



SURFACE VEHICLE RECOMMENDED PRACTICE

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Passenger Vehicle Lane Departure Warning, Lane Keeping Assistance, and Lane Centering Assistance Systems Test Procedure

RATIONALE

With the increasing prevalence of lane departure warning (LDW), lane keeping assistance (LKA), and lane centering assistance systems on passenger vehicles and light trucks with a gross vehicle weight rating (GVWR) under 4546 kg (10000 pounds), a vehicle test procedure to evaluate the performance of these systems is justified. These systems use several methods to detect, track, and communicate with the driver when an unintended lane and road departure is imminent. Additionally, LKA and lane centering assist systems actively mitigate or prevent such imminent departures.

This document outlines test procedures intended to measure performance of LDW, LKA, and lane centering assistance systems in conditions that represent most driving environments. The document also defines optional test procedures intended to represent additional situations frequently encountered in real-world driving.

Although the methods described are technology specific, future revisions may be developed to accommodate different technological solutions if necessary. This test procedure does not intend to exclude any particular system or sensing technology.

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1. SCOPE

This SAE Recommended Practice establishes a test procedure for the evaluation of lane departure warning (LDW), lane keeping assistance (LKA), and lane centering assistance systems used in passenger vehicles and light trucks. This test procedure does not intend to exclude any particular system or sensing technology.

The recommended practice can be used to test the functionality and performance of LDW, LKA, and lane centering assistance systems by assessing their ability to (1) warn (LDW) or control (LKA, lane centering assistance) in response to an unintended lane departure, and (2) the ability to indicate a system disengagement. The human machine interface (HMI) is not addressed herein but is considered in SAE J2808.

The recommended practice specifies lane markers to enable lane departure testing, or road edges, to enable testing of road departure mitigation systems.

The document is separated into two tiers. Tier One establishes a recommended minimum set of performance criteria for LDW, LKA, or lane centering assistance system operation. Tier Two defines additional tests to provide a measure of the system's anticipated performance in more challenging environments.

2. REFERENCES

2.1 Applicable Documents

The following publications form a part of this specification to the extent specified herein. Unless otherwise indicated, the latest issue of SAE publications shall apply.

2.1.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or +1 724-776-4970 (outside USA), www.sae.org

SAE J1939-22 CAN FD Data Link Layer

SAE J2808 Lane Departure Warning Systems: Information for the Human Interface

SAE J2944 Operational Definitions of Driving Performance Measures and Statistics

SAE J3016 Taxonomy and Definitions for Terms Related to Driving Automation Systems for On-Road Motor Vehicles

SAE J3045 Truck and Bus Lane Departure Warning Systems Test Procedure and Minimum Performance Requirements

SAE J3063 Active Safety Systems Terms and Definitions

2.1.2 ANSI Accredited Publications

Copies of these documents are available online at <https://webstore.ansi.org/>.

ISO 11270 Intelligent transport systems - Lane keeping assistance systems (LKAS) - Performance requirements and test procedures

ISO 17361 Intelligent transport systems - Lane departure warning systems - Performance requirements and test procedures

ISO 19638 Intelligent transport systems - Road boundary departure prevention systems (RBDPS) - Performance requirements and test procedures

ISO 22735:2021 Road vehicles - Test method to evaluate the performance of lane-keeping assistance systems

2.1.3 Federal Publications

Available from the Superintendent of Documents, U.S. Government Printing Office, Mail Stop: SSOP, Washington, DC 20402-9320.

<https://www.fhwa.dot.gov/pavement/smoothness/>

<https://www.fhwa.dot.gov/pavement/pubs/hif16032.pdf>

https://cshub.mit.edu/sites/default/files/documents/PVIRoughness_v15.pdf

Title 23, Code of Federal Regulations 655: [eCFR :: 23 CFR Part 655 -- Traffic Operations](#)

Empirical Studies on Traffic Flow in Inclement Weather

<https://ops.fhwa.dot.gov/publications/weatherempirical/sect2.htm>

Federal Highway Lighting Standards

https://safety.fhwa.dot.gov/roadway_dept/night_visib/lighting_handbook/pdf/fhwa_handbook2012.pdf

2.2 Related Publications

The following publications are provided for information purposes only and are not a required part of this SAE Technical Report.

