



Constantly Increasing Steer 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 calculate the handwheel angle at which 0.3g of lateral acceleration occurs at the total vehicle center of gravity. This steering wheel angle is used to calculate the handwheel input for the Fishhook and Sine with Dwell Maneuvers.

1.2 Applicability. This test procedure applies to any two-axle vehicle with pneumatic rubber tires that will be tested as a part of the National Highway Traffic Safety Administration (NHTSA) New Car Assessment Program for vehicles less than 4545 kg (10 000 lb) gross vehicle weight.

1.3 Remarks. This test procedure is General Motors' implementation of the Slowly Increasing Steer test developed and conducted by the United States National Highway Traffic Safety Administration (NHTSA) as a part of the New Car Assessment Program (NCAP), and is based on the "Constant Speed, Variable Steer" test defined in SAE J266. This test procedure is a prerequisite of the Fishhook Maneuver Test (GMW15254) and also for the Sine with Dwell Test (GMW15534) required for UNECE GTR-8 (Global Electronic Stability Control (ESC) performance standard).

The Constantly Increasing Steer (CI) test consists of a continuous 13.5 degree/s steer input in one (1) turn direction, while the vehicle speed is held constant at 80 km/h (49.7 mph). The test is run three (3) times in both turn directions. The results are averaged and applied to a linear regression between 0.1g and 0.375g lateral acceleration to determine the steering wheel angle at 0.3g lateral acceleration.

Additional information regarding this test procedure can be found in the NHTSA documents listed in 2.3

2 References

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

2.1 External Standards/Specifications.

ASTM E1136 ASTM E1137-90 ISO 9001 SAE J266

2.2 GM Standards/Specifications.

GMW15254 (ID) GMW15534

(ID) = This standard is limited to internal distribution within General Motors and shall not be distributed outside this company. Contact the GM Lead Engineer for further instructions.

2.3 Additional References.

- PG075179 Fishhook Vehicle Prep.

2.3.1 Fishhook Tests. The supplier must work with the responsible GM engineer to comprehend these requirements.

- Docket No. NHTSA 2001-9663-0084: U.S. DOT/NHTSA – Fishhook NCAP Final Rule:
<https://documents.naeng.gm.com/gdm3/drl/objectId/090163bc81e2ed71/chronicleId/090163bc81e2ed71&versionLabel=CURRENT>

2.3.2 Sine with Dwell Tests. The supplier must work with the responsible GM engineer to comprehend these requirements.

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May 2014

Page 1 of 18

- UNECE Global Technical Regulation (GTR) No. 8 (Electronic Stability Control Systems):
<https://documents.naeng.gm.com/gdm3/drl/objectId/090163bc81e2e552/chronicleId/090163bc81e2e552&versionLabel=CURRENT>
- Docket No. NHTSA-2007-27662-0001: FMVSS 126: Electronic Stability Control Systems:
<https://documents.naeng.gm.com/gdm3/drl/objectId/090163bc81e2ed72/chronicleId/090163bc81e2ed72&versionLabel=CURRENT>

3 Resources

3.1 Facilities. The test facilities and test equipment shall be in good working order and shall have a valid calibration record.

The test is run on a smooth, flat, dry surface with a high friction coefficient. Unless otherwise specified, the road test surface should produce a Peak Friction Coefficient (PFC) of 0.9 or greater when measured using the ASTM E1136 standard reference test tire, in accordance with ASTM 1337-90 Method E, 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.

3.1.1 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.

3.2 Equipment. Each test vehicle is to be equipped with sensors, a data acquisition system, programmable steering machine, and appropriate safety equipment. Since the Constantly Increasing Steer test is performed in conjunction with the Fishhook test and Sine with Dwell test, the same instrumentation and equipment are to be used. However, not all equipment or channels of data are required for the Constantly Increasing Steer test. Equipment locations are presented in Appendix A, Figure A1.

