attempting to remain within a traffic lane. For this stop, note any observation of severe brake fade, deviation from lane, and whether ABS activation occurred.

4.3.3.6 Soak vehicle for 20 minutes. Record brake fluid temperatures during soak. If necessary, drive the vehicle at a slow to moderate speed to a location for the soak.

4.3.4 London Metropolitan Police Braking Test. The measurement of hydraulic pressure is recommended for this test. Example data sheets are shown in Appendix D, Figures D1 to D4.

4.3.4.1 Service Brake Performance.

4.3.4.1.1 Prior to the commencement of any testing, assess the pedal travel required to achieve 500 N (50 kg) on the service brake pedal.

4.3.4.1.2 The service brake test in 4.3.4.1.3 thru 4.3.4.1.6 should be applied both before the Service Brake Fade Test (4.3.4.3) and after the Heat Soak Test (4.3.4.4).

4.3.4.1.3 Ensure all brake lining and disc/pad temperatures are $< +80^\circ\text{C}$ prior to the commencement of 4.3.4.1.4 to 4.3.4.1.6. Use the $+80^\circ\text{C}$ Initial Brake Temperature (IBT) for each stop.

4.3.4.1.4 Accelerate the vehicle to a steady speed of 48 km/h.

4.3.4.1.5 Decelerate the vehicle, in neutral, to rest, maintaining a steady pedal load of 50 N (5 kg). Record the rate of deceleration, as a percentage of 1G and the pedal travel required to achieve this pedal force.

4.3.4.1.6 Repeat 4.3.3.1.4 thru 4.3.3.1.5 for pedal loads increasing in 50 N (5 kg) intervals until a maximum of 500 N (50 kg) pedal load is achieved or consistent maximum results are maintained.

4.3.4.2 Parking Brake Performance.

4.3.4.2.1 The parking brake test in 4.3.4.2.2 thru 4.3.4.2.3 should be applied both before the Service Fade Test (4.3.4.3) and after the Heat Soak Test (4.3.4.4).

Note: The effort recorded for the park brake apply in 4.3.4.2.3 should be used for the post-fade test 4.3.4.6.

4.3.4.2.2 Accelerate the vehicle to a steady speed of 32 km/h.

GM Confidential

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September 2014

Page 4 of 17

4.3.4.2.3 With the vehicle in neutral, apply the parking brake, noting the effort required, and bring the vehicle to rest. Record the rate of deceleration as a percentage of 1G. Use the apply effort to achieve maximum deceleration rate without any wheel lock or modulation of the apply.

4.3.4.3 Service Brake Fade Test.

4.3.4.3.1 Ensure the lining/disc/pad temperature is < +80 °C prior to the commencement of 4.3.4.3.2 thru 4.3.4.3.4. Document ambient temperature in test record.

4.3.4.3.2 Accelerate the vehicle to a steady speed of 80 km/h, as quickly as possible (wide open throttle), noting the time taken.

4.3.4.3.3 With the vehicle in neutral, apply the service brake bringing the vehicle to rest at a steady deceleration of 0.5G (50 % of 1G). Record the pedal force, the pedal travel, and the maximum lining/disc/pad temperatures during the stop. Particular attention should be made to looking for signs of brake fade during stop.

4.3.4.3.4 Repeat 4.3.4.3.2 and 4.3.4.3.3 further 49 times, as quickly as possible (wide open throttle). The overall time taken for this test should be recorded.

4.3.4.4 Heat Soak Test.

4.3.4.4.1 Immediately after the Service Brake Fade Test (4.3.4.3), leave the vehicle stationary with the engine running. Note ambient temperature.

4.3.4.4.2 Apply 500 N (50 kg) to the service brake pedal. Record the pedal travel, pedal force, and hydraulic pressure (if measured).

4.3.4.4.3 Repeat 4.3.4.4.2 a further 4 times at 2 minutes intervals for a total of 5 measurements.

4.3.4.5 Service Brake Performance – 2nd Test. Repeat 4.3.4.1.

4.3.4.6 Parking Brake Performance – 2nd Test. Repeat 4.3.4.2 using the pedal force from that test.

4.3.4.7 Pad Wear Test.

4.3.4.7.1 Upon completion of all testing, measure the remaining usable brake pad material.

4.3.4.7.2 Calculate the pad wear as a percentage of the original usable material (4.1.2.3). Perform a visual examination of the brake pads, discs, and braking system.

