IVISTA

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Intelligent Safety Index
Safety Assist
Automatic Emergency Braking System Test Protocol

(Version 2023)

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Automatic Emergency Braking System Test Protocol

1 Scope

This document specifies the test methods of IVISTA China Intelligent Vehicle Index - Intelligent Safety Index - Safety Assist - AEB System.

2 Normative References

The following normative documents contain provisions which, through reference in this text, constitute indispensable provisions of this document. For dated references, only the dated edition applies to this document. For undated references, the latest edition (including all amendments) applies to this document.

GB/T 15089-2001 Classification of Power-driven Vehicles and Trailers

GB/T 33577-2017 Intelligent Transportation Systems - Forward Vehicle Collision Warning Systems - Performance Requirements and Test Procedures

GB/T 39901-2021 Performance Requirements and Test Methods for Advanced Emergency Braking System (AEBS) of Passenger Cars

GB/T 39263-2020 Road Vehicles - Advanced Driver Assistance Systems - Terms and Definitions

ISO 8855:2011 Road Vehicles - Vehicle Dynamics and Road-Holding Ability - Vocabulary

Euro NCAP AEB Car-to-Car Test Protocol

Euro NCAP AEB/LSS VRU Systems Test Protocol

NHTSA Forward Collision Warning System Confirmation Test

IIHS Autonomous Emergency Braking Test Protocol

3 Terms and Definitions

For the purposes of this document, the following terms and definitions apply.

3.1

inertial frame

the inertial frame specified in ISO 8855:2011 used in this protocol, in which the X axis points towards the front of the vehicle, the Y axis towards the left side of the driver and the Z axis upwards (right-hand coordinate system) Viewed from the origin to the positive directions of X, Y and Z axes, roll, pitch and yaw rotate clockwise around the x, y and z axes respectively. This frame is used for both left-hand and right-hand drive vehicles.

3.2

forward collision warning; FCW

a system that monitors the driving environment ahead of the vehicle in real time and sends warning messages in case of a latent forward collision hazard

[Source: GB/T 39263-2020, 2.2.10]

3.3

advanced/automatic emergency braking; AEB

a system that monitors the driving environment ahead of the vehicle in real time and automatically enables the braking system to decelerate in case of a latent collision hazard, in order to avoid a collision or mitigate the collision consequences

[Source: GB/T 39263-2020, 2.3.1]

3.4

autonomous emergency steering; AES

a system that monitors the driving conditions ahead of, on the sides of and on the side rear of the vehicle in real time and automatically controls the vehicle to steer in case of a latent collision hazard, in order to avoid a collision or mitigate the collision consequences

[Source: GB/T 39263-2020, 2.3.3]

3.5

emergency steering assist; ESA

a system that monitors the driving environment ahead of and on the sides of the vehicle in real time and assists the driver in steering in case of a latent collision hazard and an explicit steering intention from the driver

[Source: GB/T 39263-2020, 2.3.4]

3.6

subject vehicle; SV

a vehicle to be tested that is equipped with the AEB car-to-car system defined in this protocol

3.7

target vehicle; TV

the forward vehicle closest to the SV on the forward motion path of the SV, which is the target of the AEB car-to-car system when the system is in operation

3.8

passenger car target vehicle

a passenger car test device designed for the test of AEB system

3.9

truck target vehicle

a truck test device designed for the test of AEB system

3.10

express tricycle target vehicle

an express tricycle test device designed for the test of AEB system

3.11

vulnerable road user; VRU

road users vulnerable to injuries

3.12

adult pedestrian target; APT

an adult pedestrian test device designed for the test of AEB system

3.13

child pedestrian target; CPT

a child pedestrian test device designed for the test of AEB system

3.14

adult bicyclist target; ABT

an adult bicyclist test device designed for the test of AEB system

3.15

scooter target adult; STA

an e-scooter target adult test device designed for the test of AEB system

3.16

special shape target

carbons, foam boxes and woven bag designed for the test of AEB system

3.17

vehicle width

the distance between the two planes that are parallel to the longitudinal symmetry plane of the vehicle and abut against the fixed projections on both sides of the vehicle, excluding the rearview mirrors, side marker lamps, position lamps, turn signal lamps, flexible mudguards, folding pedals, tire chains and deflected part immediately above the point of contact with the ground

3.18

clearance

distance between the rear of TV and the head of SV

3.19

relative velocity

difference between the longitudinal velocities of the SV and the TV

3.20

impact point

the point at which the SV collides with the target (including passenger car target vehicle, truck target vehicle, express tricycle target vehicle, pedestrian target, adult bicyclist target, scooter target adult and special shape target) for the first time

3.21

time to collision; TTC

the remaining time before a collision between the SV and the target traveling on the same path, assuming that the relative velocity remains unchanged, calculated as per Formula (1), provided that the relative velocity is not zero. The value may be estimated through dividing the rear clearance

between the SV and the target by the relative velocity. If the calculation condition is not met or the calculated TTC is negative, the collision is impossible under the above-mentioned assumed conditions.

$$\mathrm{TTC} = \frac{X_0(t)}{V_r(t)} \qquad \cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots (1)$$

where,

$V_r(t)$ - relative velocity, in m/s

$X_0(t)$ - clearance, in m

3.22

lateral offset

the difference between distance of the planned path to the front axle center point of SV and that to rear axle center point of TV

When the center lines of both SV and TV coincide with the planned path, the lateral offset is zero. When there is no TV, the lateral offset is the distance from the front axle center point of SV to the planned path.