3.2.1 Sensors and Sensor Locations. Appendix A, Figure A9 lists the sensors recommended by NHTSA's dynamic rollover resistance test procedure. A brief description of these sensors is provided in this section.

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 is typically measured with Global Positioning System (GPS)/inertial sensors (like Oxford Technologies RT3000 series). Alternatively, vehicle velocity can also be measured with an optical sensor placed at the center rear of the vehicle or radar based or sonar based sensors. 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 centroid of the vehicle in its test configuration. These data are required to translate the motion of the vehicle at the measured location to that which occurred at the actual centroid to remove roll, pitch, and yaw effects.

3.2.1.4 Roll Height Sensors. If height sensors are used to measure left and right side vertical displacements for the calculation of vehicle roll angle, one (1) ultrasonic or laser ranging module is mounted on each side of a vehicle and is positioned at the longitudinal center of gravity. With these data, roll angle is calculated during post processing using trigonometry.

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

- Speed
- Side Slip
- Roll Rate

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May 2014

Page 2 of 18



Documents

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

See 5.4 Data Collection for more information about the data acquisition method.

3.2.3 Steering Machine. A programmable steering machine is used to generate handwheel steering inputs for all test maneuvers. The machine must be capable of generating a handwheel rate of 13.5 degrees per second 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 shall be installed on all test vehicles during all 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. Information on the titanium outrigger system is documented in PG075179 Fishhook Vehicle Prep.

3.3 Test Vehicle/Test Piece. This test procedure applies to any two-axle vehicle with pneumatic rubber tires that will be tested as a part of the NHTSA New Car Assessment Program or any other vehicle that is under study for rollover resistance by General Motors.

3.4 Test Time.

Calendar time:	1 days
Test hours:	1 hour to 2 hours
Coordination hours:	1 hour to 2 hours

Note: Part of Fishhook Maneuver test series.

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.

4 Procedure

4.1 Preparation.

4.1.1 Installation.

4.1.1.1 Remove and store the front and rear bumper and fascia assemblies.

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.

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May 2014

Page 3 of 18

Documents
Document Sharing Hub

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 passenger seat to prevent it from being dislodged in the event of loss of vehicle control or vehicle tip up.

4.1.1.3 If an optical speed sensor is used, it should be mounted at the lateral center of the vehicle. If the sensor cannot be mounted at the precise lateral center of the outrigger beam, 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 (centroid or CG), with the location recorded on the Test Vehicle Description (TVD) Sheet. Refer to Appendix B for a sample TVD Sheet. The CG of a vehicle is typically located in the area between the front driver and passenger seats. Interior components such as the center console may need to be removed in order to mount the Multi-Axis Inertial Sensor in a suitable location.

4.1.1.5 Optional Inner tubes must be installed in all four (4) tires (see 4.1.3 Tire Preparation). Avoid using lubricant of any kind, including powder, when installing tubes and mounting tires.

4.1.1.6 Optional. The roll height sensors must be securely mounted on the left and right side of the vehicle at the longitudinal CG position.

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 rearview 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 Fishhook and Sine with Dwell testing be in excellent mechanical condition. For safety reasons, the vehicle should be rigorously inspected and any chassis components should be replaced as necessary.

4.1.2.2 All equipment and ballast inside the passenger compartment of the vehicle must be secured in place. Sine with Dwell tests are conducted at Driver plus Equipment loading. For Fishhook testing, water dummies must be secured with straps in addition to the seat belts. All loose equipment should be removed from the passenger compartment, including tools, extra transducers, and personal belongings.

4.1.2.3 Fishhook Test Only. All water dummies used for any part of the Fishhook Maneuver test series are 79.4 kg (175 lb). Testing may be performed at driver plus equipment (D+E, also referred to as the Nominal Load Configuration by NHTSA) or Multi Passenger Load Configuration (D+E plus up to three (3) water dummies in each of the designated rear seating positions, if any, or in the pickup bed, if any). If the vehicle is equipped with more than two (2) designated seating positions or has a pickup bed, then it must be tested at a Multi Passenger Load Configuration. Ballast the vehicle to the required weight and weight distribution. Use the D+E configuration for vehicles with only two (2) seats and without a cargo area such as a pickup box. Use the Multi Passenger Load Configuration for all other vehicles, ballasting each vehicle as described below.