https://www.clrp.cornell.edu/q-a/041-pave_mark_retro.html

<https://www.astm.org/DATABASE.CART/HISTORICAL/E1337-90R18.htm>

MUTCD 2003 Edition, Chapter 3: <https://mutcd.fhwa.dot.gov/pdfs/2003/Ch3.pdf>, pg. 8

Meteorological Optical Range (MOR) (surface): <http://www.wmo-sat.info/oscar/variables/view/209>

UN ECE R130 (June 2014): <https://op.europa.eu/en/publication-detail/-/publication/d029cda3-f6b9-11e3-831f-01aa75ed71a1>

3. DEFINITIONS

3.1 Common

3.1.1 CONTROLLER AREA NETWORK (CAN) DATABASE

The comprehensive list of data and signal protocols used for a vehicle's set of electronic control units.

NOTE: This is typically proprietary.

3.1.2 DISTANCE-TO-LANE EDGE (DTLE)

Perpendicular distance from the inside edge of the lane to the outside edge of the front tire. A positive distance means the subject vehicle is within the lane, a negative distance means the subject vehicle has crossed a lane marker. This represents the distance to a lane crossing or a distance to a road departure.

3.1.3 DYNAMIC DRIVING TASK (DDT)

All of the real-time operational and tactical functions required to operate a vehicle in on-road traffic, excluding the strategic functions such as trip scheduling and selection of destinations and waypoints, and including, without limitation, the following subtasks. Refer to SAE J3016.

- Lateral vehicle motion control via steering (operational).
- Longitudinal vehicle motion control via acceleration and deceleration (operational).
- Monitoring the driving environment via object and event detection, recognition, classification, and response preparation (operational and tactical).
- Object and event response execution (operational and tactical).
- Maneuver planning (tactical).
- Enhancing conspicuity via lighting, sounding the horn, signaling, and gesturing, etc. (tactical).

3.1.4 LANE

Part of the traveled way intended for use by a single line of moving vehicles and usually delineated by pavement markings to guide drivers and reduce potential traffic conflicts. Refer to SAE J2944.

3.1.5 LANE BOUNDARY

Physical or implied indicators on the traveled way that define the lateral edges within which a vehicle moving single file in the same direction is expected to drive, except when passing, changing lanes, or exiting the traveled way. Refer to SAE J2944.

3.1.6 LANE CURVATURE

The radius of the lane as measured in the lane halfway between the left and right lane markers. Refer to SAE J3045.

3.1.7 LANE MARKER

See Visible Lane Marking.

3.1.8 LANE WIDTH

The distance between the inside of the inside lane marker on the left to the inside of the inside lane marker on the right (see Figure 1).

3.1.9 MANUAL ON UNIFORM TRAFFIC CONTROL DEVICES

The Manual on Uniform Traffic Control Devices for Streets and Highways, or MUTCD, defines the standards used by road managers nationwide to install and maintain traffic control devices on all public streets, highways, bikeways, and private roads open to public travel in the USA. The MUTCD is published by the Federal Highway Administration (FHWA) under [23 Code of Federal Regulations \(CFR\), Part 655, Subpart F](#). Refer to Title 23 Code of Federal Regulations 655.

3.1.10 NORMAL BROKEN LANE LINE

Normal broken lane lines are pavement markers used where changing lanes, either into same direction or opposite direction travel, is permitted. Broken lines should consist of 3 m (10 feet) line segments and 9 m (30 feet) gaps, or dimensions in a similar ratio of line segments to gaps as appropriate for traffic speeds and need for delineation. Also known as “skip lines.” Refer to MUTCD 2003 Edition, Chapter 3.



Figure 1 - Graphical representation of Warning and Control Zones

3.1.11 ROAD

The surface that a vehicle would be expected to travel along in the absence of any obstruction. Refer to SAE J2808.

3.1.12 ROADWAY BOUNDARY

Outermost edges of the roadway. Refer to SAE J2944.

NOTE: Boundaries may be defined by edges of pavement markings, edge drop offs, changes in paving materials, or barriers such as curbs, gutters, guardrails, bridge abutments, or other roadside appurtenances.

3.1.13 STATUS/FUNCTION INDICATION

An indication that reflects a system may not (or is less likely to) deliver a road/lane departure warning. Refer to SAE J2808 which follows from ISO Standard 17361.

