



Electronic Stability Control (ESC) System High Speed Testing

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 evaluate the Electronic Stability Control (ESC) System performance during high speed maneuvers.

1.2 Applicability. This standard is applicable for vehicles with antilock brake system/electronic stability control (ABS/ESC) hydraulic based brake assist systems.

1.3 Remarks. None.

2 References

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

2.1 External Standards/Specifications.

None

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 Laboratory for test vehicle build and instrumentation installation.

3.1.4 Vehicle Dynamics Test Area (VDTA) that must be of sufficient size to accommodate test maneuvers without vehicle leaving surface.

3.1.5 Various High Banked Test Tracks.

3.1.6 Vehicles weigh station capable of measuring vehicle weight at each corner.

3.2 Equipment.

3.2.1 Brake pressure sensors located at each corner and at master cylinder.

3.2.2 Vehicle steering wheel angle sensor.

3.2.3 Vehicle velocity sensor, Vx and Vy.

- Vx $\pm$ 200 km/h (124 mph) with 0.1 km/h (0.06 mph) resolution.
- Vy $\pm$ 50 km/h (31 mph) with 0.01 km/h (0.006 mph) resolution.

3.2.4 Vehicle side slip angle sensor.

3.2.5 Yaw rate sensor at vehicle's center of gravity $\pm$ 75 degrees/s.

GM Confidential

© Copyright 2017 General Motors Company All Rights Reserved

August 2017

Page 1 of 13



Documents

Document Sharing Hub

3.2.6 Lateral accelerometer at vehicle's center of gravity $\pm 1.25G$.

3.2.7 Longitudinal accelerometer at vehicle's center of gravity $\pm 1.25G$.

3.2.8 Wheel speed sensors at each corner.

3.2.9 Brake pedal force.

3.2.10 Brake pad temperatures at each corner 66 °C to 93 °C (150 °C to 200 °F).

3.3 Test Vehicle/Test Piece. See Section 4.

3.4 Test Time.

Calendar time: 2 days

Test time: 8 hours

Coordination time: 6 hours

3.5 Test Required Information. See Section 4.

3.6 Personnel/Skills. Experienced vehicle dynamics test technician for vehicle instrumentation. Vehicle dynamics test driver certified for handling tests.

4 Procedure

4.1 Preparation.

4.1.1 Instrumentation Installation. All instrumentation must be securely fastened to the vehicle due to the nature of test maneuver. Instrumentation should be located on the passenger or rear seats to avoid excessive ballast in the rear of the vehicle.

4.1.2 Vehicle Preparation. Ballast vehicle to curb weight before installation of instrumentation. After installation, the vehicle must be within suspension alignment specifications (toe) with a full tank of gas. Tire pressures should be set to 5 psi greater than placard value; tire tubes are recommended, especially on high center of gravity vehicles. Tires should be broken in but must not have excessive wear. Brake pads shall be burnished prior to test. Roll cages for low center of gravity vehicles (cars) shall be used, and outriggers shall be added for high center of gravity vehicles (trucks and crossovers). For speeds of greater than 161 km/h (100 mph) or greater, see Appendix A, Table A1.

4.1.3 Tires. Multiple sets of tires should be available for test.

4.1.4 Operators Precautions. All instrumentation must be securely fastened due to the nature of vehicle dynamics testing. The vehicle operator must use the vehicle restraint system at all times. The vehicle's air bag should be disarmed due to the steering wheel angel sensor installation. Vehicle testing must be done in the middle of a test surface to avoid leaving the boundaries of the test surface.

4.1.5 Warning Indicators. ESC and Antilock Brake System (ABS) warning indicators must be clearly visible and in working condition.

4.1.6 ESC Supplier Participation. It is highly recommended for chassis controls performance engineer to coordinate ESC supplier participation. Performance engineer may elect to use this procedure as a tool to guide ESC high speed calibration. Upon completion of calibration development, performance engineer shall formally conduct test procedure. Due to supplier's involvement, it is highly recommended that the test vehicle be equipped with supplier's instrumentation to assist in issue resolutions if applicable.

4.2 Conditions.

4.2.1 Environmental Conditions. Wind speed should be less than 32 km/h (20 mph), it should not be raining.

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.

4.2.3 The test should be performed in the designated areas of a Vehicle Dynamics Test Area, and a Banked Test Track. Test track should be dry with surface friction coefficient between 0.8 and 1.0, unless otherwise directed by requestor.

