GM	WORLDWIDE ENGINEERING STANDARDS	Test Procedure	GMW15534

Sine with Dwell Test - FMVSS 126

1 Scope

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 procedure is used to determine if a test vehicle equipped with Electronic Stability Control (ESC) meets the performance and functional requirements specified by Federal Motor Vehicle Safety Standard 126 (FMVSS 126) or by GM.

1.2 Foreword. This test procedure is General Motors Company's implementation of the Sine with Dwell Test conducted by the United States Department of Transportation's National Highway Traffic Safety Administration (NHTSA) as a part of the FMVSS 126 safety standard.

The Sine with Dwell Maneuver consists of a 0.7 Hz sine wave steering input with a 500 ms pause at the peak of the second half cycle (see Appendix A, Figure A1).

This maneuver, when executed at an entry speed of 80 km/h using peak steering wheel amplitudes in the neighborhood of 270 degrees, can cause yaw instability for nearly all vehicles not equipped with ESC.

Prior to running the Sine with Dwell Test, a Constantly Increasing Steer (CI) test (GMW15255) must be run to determine the steering wheel angle input for the Sine with Dwell test.

1.3 Applicability. This test procedure applies to any two axle vehicle with pneumatic rubber tires for vehicles less than 4545 kg (10 000 lb) gross vehicle weight.

2 References

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

2.1 External Standards/Specifications.

ASTM E1136	FMVSS 126
ASTM E1337-90	ISO 9001

2.2 GM Standards/Specifications.

GMW15255 (I)

(I) = This is a standard that is distributed only internally within General Motors. This standard cannot be distributed outside of General Motors. Contact the GM lead engineer for any instructions or see Federal Motor Vehicle Safety Standard 126.

2.3 Additional References.

FMVSS 126

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 The test requires a smooth, flat, dry surface with a high friction coefficient. Unless otherwise specified, the road test surface should produce a peak friction coefficient (PFC) between 0.9 and 1.0 when measured using an ASTM E1136 standard reference test tire, in accordance with ASTM E1337-90, at a speed of 64.4 km/h (40 mph), without water delivery.

The test surface shall have a consistent slope between level (0%) and 2.5%. Whenever possible, the test shall be conducted with the vehicle traveling up the slope. This ensures that the slope will not cause asymmetries in the measured data when turning both left and right.

3.2 Equipment. Each test vehicle is to be equipped with sensors, a data acquisition system, programmable steering machine, and appropriate safety equipment. Typical equipment locations are presented in Appendix A, Figure A2.

3.2.1 Sensors and Sensor Locations. Appendix A, Table A2 lists the type of sensors recommended for the Sine with Dwell test procedure. A brief description of these sensors is provided in this section.

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3.2.1.1 Steering Angle Encoder. Handwheel position is measured via an angle encoder integral with the programmable steering machine.

3.2.1.2 Vehicle Speed Sensor. Vehicle velocity and side slip can be measured with an optical sensor placed at the front or rear-center of the vehicle. Alternatively, radar based, sonar based, or Global Positioning Satellite (GPS) based sensors may be used. Sensor outputs are transmitted simultaneously to the data acquisition system, the steering machine, and the instrument panel mounted display. This instrument panel mounted display allows the driver to accurately monitor vehicle speed.

3.2.1.3 Multi-Axis Inertial Sensor. A multi-axis inertial sensing system is used to measure linear accelerations and the angular rates of roll, pitch and yaw. The position of the multi-axis inertial sensing system must be accurately measured relative to the center of gravity (centroid or CG) of the vehicle in the Driver plus Equipment test condition. This data is required to translate the motion of the vehicle at the measured location to that which occurred at the actual CG to remove roll, pitch, and yaw effects.

3.2.1.4 Roll Angle Sensor. This channel is not required if the acquired lateral acceleration data is already roll compensated. Height sensors may be used to collect left and right side vertical displacements for the purpose of calculating vehicle roll angle during post processing using trigonometry.

3.2.1.5 Brake Pedal Force/Actuation Switch. This transducer is used to document that the driver did not provide any braking intervention during the test maneuver as specified by the test procedure.

3.2.2 Data Acquisition System (DAS). The following channel assignments are shown to demonstrate the typical acquisition parameters.

- Speed
- Side Slip Angle
- Roll Rate
- Yaw Rate
- Lateral Acceleration
- Longitudinal Acceleration
- Vertical Acceleration
- Steering Wheel Angle
- Steering Wheel Torque (Optional)
- Roll Angle or Left Trim (roll height)
- Right Trim/roll Height (Optional)
- Brake Pedal Force/Actuation

3.2.2.1 Optional Channels. May be added as needed.

3.2.2.2 Sample Rate and Filtering. All data is to be sampled at 100 Hz. Signal conditioning consists of amplification, anti-alias filtering, and digitizing. Amplifier gains are selected to maximize the signal to noise ratio of the digitized data. Filtering is performed with two (2) pole low-pass Butterworth filters with a 25 Hz cutoff frequency.

