



Routine Transient Handling 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 procedure is used to characterize transient handling of passenger cars and light trucks in the routine customer usage range that correlates to subjective evaluation. The results from this test and select other procedures can be used to determine what vehicle content is necessary to provide the appropriate level of linear range transient handling performance.

1.2 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.

1.3 Remarks. This test procedure employs the Transient Handling Test Maneuver which consists of a 1.2 Hz, 1.5 Hz, and 1.8 Hz sine wave steering input with a 2 s pause at the peak of the second half cycle. See Appendix A, Figure A1 for an example of the steering maneuver.

This maneuver, when executed at a constant speed of 100 km/h (62.14 mph) using peak steering wheel amplitudes in the neighborhood of 10 degrees to 40 degrees, can provide characterization of both transient and steady state handling properties.

Prior to running the Transient Handling Test, a Constantly Increasing Steer test (GMW15255) at 100 km/h (62.14 mph) must be run to determine the steering wheel angle (SWA) input for the Transient Handling Test.

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

2.2 GM Standards/Specifications.

GMW15255

2.3 Additional References. None.

3 Resources

3.1 Facilities. 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.

3.1.1 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.

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3.2 Equipment. Each test vehicle is to be equipped with sensors, a data acquisition system (DAS), and a programmable steering machine.

3.2.1 Steering Angle Encoder. Hand wheel position is measured via an angle encoder integral with the programmable steering machine.

3.2.2 Vehicle Speed Sensor. Vehicle velocity and side slip is typically measured with dual-antenna Global Positioning Satellite (GPS)/Inertial sensors (e.g., Oxford Technologies RT3000 series). Alternatively, vehicle velocity and sideslip can also be measured with an optical sensor placed at the front-center or rear-center of the vehicle, or radar based sensors, or sonar based sensors. Sensor outputs are transmitted simultaneously to the DAS and the instrument panel mounted display. The instrument panel mounted display allow the driver to accurately monitor vehicle speed.

3.2.3 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 (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 the Driver plus Equipment test condition. 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.

3.2.4 Roll Angle Sensor. This channel is not required if the acquired lateral acceleration data is already roll compensated. 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 using trigonometry.

3.2.5 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
- Steering Wheel Angle
- Steering Wheel Torque (Optional)
- Roll Angle or Left Trim (roll height)
- Right Trim/roll Height (Optional)

Note: See 3.5 and 4.1.1 for more information about the data acquisition method.

3.2.6 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 lbf-ft to 44.3 lbf-ft). The steering machine must be able to apply these torques when operating with steering wheel velocities up to 400 degrees/s and be able to move each vehicle's steering system through its full range. The steering machine should initiate steering programs when commanded by the driver, and have the convenience of changing the steering program during test sessions.

3.3 Test Vehicle/Test Piece. This test procedure applies to any two-axle vehicle with pneumatic rubber tires that is under study for routine transient handling characteristics by General Motors.

3.4 Test Time.

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

3.5 Test Required Information.

3.5.1 DAS Channels with Typical Operating Range and Maximum Allowable Error. See Table 1.

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Table 1: DAS Channels with Typical Operating Range and Maximum Allowable Error

Channel	Typical Operating Range	Recommended Maximum Error For Combined Transducer/Recorder System
Vehicle Speed	0 m/s to 40 m/s	± 0.5 m/s
Vehicle Side Slip ^{Note}	± 5 degrees	± 0.05 degrees
Yaw Velocity	± 20 /s	± 0.1 /s
Steering Wheel Angle	± 180 degrees	± 0.1 degree
Steering Wheel Torque	± 10 Nm (7.38 lbf-ft)	± 0.1 Nm (0.074 lbf-ft)
Lateral Acceleration	± 10 m/s ²	± 0.1 m/s ²
Roll Angle	± 5 degrees	± 0.1 degree

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. 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 a two-pole, low-pass Butterworth filter with a 25 Hz cut-off frequency.

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 The DAS must be well-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 vehicle CG, with the location recorded on the Test Vehicle Description (TVD) sheet (or similar). Refer to Appendix B, Data Sheets B1 and B2 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.

4.1.1.3 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.

4.1.1.4 If roll height sensors are used, they 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.

4.1.1.5 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.

4.1.2 Vehicle Preparation.

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4.1.2.1 It is expected that the vehicle provided for Transient Handling 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 Transient Handling 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, DAS 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 foot well area.