3.1.14 SUBJECT VEHICLE (SV)

Vehicle being tested.

3.1.15 DRIVER INTENT SUPPRESSION REQUEST

The driver intent suppression request involves a driver activity that causes a cessation or cancellation of a warning and/or control action.

3.1.16 SYSTEM INCAPABLE

For lane departure warning systems, a state of the system in which it is unable to warn the driver of a lane departure due to temporary conditions. Refer to SAE J2808 which follows from ISO Standard 17361. For Lane Keeping and Lane Centering Assistance Systems, a state of the system in which it is unable to control the vehicle within Warning and/or Activation Threshold Placement Zone due to temporary conditions.

3.1.17 TIME TO LINE CROSSING (TTLC)

Calculated time to a lane departure. Refer to ISO 17361.

3.1.18 VISIBILITY

The distance at which the illuminance of a non-diffusive beam of white light with a color temperature of 2700K is decreased to 5% of its original light source illuminance. Refer to Meteorological Optical Range (MOR) (surface).

3.1.19 VISIBLE LANE MARKING

Delineators intentionally placed on the borderline of the lane that are directly visible by the driver while driving (i.e., not covered by snow, etc.). Refer to ISO 17361.

3.2 Lane Departure

3.2.1 LANE DEPARTURE

Period when the outside edge of the front tire has crossed the inside edge of the lane boundary until all tire contact patches are back inside the lane boundary or the vehicle comes to a stop before returning to the lane, excluding lane changes and turning maneuvers. Refer to SAE J2944.

3.2.2 LANE DEPARTURE WARNING

A warning given to the driver in accordance with the lane departure warning condition in the absence of suppression requests. Refer to SAE J2808, which follows from ISO Standard 17361.

3.2.3 LANE DEPARTURE WARNING (SYSTEM)

Monitors vehicle's position within the driving lane and alerts driver as the vehicle approaches or crosses lane markers. This warning is typically multimodal, and can include an auditory alert, visual alert, haptic vibration, or any combination thereof. Some systems also provide a warning when the vehicle approaches or crosses the road edge in the absence of lane markers. Refer to SAE J3063.

3.2.4 LANE DEPARTURE WARNING CONDITION

The condition where an unintended lane departure event is detected, and a warning is provided to the driver.

3.2.5 LATEST WARNING LINE

The outermost lateral position limit of the warning threshold, representing the latest time a lane departure warning is permitted. See Figure 1 for a graphical representation of the latest warning line. Refer to SAE J2808, which follows from ISO Standard 17361.

3.2.6 RATE OF DEPARTURE

The component of the subject vehicle's approach speed that is perpendicular to the lane boundary at the instant the lane departure warning occurs. Refer to SAE J2808, which follows from ISO Standard 17361.

3.2.7 ROAD DEPARTURE

Period when any part of one or more tire contact patches are no longer on the roadway until all tire contact patches are back on the roadway surface or the vehicle has stopped or crashed without returning to the roadway. Refer to SAE J2944.

3.2.8 ROAD DEPARTURE WARNING

A warning given to the driver in accordance with the road departure warning condition in the absence of suppression requests. Refer to SAE J2808, which follows from ISO Standard 17361.

3.2.9 ROAD DEPARTURE WARNING SYSTEM

A system which provides road departure warnings. Refer to SAE J2808.

3.2.10 TIME GAP

The amount of time it takes for the front of the subject vehicle to reach the present, instantaneous position of the rear of the preceding vehicle. Usually calculated as:

$$\text{Distance to preceding vehicle (m) / Subject Vehicle Velocity (m/s)} \quad (\text{Eq. 1})$$

3.2.11 WARNING CONDITION

A condition in which lane or road departure across the warning threshold occurs. Refer to SAE J2808, which follows from ISO Standard 17361.

3.2.12 WARNING THRESHOLD

Location where the warning is issued relative to the inboard edge of the lane line or road boundary, which corresponds to a warning trigger point set in the system. Refer to ISO Standard 17361.

3.2.13 WARNING THRESHOLD PLACEMENT ZONE

The zone between the earliest and latest warning lines within which the warning threshold is placed, in which a lane departure warning is permissible (see Figure 1). Refer to ISO Standard 17361.

