On-Center Handling

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.

Note: This standard uses terminology related to the directional control of vehicles as defined by SAE J670.

1.1 Purpose. The purpose of this test procedure is to measure the steering feel properties of a vehicle during low lateral acceleration maneuvers appropriate for straight highway driving.

1.2 Applicability. This test procedure applies to any two (2) axle pneumatic rubber tired vehicle at any load condition.

1.3 Remarks. Steering feel properties are derived from steering wheel torque and steering sensitivity measurements during low lateral acceleration highway driving maneuvers. They include steering sensitivity, steering torque non-linearity, hysteresis, friction and work gain sensitivity.

This test procedure is very similar to ISO 13674-1.

2 References

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

2.1 External Standards/Specifications.

ISO 9001	ISO 13674-1	ISO 15037-1	SAE J670

2.2 GM Standards/Specifications.

GMW14798	GMW14799

2.3 Additional References.

- RT3000; Oxford Technical Solutions, Oxfordshire, United Kingdom (http://www.oxts.com/products/rt3000-family/)
- Vehicle Handling Test Resource Information Management System (VHTRIMS) (ID) https://vhtrims.gm.com/vhtrimswebquery/index.asp

(ID) = This website is limited to internal access within General Motors and shall not be accessed outside the company. Contact the GM Lead Engineer for further instructions.

3 Resources

3.1 Facilities. This procedure requires a minimum two (2) lane straight roadway that is at least 1600 m (1 mi) long with an adequate berm or run off for safety. Three (3) lanes are preferred.

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.

3.2.1 Steering Wheel Angle Transducer.

3.2.2 Steering Wheel Torque Transducer.

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3.2.3 Vehicle Speed Sensor. Vehicle velocity and side slip is typically measured with Global Positioning Satellite (GPS)/inertial sensors (e.g., Oxford Technologies RT3000 series (http://www.oxts.com/products/rt3000-family/)). Vehicle velocity and sideslip can also be measured with radar based sensors, sonar based sensors or optical sensors placed at the front center or rear center of the vehicle. Sensor outputs are transmitted simultaneously to the data acquisition system and the instrument panel mounted display. The instrument panel mounted display allows the driver to accurately monitor vehicle speed.

3.2.4 Multi Axis Inertial Sensor. A multi axis inertial sensing system is used to measure lateral and fore/aft acceleration and yaw rates (e.g., Oxford Technologies RT3000 series). The position of the multi axis inertial sensing system must be accurately measured relative to the total vehicle Center of Gravity (CG) or centroid of the vehicle in its test configuration. These data points 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. Alternatively, a motion box package may be used to measure lateral and fore/aft acceleration and yaw rate.

3.2.5 Roll Height Sensors. Height sensors are used to measure left and right side vertical displacements for the calculation of vehicle roll angle by using one (1) ultrasonic or laser ranging module mounted on each side of a vehicle. With these data points, roll angle is calculated during post processing through the use of trigonometry.

3.2.6 Data Acquisition System (DAS). See 3.5 and 4.1.1 for more information about the data acquisition method.

3.3 Test Vehicle/Test Piece. Any vehicle with two (2) axles and pneumatic rubber tires at any load condition.

3.4 Test Time.

Calendar time:	1 day to 2 days
Test hours:	1 hour to 4 hours
Coordination hours:	1 hour to 4 hours

3.5 Test Required Information.

3.5.1 DAS Channels and Full Scale Values. See Table 1.

Table 1: DAS Channels and Full Scale Values

Channel	Value
Steering Wheel Angle	1440 degrees
Steering Wheel Torque	40 Nm
Vehicle Speed	150 km/h (93.2 mph)
Vehicle Sideslip	10 degrees
Lateral Acceleration	10 m/s^2
Yaw Velocity (Rate)	10 degrees/s
Roll Angle	10 degrees

Note: If using an Oxford Technical Solutions RT3000 to measure vehicle side slip, it should be noted that a single antenna setup cannot generate accurate sideslip measurements at vehicle speeds less than 40 km/h (24.85 mph). For best accuracy and reliable results, a dual antenna setup should be used with the RT3000.

3.5.2 Additional Channels. May be used as required.

3.5.3 Sample Rate. All data is to be sampled at 100 Hz. Typical antialiasing filter frequency is 25 Hz.

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

Note: This standard follows the general conditions that apply when vehicle dynamics properties are determined, as specified in ISO 15037-1.

4.1 Preparation.

4.1.1 Installation

4.1.1.1 The DAS must be restrained inside the vehicle. The front passenger seat is a typical and acceptable location.

4.1.1.2 The multi axis inertial sensor must be installed and securely mounted at or near the total vehicle CG, or centroid, with the location recorded on the Test Vehicle Description (TVD) sheet (or similar). Refer to Appendix A, Figure A1 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 (e.g., center console) may need to be removed in order to mount the multi axis inertial sensor in a suitable location.

4.1.1.3 The roll height sensors must be securely mounted on the left and right side of the vehicle. Typically, the sensors are installed at the end of a bar that can be strapped securely to the front of the vehicle. The fore/aft location of the sensors and the lateral distance between the sensor heads should be recorded in the TVD sheet.

4.1.1.4 If an optical speed sensor is used, it should be mounted at the front or rear of the vehicle and centered laterally. If the sensor cannot be mounted at the precise lateral center of the vehicle, the magnitude and direction of offset from center should be documented and reported to the appropriate test engineer.

4.1.1.5 If a motion box package is used, it should be installed in a level position as close to the centroid as is practical. The front passenger seat foot well is a typical and acceptable location. The for/aft location of the motion package should be recorded on the TVD sheet.

4.1.1.6 All ballast inside the passenger compartment of the vehicle must be secured in place. 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 Vehicle Preparation.