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 Vehicles equipped with a "tilt-wheel" steering column should be adjusted such that the position of the column is as straight as possible.

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 with several moderate lateral acceleration events (0.4g) and several hard braking events (without locking the wheels). The tires used for each Transient Handling Test should have less than 15% tread wear.

4.1.4 Operator Precautions.

4.1.4.1 Seat belts must be worn during all 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. The test is to be run on dry, clean asphalt surfaces that are clear of debris. Wet surfaces may be specified only in special cases. Wind speed should be less than 16 km/h (10 mph). If wind exceeds 5 km/h (3 mph), ideally the test should be run such that it is a tail wind. Ambient air temperature should be above 7 °C (45 °F) and below 40 °C (104 °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 Turn on the instrumentation and data acquisition packages. Allow several minutes for equipment to warm up.

4.3.2. The data acquisition Constantly Increasing (CI) steer Test Control Screen is shown in Appendix A, Figure A2. Determine the steering wheel angle at 0.35g (to the nearest 0.1 degree) by conducting the CI test at 100 km/h (62.14 mph).

4.3.3 Select the appropriate steering machine steering program input parameters based on the results of the aforementioned CI test and the starting steer frequency of 1.2 Hz. The data acquisition Transient Handling Test Control Screen is shown in Appendix A, Figure A3.

4.3.4 Establish straight ahead settings on the steering wheel unit by driving in a straight ahead direction and pushing the appropriate button on the steering unit. It may be necessary to balance some of the sensors while recording data at rest.

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 program, direction and speed on the steering wheel command module. Run all Left to Right maneuvers first, followed by all Right to Left maneuvers.

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4.3.7 Accelerate the vehicle to the applicable test speed, maintaining a straight path.

4.3.8 Once the vehicle is heading straight and the vehicle speed has stabilized, initiate the steer maneuver by depressing the appropriate trigger on the steering machine. Ensure there is 1 s of straight ahead steering before the steer controller starts its sequence.

4.3.9 Maintain a constant vehicle speed throughout the maneuver. Acceptable deviation from the planned test speed is ± 1 km/h (± 0.62 mph).

4.3.10 At the end of each run, review the entry speed, yaw rate, and all other data channels to ensure data integrity.

4.3.11 Repeat steps 4.3.5 thru 4.3.10 until six (6) acceptable runs in each turn direction have been recorded.

4.3.12 Change the steering frequency to 1.5 Hz and repeat steps 4.3.5 thru 4.3.10 until six (6) acceptable runs in each turn direction have been recorded.

4.3.13 Change the steering frequency to 1.8 Hz and repeat steps 4.3.5 thru 4.3.10 until six (6) acceptable runs in each turn direction have been recorded.

5 Data

5.1 Calculations. An example of the test data is shown in Appendix C, Figure C1. The test data is processed using global Vehicle Handling Test Resource Information Management System (VHTRIMS) data processing for Transient Handling.

5.2 Interpretation of Results. An example of test results processed by VHTRIMS are shown in Appendix D, Figures D1 and D2.

5.3 Test Documentation.

5.3.1. The data stored on the data acquisition computer should be uploaded to the appropriate storage location for processing, using documented procedures and the dataset names specified on the test request sheet.

5.3.2 All required information should be recorded on the TVD worksheet (or similar). For a sample TVD sheet, refer to Appendix B, Data Sheets B1 and B2.

5.3.3 Inform the assigned engineer when the dataset is loaded. Be prepared to provide a full vehicle description at this time.

This description should include the following:

- Vehicle description and fleet number or Vehicle Identification Number (VIN)
- Vehicle option content
- Wheelbase and track
- Steering wheel diameter
- Location (x, y, z) of the inertial transducers
- Tire brand, size and pressures
- Channel assignments and scaling if different from standard
- First and last calibration segment numbers
- Total number of segments
- Test loads
- Test date, time and operator
- Dataset name

Note: All data gathered, via the sample TVD worksheets or similar methodology, will be subsequently uploaded to the VHTRIMS database.

5.3.4 The responsible test engineer should be notified when the data set is archived and ready for processing.

6 Safety

This standard may involve hazardous materials, operations, and equipment. This standard does not propose to address all the safety problems associated with its use. It is the responsibility of the user of this standard to

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