3.3 Lane Keeping Assistance/Lane Centering Assistance

3.3.1 LANE KEEPING ASSISTANCE (LKA)

Provides steering support to assist the driver in keeping the vehicle in the lane. The system reacts only when the vehicle approaches or crosses a lane line or road edge.

These systems typically provide steering assistance for detected lane markings. Steering assistance could be torque applied to the steering wheel, the steerable road wheels, differential braking to achieve a steering moment, or any combination or other means to laterally move the vehicle.

Some systems can detect the edge of the road. Systems that can detect the edge of the road may react differently from the way it would for a detected lane marker. Some systems provide a greater margin to the lane marker if there is a vehicle in an adjacent lane. Some systems provide a greater margin to the lane marker if there is a pedestrian or cyclist in an adjacent lane. Refer to SAE J3063.

3.3.2 LANE CENTERING ASSISTANCE

Provides steering support to assist the driver in continuously maintaining the vehicle at or near the center of the lane. Refer to SAE J3063.

3.3.3 ACTIVATION CONDITION

A condition in which LKA lateral control is initiated in an effort to prevent the vehicle from a lane departure.

3.3.4 ACTIVATION ISSUE POINT

Measured location and time at which LKA lateral control initiates.

3.3.5 ACTIVATION THRESHOLD

The location where the LKA or LDW activation is initiated relative to the inboard edge of the lane line or road boundary, which corresponds to an activation trigger point set in the system.

3.3.6 ACTIVATION THRESHOLD PLACEMENT ZONE

The zone between the earliest and latest activation lines within which the activation threshold is placed (see Figure 1).

4. TEST INSTRUMENTATION, DATA, AND ACCURACY LEVELS

4.1 Performance Measurement Instrumentation

The tester is free to choose the mix of instrumentation. Options include, but are not limited to:

4.1.1 Differential RTK (Real Time Kinematic) GPS

A differential RTK GPS including a base station providing an accuracy of within 2 cm (0.787 inch) can be used. This method records the location of the lane lines and road edges before the start of the test. RTK GPS can provide the position of the wheels with 2 cm (0.787 inch) accuracy. This method requires extra instrumentation (RTK base and rover stations) and calibration effort (survey of the lane lines and road edges).

4.1.2 External Video Overlayed with CAN Outputs

External camera(s) can be mounted and configured so that the front wheel position with reference to lane lines and road edges can be determined, and data (video and CAN) recorded simultaneously. When the video is synchronized with the CAN outputs, playing back the data file can show when the warning and/or activation occurred. The tire width can be used as reference to estimate the position of the outer wheel edge when the warning and/or activation happens. This method requires knowledge of the subject vehicle's CAN database.

4.1.3 External Video with Internal Microphone

An external camera can be mounted and configured so that the wheel position with reference to lane lines and road edges can be determined. If different warning methods are available, the audio option is selected.

4.2 End of Test

If the test is evaluating LDW, the test ends when one of the following occurs:

- The warning is issued.
- The vehicle crosses 0.3 m (0.98 feet) over the lane boundary (see Figure 6).

If the vehicle can be laterally controlled by an LKA or lane centering assistance, the end of test occurs 2 seconds after one of the following occurs:

- The system fails to maintain the subject vehicle within the LKA/Lane Centering Assistance Intervention Zone (see Figure 7).
- The system intervenes to maintain the subject vehicle within Lane Keeping Assistance Intervention Zone, such that a maximum lateral deviation is achieved that subsequently diminishes causing the subject vehicle to turn back toward the lane.

NOTE: While lane centering assistance systems are expected to stay within the Lane Keeping Assistance Intervention Zone, the control philosophy of the typical lane centering assistance system would see much tighter control and much less lateral deviation.

4.3 Test Data to be Collected

4.3.1 Vehicle Dynamics Data

The data sufficient and necessary to ensure that the subject vehicle properly executed the prescribed test trajectory (see 9.1).

- Yaw rate measured to an accuracy of 0.1 deg/s.
- Vehicle forward speed measured to an accuracy to 0.05 m/s (0.164 ft/s).
- Rate of departure (lateral velocity) measured to an accuracy to 0.05 m/s (0.164 ft/s).

4.3.1.1 Lateral Position from Front Tire Outside Edge to Inside Lane Marker Inside Edge or Road Edge

Test measurement accuracy to 0.03 m (1.2 inches).