4.1.2.4 Fishhook Test Only. For vehicles with three (3) or more designated rear seating positions, three (3) water dummies are positioned on the rear seats (second seating row) closest to driver and front passenger seats (first seating row). If there are only two (2) seating positions in the second seating row, the third water dummy shall be placed in the center of the third seating row, provided it is a designated seating position (see Appendix A, Figure A2). If there are only two (2) seating positions in the third seating row, the third water dummy shall be placed in the passenger side seating position of the third row opposite the driver's side.

4.1.2.5 Fishhook Test Only. For vehicles with two (2) designated rear seating positions, two (2) water dummies shall be positioned in the rear seats. (See Appendix A, Figure A3.)

4.1.2.6 Fishhook Test Only. For pickup trucks with only front designated seating positions, three water dummies shall be positioned behind the cab in a manner that emulates a second seating row. If it is not possible to fit three water dummies directly behind the cab, the third water dummy shall be placed in the center of a simulated third seating row. (See Appendix, A Figure A4.)

4.1.2.7 Fishhook Test Only. For pickup trucks with two (2) seating rows, three (3) water dummies will be used. If the second seating row includes three (3) designated seating positions, each water dummy shall be placed in these positions. If the second seating row includes two (2) designated seating positions, two (2) water dummies

GM Confidential

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May 2014

Page 4 of 18

shall be positioned in the second seating row of the cab, and the third water dummy shall be positioned behind the cab in a manner that emulates the center seating position of a third seating row. (See Appendix A, Figure A5.)

4.1.2.8 Fishhook Test Only. For all vehicles, if the Multi Passenger Configuration results in the vehicle exceeding its Gross Vehicle Weight Rating (GVWR) and/or Rear Gross Axle Weight Rating (GAWR), the weight of each dummy will be equally reduced until the GVWR and Rear GAWR are no longer exceeded. In the same manner, the Front GAWR shall not be exceeded by more than 22.7 kg (50 lb).

If it is not possible to reduce weight sufficiently by removing water from the dummies, the responsible test engineer may elect to remove the hood, fenders, headlights, and any expendable fluids from the front engine compartment, as necessary.

4.1.2.9 Fishhook Test Only. For non-pickup truck vehicles with only front designated seating positions, the Nominal Load Configuration (D+E) is used.

4.1.2.10 Fishhook Test Only. If there are any questions as to the proper loading configuration for the Multi Passenger Configuration, contact the responsible test engineer for clarification.

4.1.2.11 The vehicle suspension should be aligned to nominal specifications.

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

4.1.2.13 Check engine oil and fill to capacity if necessary.

4.1.2.14 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.

4.1.2.15 Electronic stability control (ESC) should be enabled as the default condition. The requesting engineer may wish to study the effects of ESC OFF. If so, notify the responsible test engineer if ESC should first be disabled, or if ESC cannot be disabled.

4.1.3 Tire Preparation.

4.1.3.1 Though not required for the Constantly Increasing Steer test, inner tubes could be installed to prevent debanding associated with loss of air pressure. Do not use lubricant of any kind, including dry powder, during tube installation or tire mounting.

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

4.1.3.3 The Constantly Increasing Steer test should start with a new set of tires. As a result of either the maximum lateral acceleration achieved in the extended version of the test or the Maximum Lateral Acceleration test that may follow the Constantly Increasing Steer test, a tire change before initiation of Fishhook Maneuver testing is required, as tire wear associated with these tests may potentially confound Fishhook Maneuver test outcome.