4.3 Instructions.

4.3.1 Zero the Instrumentation. Drive vehicle straight ahead. The longitudinal/lateral accelerometer should be at $0G \pm 0.02G$ respectively with vehicle traveling straight ahead with no vehicle acceleration or deceleration. The

GM Confidential

© Copyright 2017 General Motors Company All Rights Reserved

August 2017

Page 2 of 13

steering wheel angel sensor should be 0 degrees $\pm$ 1.0 degrees with vehicle traveling straight ahead. Yaw rate sensor should be at 0 degrees $\pm$ 0.5 degrees/s. The velocity sensor V_y speed shall be 0 km/h $\pm$ 0.1 km/h (0 mph $\pm$ 0.06 mph). Brake pressure sensors should be at 0 psi $\pm$ 10 psi with no brake pedal input.

4.3.2 Subjective Evaluations The following listed maneuvers will be subjectively evaluated by the designated chassis controls performance engineer to assess the performance level of the ESC system. The foundation turn maneuver is defined as taking the vehicle to the maximum, between 90% and 100%, lateral acceleration by using a steering input less than 45 degrees/s. The driver will then allow the vehicle to stabilize for 3 s before changing the brake pedal and/or accelerator pedal positions. The maneuvers will be performed with traction control and ESC enabled. Both left and right hand turns must be performed. Evaluator(s) will subjectively evaluate the handling performance of the vehicle and will record vehicle dynamic data including vehicle sideslip angle in order to resolve any vehicle performance issues. Evaluators will utilize the data sheets in Appendix B, Data Sheet B1, to record the maneuvers and the subjective ratings. Brake pedal inputs will be made after reaching maximum lateral acceleration.

4.3.2.1 Foundation Turns.

4.3.2.1.1 Perform Foundation Turn - No Brake Pedal Apply at 100, N - 80, N - 60, N - 40, N - 20, and N km/h (mph), where N = top vehicle speed achievable on VDTA.

4.3.2.1.2 Perform Foundation Turn - Light Brake Pedal Apply < 500 psi caliper pressure, sufficient to slightly upset the vehicle balance at 100, N - 80, N - 60, N - 40, N - 20, and N km/h (mph), where N = top vehicle speed achievable on VDTA.

4.3.2.1.3 Perform Foundation Turn - Heavy Brake Pedal Apply Inducing ABS at vehicle top speed (N) or 100, N - 80, N - 60, N - 40, N - 20, and N km/h (mph), where N = top vehicle speed achievable on VDTA.

4.3.2.1.4 Perform Foundation Turn Spike Brake Pedal Apply and Release to light brake pedal at vehicle top speed (N) or 100, N - 80, N - 60, N - 40, N - 20 km/h (mph), where N = top vehicle speed achievable on VDTA.

4.3.2.1.5 Perform Foundation Turn Drop Throttle at 100, N - 80, N - 60, N - 40, N - 20, and N km/h (mph), where N = top vehicle speed achievable on VDTA, for manual transmission place in gear 1000 rpm to 2000 rpm below red line.

4.3.2.1.6 Perform Foundation Turn Increase Throttle at a sufficient rate to slightly upset the vehicle balance at 100, N - 80, N - 60, N - 40, N - 20, and N km/h (mph), where N = top vehicle speed achievable on VDTA.

4.3.2.2 High Speed Evasive Single Lane Changes. ESC activation during single changes will be performed on both wet and dry asphalt (for wet asphalt delete N - 20 and N). ESC performance shall be evaluated using the following four (4) driving techniques:

- Aggressive turn in/aggressive turn back,
- Aggressive turn in/at the limit turn back,
- At the limit turn in/aggressive turn back, and
- At the limit turn in/at the limit turn back.

Aggressive turn in is defined as performing a steering wheel input typically exceeding 90 degrees/s with the intent of quickly maneuvering the vehicle into to the next lane. Aggressive turn back is defined as performing a steering wheel input typically exceeding 120 degrees/s with the intent of quickly straightening the vehicle into the next lane. At the limit turn in is defined as performing a steering wheel input which typically exceeds 45 degrees/s but does not exceed 90 degrees/s with the intent of maneuvering the vehicle into the next lane at the vehicle dynamics handling limit of the vehicle. At the limit turn back is defined as performing a steering wheel input which typically exceeds 45 degrees/s but does not exceed 90 degrees/s with the intent of straightening the vehicle into the next lane at the vehicle dynamics handling limit of the vehicle. Steering wheel angles and rates will have to be adjusted as vehicle speed is increased. The purpose of using the four (4) driving techniques is to evaluate ESC performance during aggressive maneuvers where the vehicle dynamics handling limit is exceeded and to also evaluate ESC performance at the vehicle dynamics handling limit of the vehicle to assess ESC activation threshold performance. The maneuvers will be performed with traction control and ESC enabled. Both left and right hand lane changes must be made.