4.3.1.2 Lateral Velocity with Respect to the Lane Marker or Road Edge

Test measurement accuracy to 0.05 m/s (2 in/s).

4.3.2 LDW Warning Onset

This data is necessary and sufficient to validate the output of LDW during the test.

If the LDW system contains more than one warning modality, the most prominent warning modality is the one measured. The most prominent warning modality is the first occurrence of an auditory or haptic warning.

4.3.3 LKA Activation Onset

This data is necessary and sufficient to validate the output of LKA during the test.

4.3.3.1 Driver (Manual) Steering Inputs

The steering wheel angle inputs shall be measured to an accuracy of 0.1 degree.

The driver steering torque inputs shall be measured to an accuracy of 0.1 N·m.

5. VEHICLE INFORMATION

5.1 Vehicle Weight

Recorded vehicle weight shall be the vehicle's curb weight + weight of the driver + weight of the test equipment.

5.2 Tire Pressures

The tires shall be inflated to the Vehicle Manufacturer's recommended tire pressure.

6. TEST CONDITIONS AND VEHICLE PREPARATION

Concept:

LDW, LKA, and Lane Centering Assistance systems are required to provide consistent warning and control actions. To evaluate this, the test conditions should be controlled in a way that highlights performance differences attributable to technological limitations and algorithmic choices under tightly defined and controlled environmental conditions (Tier One test suite).

Tier One tests are conducted under the weather and environmental conditions described in 6.1, 6.2, and 6.3. These conditions are broadly similar to those defined in consumer metric protocols such as Euro NCAP.

To provide further differentiation, a series of optional tests may also be conducted (Tier Two test suite). The Tier Two concept is that the systems are expected to continue to operate in environmental conditions that might make it more challenging for system performance, so some of these less-controlled circumstances can be used to evaluate the robustness of the system. For these cases, Robustness Test Conditions are defined below.

Tier Two tests are comprised of three sets of test protocols in which one Tier Two criterion is selected in each, with all other test criteria meeting what is defined in the Tier One tests.

For Robustness Condition A, the test must be run on a straight road at 120 kph or on a curved road that meets the definition of the Tier Two Curved road defined in 6.3.8.2.

For Robustness Condition B, either the Tier Two Road Condition Roughness (see 6.3.1.2), the Tier Two Road Striping Condition (see 6.3.2.2), or Tier Two Surrounding Traffic (see 6.3.9.2) is evaluated.

For Robustness Condition C, either one of the Tier Two Precipitation conditions (see 6.1.2.2) or one of the Tier Two Ambient Lighting conditions (see 6.1.4.2) is evaluated.

Manufacturers can choose to evaluate their system under the Tier One protocols, or they could choose to also evaluate their systems using the more challenging Tier Two conditions. However, Tier Two evaluations shall only be performed if the systems first satisfy the Tier One performance requirements.

6.1 Environmental Conditions

6.1.1 Ambient Temperature

6.1.1.1 Tier One Ambient Temperature

The tests shall be performed when the ambient temperature is within the following range:

$$0 < T < 45\text{ }^{\circ}\text{C} \quad (32 < T < 104\text{ }^{\circ}\text{F}) \quad (\text{Eq. 2})$$

6.1.1.2 Tier Two Ambient Temperature

There are no Tier Two conditions specified. All Tier Two tests are conducted when the ambient temperature is within the range specified in Tier One.

6.1.2 Precipitation

6.1.2.1 Tier One Precipitation

Tier One tests shall be performed when there is no precipitation falling and the test surface is dry.

6.1.2.2 Tier Two Precipitation

6.1.2.2.1 Light Rain

Tier Two tests may be conducted when rainfall/hour $>0.25\text{ mm/h}$ and $<6.4\text{ mm/h}$ ($>0.01\text{ in/h}$ and $<0.25\text{ in/h}$). The peak friction coefficient (PFC) of the test surface shall be ≥ 0.5 when measured in accordance with ASTM E1337-90. Refer to Empirical Studies on Traffic Flow in Inclement Weather.

6.1.2.2.2 Heavy Rain

Tier Two tests may be conducted when rainfall/hour is $>6.4\text{ mm/h}$ and $<25\text{ mm/h}$. Refer to Empirical Studies on Traffic Flow in Inclement Weather. The PFC shall be ≥ 0.5 when measured in accordance with ASTM E1337-90.