4.1.2.1 The test vehicle should be inspected to ensure that the proper tires and suspension components are installed, and that all chassis components are in good mechanical condition.

4.1.2.2 The vehicle suspension should be aligned to nominal specifications.

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

4.1.2.4 Vehicles equipped with a “tilt wheel” steering column should be adjusted such that the steering wheel is in the center of the tilt range.

4.1.3 Tire Preparation.

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

4.1.3.2 Note the condition of the tires. New tires should be broken in by driving 10 km (6.21 mi) at 100 km/h (62.1 mph), including moderate cornering and several heavy brake stops (without inducing skidding). Obviously worn tires should be noted and the appropriate wear state checked on the TVD worksheet.

4.1.4 Operator Precautions.

4.1.4.1 Seat belts must be worn during testing. 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 their presence using the appropriate site specific communications protocol.

4.2 Conditions.

4.2.1 Environmental Conditions.

4.2.1.1 There should be no standing water or ice patches on the roadway; however, a damp roadway is acceptable.

4.2.1.2 The ambient air temperature should be above 0 °C (32 °F) and below 40 °C (104 °F).

4.2.1.3 The wind speed component perpendicular to the direction of travel should be no more than 15 km/h (9.32 mph). While the data processing software automatically compensates for wind gust effects, steady side winds will influence the symmetry results.

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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.

4.2.2.1 The standard test speed is 100 km/h, and should not vary by more than ± 2 km/h. If other test speeds are requested, it is recommended to perform these tests in 20 km/h increments, and also should not vary by more than ± 2 km/h.

4.2.2.2 This test requires that a steering ratio test be performed, per GMW14798.

4.3 Instructions.

4.3.1 Turn on all instrumentation and data acquisition equipment and allow at least 5 minutes to warm up.

4.3.2 Establish the straight ahead setting on the steering wheel by driving in a straight direction at 100 km/h (62 mph). Mark the 12 o'clock position on the steering wheel with a piece of tape. If the steering wheel transducer is equipped with a protractor to reference steering wheel zero and steering amplitudes, line up the steering wheel protractor zero degree mark with the pointer when the steering wheel is directing the vehicle in a straight ahead direction.

4.3.3 With the vehicle at rest, the steering wheel in the straight ahead position, and hands off the wheel, record the balance and calibration data. If the steering wheel transducer is equipped with a digital readout, zero the steering wheel angle and torque outputs.

4.3.4 Drive at 100 km/h, or the selected test speed, (set cruise control if available) and perform a sinusoidal steer input at a frequency of 0.2 Hz (one (1) cycle every 4.5 s to 5.5 s) and at a steering wheel angle such that the peak lateral acceleration is 0.2 *g*. Maintain test speed during entire test segment.

4.3.5 Check that the amplitude for lateral acceleration is 0.2 *g*, regardless of test speed. In the data verification program, there are target lines at the top and bottom of the lateral acceleration plot at 0.18 *g* and 0.22 *g*. The peak lateral acceleration should be between these two (2) lines. Figure 1 shows an example of the lateral acceleration for a satisfactory steer input.

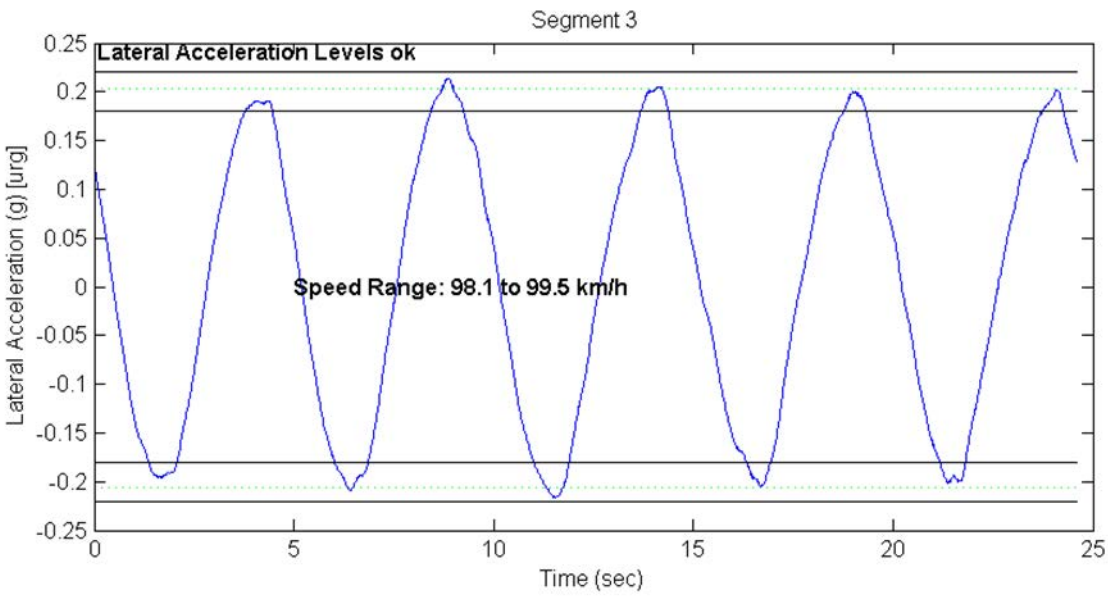

Figure 1: Sample Steer Input – Lateral Acceleration (*g*)

4.3.6 Check that the steer input is smooth and sinusoidal, not a square wave or saw tooth wave. In the data verification tool, there is a blue trace in the steering wheel angle plot at a frequency of 0.2 Hz. The steering wheel angle should match this blue trace. Figure 2 shows an example of the steer input for a satisfactory steer input.

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