4.1.3.4 Prior to each test, new tires must be "scrubbed in" to wear away mold sheen and be brought up to operating temperature. Test vehicles are to be driven around a circle 30.5 m (100 ft) in diameter at a speed that produces a lateral acceleration of approximately 0.5g to 0.6g. Run three (3) clockwise laps followed by three (3) counterclockwise laps. Once the six (6) laps are complete, the driver inputs sinusoidal steering at a frequency of 1 Hz and steering wheel amplitude corresponding to 0.5g to 0.6g for ten (10) cycles while maintaining a vehicle speed of 56 km/h. A total of four (4) passes using this sinusoidal steering input are used. The steering wheel magnitude of the final cycle of the final pass is twice that of the amplitude required for 0.5g to 0.6g lateral acceleration. These four (4) sinusoid passes typically require an area similar in size to that required by the Constantly Increasing Steer test or Fishhook Maneuver test. 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.

4.1.4 Operator Precautions.

4.1.4.1 Helmet and seat belts must be worn during test. Lock all doors and close all windows prior to testing.

4.1.4.2 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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May 2014

Page 5 of 18



Documents

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4.2 Conditions.

4.2.1 Environmental Conditions. The test is run on dry, clean asphalt surfaces that are clear from debris. Wet surfaces may be specified only in special cases. Wind speed should be less than 35 km/h (22 mph).

Ambient air temperature should be above 0 °C (32 °F).

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 The test is generally conducted with automatic transmissions in **Drive**. Manual transmissions are run in the highest gear capable of sustaining the desired test speed. The clutch is not disengaged during any test maneuver. The vehicle's cruise control may be used to help maintain the vehicle test speed of 80 km/h (49.7 mph).

4.3.2 For each test vehicle, testing will likely be performed according to the following general plan, combining the Constantly Increasing Steer and Fishhook Maneuver tests or Constantly Increasing Steer and Sine with Dwell tests:

4.3.2.1 Installation of new tires.

4.3.2.2 Establishing reference heights.

4.3.2.3 Tire break-in.

4.3.2.4 Constantly Increasing Steer test series at the Multi Passenger Load Configuration.

4.3.2.5 Fishhook Maneuver test series at the same load configuration with additional tire changes and tire break-ins as indicated in the maneuver protocol.

4.3.3 Input or install the appropriate steering command information for the steering machine.

4.3.4 Turn on the instrumentation and data acquisition packages. Allow five (5) minutes for equipment to warm up.

4.3.5 Position the vehicle at the test site such that there will be ample room to the left and right of the vehicle when at speed to accommodate for the left and right steer inputs.

4.3.6 Select the steering input program and turn direction on the steering machine.

4.3.7 Accelerate the vehicle to 80 km/h (49.71 mph) and then maintain 80 km/h (49.71 mph).

4.3.8 Trigger the data acquisition system and depress and start the steering machine.

4.3.9 After reaching a lateral acceleration (not roll corrected) of 0.55g, hold the steering wheel angle constant for 4 s. (See Appendix A, Figure A6.) The test run then concludes.

Alternatively, the test run may conclude after 270 degrees of steering is achieved. (See Appendix A, Figure A7.)

4.3.10 At the end of each run, review the data to ensure the average test speed was between 78 km/h (48.47 mph) and 82 km/h (50.95 mph).

4.3.11 Repeat 4.3.4 thru 4.3.10 for a total of three (3) runs in the same turn direction, followed by a total of three (3) runs in the opposite turn direction.

5 Data

5.1 Calculations.

5.1.1 Steering Wheel Angle at 0.3g. When lateral acceleration is plotted with respect to time, a first order polynomial best fit line accurately describes the data from 0.1g to 0.375g. NHTSA defines this as the linear range of the lateral acceleration response. A simple linear regression is used to determine the best fit line. (See Appendix A, Figure A8.)

Using the slope of the best fit line, the average steering wheel position at 0.3g is calculated using data from the Constantly Increasing Steer test. This average steering wheel position is used to calculate Fishhook Maneuver steering inputs.

5.2 Interpretation of Results. Not applicable.

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May 2014

Page 6 of 18

Documents
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