6.1.2.2.3 Light Snow

Tier Two tests may be conducted when snowfall/hour $>3\text{ mm/h}$ and $<10\text{ mm/h}$ without obscuring the lane markings (i.e., active snowfall, wet road). Once lane markings are obscured, testing is not possible. The intent is for the snow to be in the air but not covering the lane markings. The PFC shall be ≥ 0.5 when measured in accordance with ASTM E1337-90.

6.1.3 Minimum Atmospheric Visibility

6.1.3.1 Tier One Minimum Atmospheric Visibility

Tier One tests shall be conducted when the horizontal visibility at ground level is greater than 1 km.

6.1.3.2 Tier Two Minimum Atmospheric Visibility

There are no Tier Two conditions specified. All Tier Two tests are conducted when the minimum atmospheric visibility is within the range specified in Tier One.

6.1.4 Ambient Lighting

6.1.4.1 Tier One Ambient Lighting

Tier One tests shall be conducted during daylight hours in excess of 2000 lux, with good atmospheric visibility defined as an absence of fog and the ability to see clearly for more than 5 km (3.1 miles). Tests shall not be conducted with the vehicle oriented into the sun during very low sun angle conditions, where the sun is oriented 15 degrees or less from horizontal, and potential camera “washout” or system inoperability could result.

6.1.4.2 Tier Two Ambient Lighting

6.1.4.2.1 Dusk

Tier Two tests may be conducted when natural ambient illumination is homogenous in the test area and brightness is >50 lux and <200 lux with no strong shadows cast across the test area other than those caused by the subject vehicle.

6.1.4.2.2 Nighttime with Streetlights

Tier Two tests may be conducted when natural ambient illumination is homogenous in the test area and brightness <1 lux for nighttime testing. The vehicle’s low-beam headlights shall be on. If the vehicle is equipped with an Automatic High Beam or Adaptive Driving Beam feature, that system shall be in its factory default setting. Streetlights shall be on.

The lighting created by the streetlights shall meet the standards and design criteria used in the FHWA Lighting Handbook. Refer to https://safety.fhwa.dot.gov/roadway_dept/night_visib/lighting_handbook/pdf/fhwa_handbook2012.pdf.

6.1.4.2.3 Nighttime without Streetlights

Tier Two tests may be conducted when natural ambient illumination is homogenous in the test area and <1 lux for nighttime testing. The vehicle’s low-beam headlights shall be on. If the vehicle is equipped with an Automatic High Beam or Adaptive Driving Beam feature, that system shall be in its factory default setting.

6.1.4.2.4 Daytime, Sun Angle

Tier Two tests may be conducted while the vehicle is heading towards the sun and the sun angle is <15 degrees above the horizon.

6.1.5 Maximum Wind Speed

6.1.5.1 Tier One Maximum Wind Speed

Tier One tests shall be conducted when wind speeds are below 10 m/s (22.4 mph).

6.1.5.2 Tier Two Maximum Wind Speed

There are no Tier Two conditions specified. All Tier Two tests are conducted when the maximum wind speed is within the range specified in Tier One.

6.1.6 Roadway Surface

6.1.6.1 Tier One Roadway Surface

Tier One tests shall be conducted on either an asphalt or a concrete surface.

6.1.6.2 Tier Two Roadway Surface

There are no Tier Two conditions specified. All Tier Two tests shall be conducted on either an asphalt or concrete roadway surface.

6.2 Test Speeds

NOTE 1: It is permissible to control test speeds through the use of conventional cruise control. The use of adaptive cruise control is prohibited unless it is required for lane centering operation. Tests that involve a manual steering input to induce a lane departure may not be possible with most lane centering features.

NOTE 2: If adaptive cruise control is used along with lane centering assistance, this could be considered a form of active driving assistance, a driving automation level 2 feature. However, for the purpose of the performance evaluations described within this document, only the lane centering assistance feature is tested. Care shall be taken to ensure any additional prerequisites are fulfilled, e.g., if adaptive cruise control is used to control the speed for such a vehicle in these tests (e.g., ensuring a Driver Monitoring System is functional, and that any DMS operational requirements have been satisfied during the assessment of lane centering assistance performance).

6.2.1 Tier One Test Speeds

Tier One tests shall be conducted at speeds of 72 to 100 kph $\pm$ 4 kph depending on the road curvature of the test surface.

