Steering While Braking Physical Procedure

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 objectively quantify the yaw response of a vehicle to steer application while undergoing steady state deceleration.

1.2 Applicability. This procedure is applicable at all permissible loading conditions to all passenger cars and light trucks up to 3500 kg Gross Vehicle Mass (GVM). Trucks with GVM > 3500 kg may use this procedure, but reduced test speeds may be necessary.

1.3 Remarks. This procedure is intended to quantify the yaw response of a vehicle to steering while braking. The entire deceleration range is tested to measure the influence of chassis, tire, brake and control systems.

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

2.3 Additional References. 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 To be conducted on flat, level surfaces (less than 1% grade in any direction) with adequate length, width and runoff to allow fixed control steering and braking. Surface friction characteristics should be known to allow comparisons between vehicles and test sites.

3.1.4 Vehicle weighing station providing measurements of at least the front and rear axle ballast.

3.2 Equipment.

3.2.1 Speed Measurement Device and Readout. The speed transducer must be capable of reading velocity in excess of the vehicle test speed, a minimum of 150 km/h is recommended. The transducer accuracy must be within 0.5 km/h over the speed range of 5 km/h to 150 km/h.

3.2.2 Accelerometer Oriented to Measure Longitudinal Acceleration. The accelerometer must be capable of measuring a minimum of 1.2 m/s^2, with an accuracy of 0.01 m/s^2.

3.2.3 Accelerometer Oriented to Measure Lateral Acceleration. The accelerometer must be capable of measuring a minimum of 1.2 m/s^2, with an accuracy of 0.01 m/s^2.

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3.2.4 Angular Rate Sensor Oriented to Measure Yaw Velocity. The angular rate transducer must be capable of measuring at ± 50 degrees/s with an accuracy of 0.01 degrees/s.

3.2.5 Steering wheel angle (SWA) transducer and constraint.

3.2.6 Driver readable deceleration indicator.

3.2.7 Brake application indicator or pedal force transducer.

3.2.8 Digital data acquisition system (DAS). Scan data at a sample rate of 100 Hz.

3.2.9 Appropriate signal conditioning equipment and cabling.

3.2.10 Device providing an audible signal at the test speed.

3.2.11 Roll angle transducer (optional).

3.2.12 Sideslip angle transducer. Vehicle Sideslip angle measurement is required for Electronic Stability Control (ESC) Vehicles (optional for non-ESC vehicles).

3.3 Test Vehicle/Test Piece. The specific vehicle chosen for testing should be representative of the vehicle population with respect to brake system, tire, suspension and mass distribution properties. Extreme cases of the preceding parameters should also be addressed.

3.4 Test Time.

Calendar time:	2 d
Test time:	4 h
Coordination time:	8 h

3.5 Test Required Information. Not applicable.

3.6 Personnel/Skills. An experienced brake/vehicle dynamics test technician is required to perform vehicle and instrumentation setup and conduct the test.

4 Procedure

4.1 Preparation.

4.1.1 The vehicle to be tested must be in safe operating condition for maneuvering levels approaching the limit of vehicle performance. Condition of tire, brake, and suspension components should be inspected carefully. All vehicle safety equipment must be in proper operating condition.

4.1.2 Vehicles with obviously high centers of gravity must be reviewed for roll stability, and maneuvers limited or safety equipment added as appropriate.

4.1.3 Brake components are to be prepared per test engineer's instructions. Burnish per FMVSS 135 in the absence of other instructions.

4.1.4 Install transducers, DAS, driver readouts and steering control equipment.

4.1.5 Calibrate instrumentation as necessary.

4.1.6 Ballast vehicle to achieve loading desired. All ballast must be properly secured.

4.1.7 Inflate tires to manufacturer's recommended pressure or per test engineer's instructions.

4.1.8 Weigh vehicle in test configuration with full fuel load and driver.

4.2 Conditions.

4.2.1 Environmental Conditions.

4.2.1.1 Wind speed should be < 24 km/h.

4.2.1.2 Test surface should be clean and appropriately wetted for the test condition being sought.

4.2.1.3 Recommended test speeds are compiled in Table 1. For this procedure, the test speed is defined to be the speed of steer application.

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Table 1: Recommended Test Speeds

Surface	Recommended Test Speed (km/h)
Dry Asphalt or Concrete	100
Wet Surfaces – Coefficient < 0.6	50

Note: Other speeds may be specified to suit the vehicle/surface combination depending on facility, vehicle or safety constraints.

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 Steering While Braking Test.

4.3.1.1 Accelerate Vehicle Above the Test Speed and Stabilize. The brake application must be made at a speed sufficiently high to allow a minimum of 1.0 s of braking before the test speed is reached.

4.3.1.2 Stabilize vehicle in a straight running condition approaching test area.

4.3.1.3 Lock steering in straight ahead position.

4.3.1.4 Start data acquisition.

4.3.1.5 Maintain speed for a minimum of 1.0 s.

4.3.1.6 Apply brakes to attain the desired deceleration. For high coefficient surfaces, the recommended decelerations are from 0.2 m/s^2 up to the vehicle limit in 0.2 m/s^2 increments. For lower coefficient surfaces (< 0.6), use 0.1 m/s^2 increments from 0.1 m/s^2 up to the vehicle limit.

For vehicles not equipped with antilock brake system (ABS), the vehicle braking limit is defined to be the deceleration of first axle lock.

For vehicles with ABS, the limit is defined by a spike apply.

4.3.1.7 At the test speed, input the desired steer angle as quickly as possible and hold steer against steering wheel stop.

Steer amplitude is to be specified by test engineer. It is recommended that it correspond to 80% of maximum lateral acceleration and be determined by using a step steer or control response test.

4.3.1.8 For vehicles not equipped with ESC or vehicles with ESC disabled or malfunctioning, hold brake force constant and steer fixed for 4 s after steer application.

For vehicles equipped with ESC, hold brake force constant and steer fixed until vehicle comes to rest.

4.3.1.9 Stop data acquisition.

4.3.1.10 Repeat 4.3.1.1 thru 4.3.1.8 until two (2) runs have been completed for each sub-limit brake application level and four (4) runs have been completed with spike applies (spike apply stops are for ABS equipped vehicles only).

4.3.1.11 Run two (2) reference step steer runs at the desired steer angle and test speed. Reference step steer runs are defined as runs without the brake apply.

4.3.1.12 Repeat 4.3.1.1 thru 4.3.1.10 for right and left turns.

4.3.1.13 Run four (4) corrective steer straight line stops with spike brake applications from the test speed on the surface used for the Steering While Braking test.

5 Data

5.1 Calculations.

5.1.1 Yaw Velocity Response Metrics.

5.1.1.1 Calculate initial yaw velocity before brake application. This value becomes the "zero" for the run.

5.1.1.2 Reference Calculations. Calculate the steady state yaw velocity of the vehicle from the step steer tests. Allow at least 3.0 s after the steer input for the vehicle to stabilize; use at least 1.0 s of data to calculate an average yaw velocity.

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