5 Data

5.1 Calculations.

5.1.1 Correct the measured stopping distance for each stop for initial speed using the following correction equation.

$$S_c = S_m * \frac{v_r^2}{v_a^2} \text{ (in m)}$$

Where:

S_c = Corrected stopping distance

S_m = Measured stopping distance

v_a = Actual initial speed

v_r = Requested initial speed

5.1.2 Calculate deceleration rate for each 100 km/h stop in Phase I and Phase II using the following equation.

$$DR = \frac{(v_i)^2}{2(SD)} \text{ (in m/s}^2 \text{)}$$

Where:

DR = Average deceleration rate in m/sec²)

SD = Stopping distance in meters

v_i = Initial vehicle velocity in m/second

5.1.3 Simulated Michigan State Police Test.

5.1.3.1 Calculate the average deceleration rate for the stops in Phase I (DR_i).

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September 2014

Page 5 of 17

5.1.3.2 Calculate the average deceleration rate for the stops in Phase II (DR_{II}).

5.1.3.3 Calculate the average deceleration rate for Phase I and Phase II ($DR_{I\&II}$) by averaging the averages in 5.1.2 and 5.1.3.

5.1.3.4 Calculate the test stopping distance using the following equation. This stopping distance is not the same as the stopping distances measured during the test.

$$SD_{100} = \frac{(v_{100})^2}{2 DR_{I\&II}} = \frac{(100 * 0.2778)^2}{2 DR_{I\&II}} \text{ (in m)}$$

5.2 Interpretation of Results.

5.1.1 Correct the measured stopping distance for each stop for initial speed using the following correction equation.

$$S_c = S_m * \frac{v_r^2}{v_a^2} \text{ (in m)}$$

Where:

S_c = Corrected stopping distance

S_m = Measured stopping distance

v_a = Actual initial speed

v_r = Requested initial speed

5.1.2 Calculate deceleration rate for each 100 km/h stop in Phase I and Phase II using the following equation.

$$DR = \frac{(v_i)^2}{2(SD)} \text{ (in m/s}^2 \text{)}$$

Where:

DR = Average deceleration rate in m/s^2

SD = Stopping distance in m

v_i = Initial vehicle velocity in m/s

5.1.3 Simulated Michigan State Police Test.

5.1.3.1 Calculate the average deceleration rate for the stops in Phase I (DR_I).

5.1.3.2 Calculate the average deceleration rate for the stops in Phase II (DR_{II}).

5.1.3.3 Calculate the average deceleration rate for Phase I and Phase II ($DR_{I\&II}$) by averaging the averages in 5.1.2 and 5.1.3.

5.1.3.4 Calculate the test stopping distance using the following equation. This stopping distance is not the same as the stopping distances measured during the test.

$$SD_{100} = \frac{(v_{100})^2}{2 DR_{I\&II}} = \frac{(100 * 0.2778)^2}{2 DR_{I\&II}} \text{ (in m)}$$

5.2 Interpretation of Results.

5.2.1 Simulated Michigan State Police Test.

5.2.1.1 Observations. Record in test record any brake fade during the stops. Record if vehicle remained in test lane during the stops. While these observations are not part of the official score for the braking evaluation, these are recorded during the actual State Police evaluation process.

5.2.1.2 Deceleration Rate. The average deceleration rate $DR_{I\&I}$ should be compared to the State Police requirements, if known, or to the performance of other vehicles.

5.2.1.3 Cooling Time. Be aware that actual testing using the East-West Straightaway of Daimler Chrysler Proving Grounds will have ≈ 0.8 km ($\frac{1}{2}$ miles) less cooling between the 145 km/h to 0 km/h heat-up stops and the six 100 km/h to 0 km/h stops and between the Phase I 100 m/h to 0 m/h stops and the start of Phase II. This is due to the Daimler Chrysler track being ≈ 0.8 km shorter than the MPG N-S Straightaway.

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September 2014

Page 6 of 17