6.2.2 Tier Two Test Speeds

Tier Two tests may be conducted with the vehicle traveling at speeds of 72 to 120 kph $\pm$ 4 kph depending on the road curvature of the test surface. If the straight road is chosen, Robustness Condition A is evaluated at a speed of 120 kph $\pm$ 4 kph.

6.3 Road Condition

6.3.1 Roughness

6.3.1.1 Tier One Road Condition Roughness

The test surface used for Tier One evaluations shall have an International Roughness Index (IRI) <95 in/mile (considered smooth by FHWA).

6.3.1.2 Tier Two Road Condition Roughness

The test surface used for Tier Two evaluations may have an International Roughness Index (IRI) >170 in/mile (a value of 170 is considered "acceptable" by FHWA).

6.3.2 Road Striping Condition

6.3.2.1 Tier One Road Striping Condition

6.3.2.1.1 Retroreflectivity

Lane marker retroreflectivity shall meet all applicable standards. These standards include, but are not limited to, those from the International Commission of Illumination (CIE) for color and the American Society for Testing and Materials (ASTM). The minimum retroreflectivity of pavement markings (measured at standard 30 m geometry in units of mcd/m²/lux), is $\geq$ 50. Refer to MUTCD 2009 Rev 3 Section 3A.-03, <https://mutcd.fhwa.dot.gov/pdfs/2009r1r2r3/part3.pdf>.

6.3.2.1.2 Striping Type

Tier One tests shall be conducted when the line striping is a white solid fog line, white normal broken lane line, yellow solid lane line, or yellow normal broken lane line per the MUTCD or ECE R130, with variations allowed for different lane markings used in countries other than the U.S. Refer to MUTCD 2003 Edition, Chapter 3 and UN ECE R130 (June 2014).

6.3.2.1.3 Striping Width

Line striping width shall be 10.2 cm (4 inches) minimum, 15.2 cm (6 inches) maximum.

6.3.2.2 Tier Two Road Striping Condition

6.3.2.2.1 Retroreflectivity

Tier Two tests may be conducted with pavement markers of a retroreflectivity of 30 to 50 mcd/m²/lux.

NOTE: The minimum retroreflectivity for “aged” pavement markings (measured at standard 30m geometry in units of mcd/m²/lux), is $\pm \leq 50$.

Refer to MUTCD 2009 Rev 3 Section 3A.-03, <https://mutcd.fhwa.dot.gov/pdfs/2009r1r2r3/part3.pdf>.

6.3.2.2.2 Striping Type

There are no Tier Two conditions specified. All Tier Two tests shall be conducted when the line striping is a white solid fog line, white normal broken lane line, yellow solid lane line, or yellow normal broken lane line per the MUTCD or ECE R130, with variations allowed for different lane markings used in countries other than the U.S.

6.3.2.2.3 Striping Width

There are no Tier Two conditions specified. All Tier Two tests are conducted when the striping width is within the range specified in Tier One.

6.3.3 Lane Curvature

6.3.3.1 Tier One Lane Curvature

Tier One tests shall be conducted on a straight road, or when the road curvature is between 320 and 1029 m and the speed of the subject vehicle is between 72 and 100 kph and the lateral acceleration of the subject vehicle is between 0.75 and 1.25 m/s².

6.3.3.2 Tier Two Lane Curvature

Tier Two tests may be conducted when the road curvature is between 178 and 741 m and the speed of the subject vehicle is between 72 and 120 kph, and the lateral acceleration of the subject vehicle is between 1.5 and 2.25 m/s² (e.g., 400 m radius curve at 90 kph).

6.3.4 Road Grade

6.3.4.1 Tier One Road Grade

Tier One tests shall be conducted using a lane with a road grade no greater than 1%.

6.3.4.2 Tier Two Road Grade

There are no Tier Two conditions specified. All Tier Two tests shall be conducted when the road grade is within the range specified in Tier One.

6.3.5 Road Cross-Slope

6.3.5.1 Tier One Road Cross-Slope

Tier One tests shall be conducted using a lane with a road cross-slope no greater than 2%.

6.3.5.2 Tier Two Road Cross-Slope

There are no Tier Two conditions specified. All Tier Two tests shall be conducted when the road cross-slope is within the range specified in Tier One.