3.2.3 Steering Machine. A programmable steering machine is used to generate hand wheel steering inputs for all test maneuvers. The steering machine shall be capable of supplying steering torques between 40 Nm to 60 Nm (29.5 lb-ft to 44.3 lb-ft). The steering machine must be able to apply these torques when operating with steering wheel velocities up to 1200 degrees/s and be able to move each vehicle's steering system through its full range. The steering machine should initiate steering programs at a preset road speed, and have the convenience of changing the steering program during test sessions.

3.2.4 Outriggers. Safety outriggers are installed on all test vehicles whose track width divided by twice the center of gravity height (T/2h) is less than 1.3 during all Sine with Dwell test maneuvers. It is recommended to use outriggers machined from 6Al-4V titanium I-beams. Lightweight outriggers are used for vehicles with baseline weights under 1588 kg (3500 lb) in a baseline condition (as delivered); standard outriggers are used for vehicles with baseline weights 1588 kg (3500 lb) and up.

3.2.5 Video Recording Equipment (optional).

3.3 Test Vehicle/Test Piece. This test procedure applies to any two (2) axle vehicle with pneumatic rubber tires that is under study for nonlinear handling stability and responsiveness characteristics by General Motors.

3.4 Test Time.

Calendar time:	2 to 4 days
Test hours:	2 to 3 hours
Coordination hours:	3 to 5 hours

3.5 Test Required Information. Not applicable.

3.6 Personnel/Skills. Operator must be qualified and documented as capable to run this test as required by ISO 9001.

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4 Procedure

4.1 Preparation. Consult test engineer for Fishhook vehicle preparation, vehicle setup, outrigger bracket system fabrication, and necessary precautions.

4.1.1 Installation.

4.1.1.1 For all vehicles that must be tested using outriggers, remove and store the front and rear bumpers and/or fascias.

Outrigger mounting brackets must be fabricated for both the front and rear locations. Each mounting bracket must attach to the vehicle frame or structure, preferably at the existing bumper mounting location. Additionally, the mounting brackets must allow the attachment of the Outrigger Adapter Interface (the NHTSA universal adapter interface is 425 mm (16.75 in) from ground to centerline). The outrigger adapter interface may follow a standardized design. However, the mounting brackets required to attach the adapter interface to the vehicle will be unique to each family of vehicles.

For vehicles greater than 1588 kg (3500 lb) curb weight, the standard outriggers should be installed and adjusted such that the skid pads are 406 mm (16 in) above level ground in the front and rear. This height may be adjusted as necessary during the test.

The lightweight outriggers, used for vehicles less than 1588 kg (3500 lb) at a curb condition, should be installed and adjusted such that the skid pads are 305 mm (12 in) above level ground in the front and rear and adjusted as necessary during the test.

4.1.1.2 The data acquisition module must be fastened securely to the vehicle interior to prevent it from being dislodged in the event of loss of vehicle control or vehicle tip-up.

4.1.1.3 The external speed sensor (if required) should be mounted at the longitudinal vehicle centerline at the front of the vehicle. If the sensor cannot be mounted at the precise center, the magnitude and direction of offset from center should be documented and reported to the appropriate test engineer.

4.1.1.4 The multi-axis inertial sensor must be installed and securely mounted at or near the total vehicle center of gravity, with the location recorded on the Test Vehicle Description (TVD) Sheet. See Appendix B for a sample TVD. The CG is typically in or around the vehicle's front center console (if any), which may be removed as necessary.

4.1.1.5 Inner tubes may be installed in all four tires for vehicles equipped with outriggers (see 4.1.6). Avoid using lubricant of any kind, including powder, when installing tubes and mounting tires.

4.1.1.6 Roll height sensors (if required) must be securely mounted to the vehicle.

4.1.1.7 It is preferable to remove the steering wheel and air bag in order to install the steering machine. The steering machine command module should be securely mounted for easy driver access, typically near the rear view mirror. The steering machine electronics box should be secured to the floor behind the passenger seat, or alternatively, in a position convenient to the driver while as close as possible to the vehicle CG.

4.1.2 Vehicle Preparation.

4.1.2.1 It is expected that the vehicle provided for Sine with Dwell testing be in excellent mechanical condition. For safety reasons, the vehicle should be thoroughly inspected and any chassis components should be replaced as necessary.

4.1.2.2 For FMVSS 126 compliance tests, the vehicle total interior load of 168 kg (370 lb) is comprised of the test driver, approximately 59 kg (130 lb) of test equipment (automated steering machine, data acquisition system and the power supply for the steering machine), and ballast as required by differences in the weight of test drivers and test equipment. Where required, ballast shall be placed on the floor behind the passenger front seat or if necessary in the front passenger footwell area.

This test can also be run to examine nonlinear handling performance at other load conditions.