4.3.2.2.1 Perform High Speed Evasive Single Lane Change No Brake Pedal Apply at 100, N - 80, N - 60, N - 40, N - 20, and N km/h (mph), where N = top vehicle speed achievable on VDTA.

GM Confidential

© Copyright 2017 General Motors Company All Rights Reserved

August 2017

Page 3 of 13



Documents

Document Sharing Hub

4.3.2.2.2 Perform High Speed Evasive Single Lane Change - Light Brake Pedal Apply (< 500 psi) at 100, N - 80, N - 60, N - 40, N - 20, and N km/h (mph), where N = top vehicle speed achievable on VDTA.

4.3.2.2.3 Perform High Speed Evasive Single Lane Change - Heavy Brake Apply inducing ABS at 100, N - 80, N - 60, N - 40, N - 20, and N km/h (mph), where N = top vehicle speed achievable on VDTA.

4.3.2.3 High Speed Evasive Double Lane Changes. ESC activation during double lane changes will be performed on both wet and dry asphalt. ESC performance shall be evaluated using the following four (4) driving techniques:

- Aggressive turn in/aggressive turn back,
- Aggressive turn in/at the limit turn back,
- At the limit turn in/aggressive turn back, and
- At the limit turn in/at the limit turn back.

Aggressive turn in is defined as performing a steering wheel input typically exceeding 90 degrees/s with the intent of quickly maneuvering the vehicle into to the next lane. Aggressive turn back is defined as performing a steering wheel input typically exceeding 120 degrees/s with the intent of quickly maneuvering the vehicle back into the original lane. At the limit turn in is defined as performing a steering wheel input which typically exceeds 45 degrees/s but does not exceed 90 degrees/s with the intent of maneuvering the vehicle into the next lane at the vehicle dynamics handling limit of the vehicle. At the limit turn back is defined as performing a steering wheel input which typically exceeds 45 degrees/s but does not exceed 90 degrees/s with the intent of maneuvering the vehicle back into the original lane at the vehicle dynamics handling limit of the vehicle. Steering wheel angles and rates will have to be adjusted as vehicle speed is increased. The purpose of using the four (4) driving techniques is to evaluate ESC performance during aggressive maneuvers where the vehicle dynamics handling limit is exceeded and to also evaluate ESC performance at the vehicle dynamics handling limit of the vehicle to assess ESC activation threshold performance. The maneuvers will be performed with traction control and ESC enabled. Both left and right hand lane changes must be made.

4.3.2.3.1 Perform High Speed Evasive Double Lane Change No Brake Pedal Apply at 100, N - 80, N - 60, N - 40, N - 20 km/h (mph), where N = top vehicle speed achievable on VDTA.

4.3.2.3.2 Perform High Speed Evasive Double Lane Change Light Brake Pedal Apply (< 500 psi) at 100, N - 80, N - 60, N - 40, N - 20 km/h (mph), where N = top vehicle speed achievable on VDTA.

4.3.2.3.3 Perform High Speed Evasive Double Lane Change Heavy Brake Pedal Apply inducing ABS at 100, N - 80, N - 60, N - 40, N - 20 km/h (mph), where N = top vehicle speed achievable on VDTA.

4.3.2.4 Bank Angle Evaluations. Bank angle evaluations will be used to validate the bank angle compensation that resides in the vehicle model and/or vehicle characterization algorithm. The maneuvers will be performed with traction control and ESC enabled on various high bank angle tracks with grades ranging from approximately 30% to 60% (17 degrees to 30 degrees). Sinusoidal steering inputs involve slowly performing a slalom type maneuver within the handling limits of the vehicle. Requestor may adjust test speeds as required based on the type of vehicle.

4.3.2.4.1 Perform high speed bank angle. One (1) steady state driving in top lane of banked track at 40, N - 140, N - 120, N - 100, N - 80, N - 60, N - 40, and N - 20 km/h (mph) where N = top vehicle speed achievable using top lane of banked track.

4.3.2.4.2 Perform high speed bank angle. Two (2) sinusoidal steering inputs in top lane of banked track at 40, N - 140, N - 120, N - 100, N - 80, N - 60, N - 40, and N - 20 km/h (mph) where N = top vehicle speed achievable using top lane of banked track.

5 Data

5.1 Calculations. Data to be reviewed by engineer to resolve any issues surfacing during vehicle evaluation.

5.2 Interpretation of Results. Subjective evaluation by test operator.

5.3 Test Documentation. Publish test information in Appendix B, Data Sheet B1 and results according to departmental protocol.

GM Confidential

© Copyright 2017 General Motors Company All Rights Reserved

August 2017

Page 4 of 13



Documents

Document Sharing Hub