4.1.2.3 All equipment and ballast inside the passenger compartment of the vehicle must be secured in place. All loose equipment should be removed from the passenger compartment, including tools, extra transducers, and personal belongings.

4.1.2.4 The vehicle suspension should be aligned to nominal specifications.

4.1.2.5 With the fuel tank full, the vehicle test weights should be determined and recorded.

4.1.2.6 Check engine oil and fill to capacity if necessary.

4.1.2.7 Check wheel lug nut torques, tire pressures, and state of tire wear at the start of each test and regularly during testing in order to identify any deviations from nominal.

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4.1.2.8 Before the start of testing, use a diagnostic scan tool to extract and clear any diagnostic codes from the ESC system.

4.1.2.9 The use of Electronic Stability Control in the default mode is the standard condition for the Sine with Dwell test. Testing with any alternative ESC modes or ESC disabled should be discussed and agreed upon between the requesting engineer and responsible test engineer.

4.1.3 Telltale Bulb Check. With the vehicle stationary and the ignition locking system in the **Lock** or **Off** position, activate the ignition locking system to the **On (Run)** position or, where applicable, the appropriate position for the lamp check. The ESC malfunction telltale must be activated as a check of lamp function, as specified in FMVSS 126 S5.3.4, and if equipped, the **ESC Off** telltale must also be activated as a check of lamp function, as specified in FMVSS 126 S5.5.6. The telltale bulb check is not required for a telltale shown in a common space as specified in FMVSS 126 S5.3.6 and S5.5.8.

4.1.4 ESC Off Control Check. For vehicles equipped with an **ESC Off** control, with the vehicle stationary and the ignition locking system in the **Lock** or **Off** position, activate the ignition locking system to the **On (Run)** position. Activate the **ESC Off** control and verify that the **ESC Off** telltale is illuminated, as specified in FMVSS 126 S5.5.4. Turn the ignition locking system to the **Lock** or **Off** position. Again, activate the ignition locking system to the **On (Run)** position and verify that the **ESC Off** telltale has extinguished indicating that the ESC system has been reactivated as specified in FMVSS 126 S5.4.1.

4.1.5 Brake Conditioning. Condition the vehicle brakes as follows:

4.1.5.1 Ten stops are performed from a speed of 56 km/h (35 mph), with an average deceleration of approximately 0.5 g.

4.1.5.2 Immediately following the series of 56 km/h (35 mph) stops, three additional stops are performed from 72 km/h (45 mph).

4.1.5.3 When executing the stops in 4.1.5.2, sufficient force is applied to the brake pedal to activate the vehicle's antilock brake system (ABS) for a majority of each braking event.

4.1.5.4 Following completion of the final stop in 4.1.5.2, the vehicle is driven at a speed of 72 km/h (45 mph) for five minutes to cool the brakes.

4.1.6 Tire Preparation.

4.1.6.1 Inner tubes (if applicable) must be installed prior to tire mounting. Do not use lubricant of any kind during tube installation or tire mounting to eliminate the possibility of tire lubricant contributing to tire debeading. Because no lubricant is used, care must be taken to confirm that the tire is fully seated on the wheel rim at the completion of the mounting procedure.

4.1.6.2 Tire pressures should be set to the requesting engineer's recommended cold pressure for each tire, unless otherwise stated on the test request.

4.1.6.3 A new set of tires is to be used for each Sine with Dwell Test series that documents FMVSS 126 compliance. The actual number of tire sets used is dependent on the number of configurations in the test request and the use of each tire set agreed upon by the requesting engineer and the responsible engineer.

4.1.7 Tire Conditioning. Condition the tires using the following procedure to wear away mold sheen and achieve operating temperature immediately before beginning Constantly Increasing Steer or Sine with Dwell test runs.

4.1.7.1 The test vehicle is driven around a circle 30 m (100 ft) in diameter at a speed that produces a lateral acceleration of approximately 0.5 g to 0.6 g for three (3) clockwise laps followed by three (3) counterclockwise laps.

4.1.7.2 Using a sinusoidal steering pattern at a frequency of 1 Hz, a peak steering wheel angle amplitude corresponding to a peak lateral acceleration of 0.5 g to 0.6 g, and a vehicle speed of 56 km/h (35 mph), the vehicle is driven through four (4) passes performing ten (10) cycles of sinusoidal steering during each pass.

4.1.7.3 The steering wheel angle amplitude of the final cycle of the final pass is twice that of the other cycles. The maximum time permitted between all laps and passes is five minutes

The steering machine can be programmed to execute the sinusoidal inputs.

There should be only a minimal delay between the completion of the tire break-in and the start of a test series to allow for the collection of a static data file, steering machine and data acquisition system adjustment, and final driver briefing.

4.1.8 Operator Precautions.

4.1.8.1 A helmet and seat belts must be worn during all testing. Lock all doors and close all windows prior to testing.

4.1.8.2 The test operator (driver) must inform any others at the test site of his/her presence using the appropriate site specific communications protocol.

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