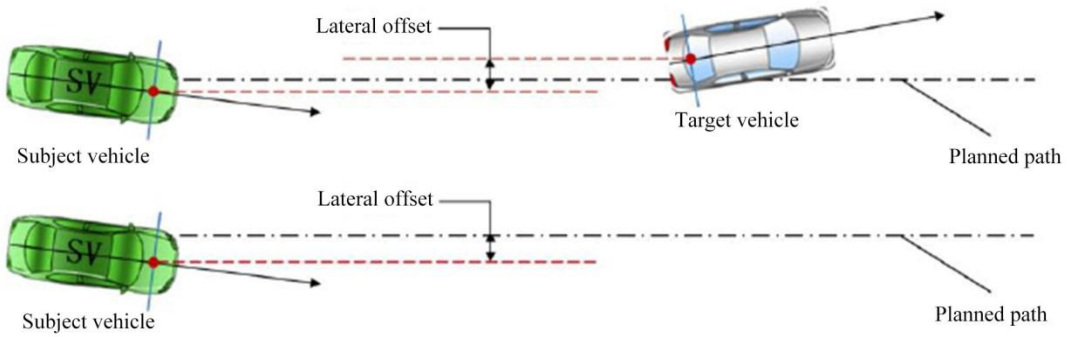


Fig. 1 Lateral Offset

3.23

rear clearance

distance from the center point of the SV's head to the target on the planned path of the SV

a) In the car-to-car scenario, it refers to the distance from the center point of the SV's head and the center point of the TV's tail to the planned path;

b) In the pedestrian crossing scenario, it refers to the distance between the center point of the SV's head and the outer side of the pedestrian's arms on the planned path of the SV;

c) In the pedestrian longitudinal rear-end collision scenario, it refers to the distance between the center point of the SV's head and the rear side of the pedestrian's buttocks on the planned path of the SV;

d) In the bicyclist crossing scenario, it refers to the distance between the center point of the SV's head and the outer side of the bicyclist's legs on the planned path of the SV;

e) In the car to bicyclist longitudinal adult scenario, it refers to the distance between the center point of the SV's head and the rear of the bicycle on the planned path of the SV;

f) In the scooter crossing scenario, it refers to the distance between the center point of the SV's head and the foremost end of the scooter's front wheel on the planned path of the SV.

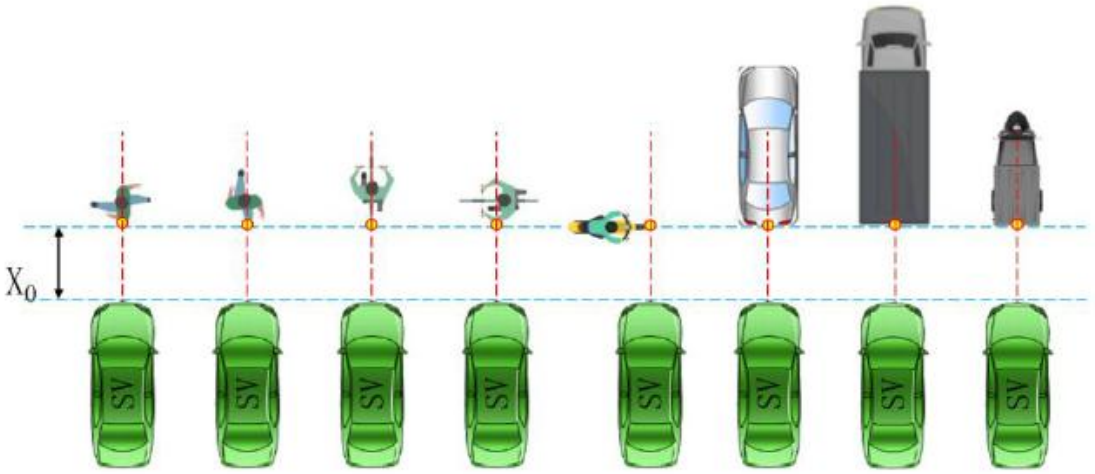


Fig. 2 Rear Clearance

3.24

lateral overlap

a percentage of the width overlap between the TV and the SV to the SV width

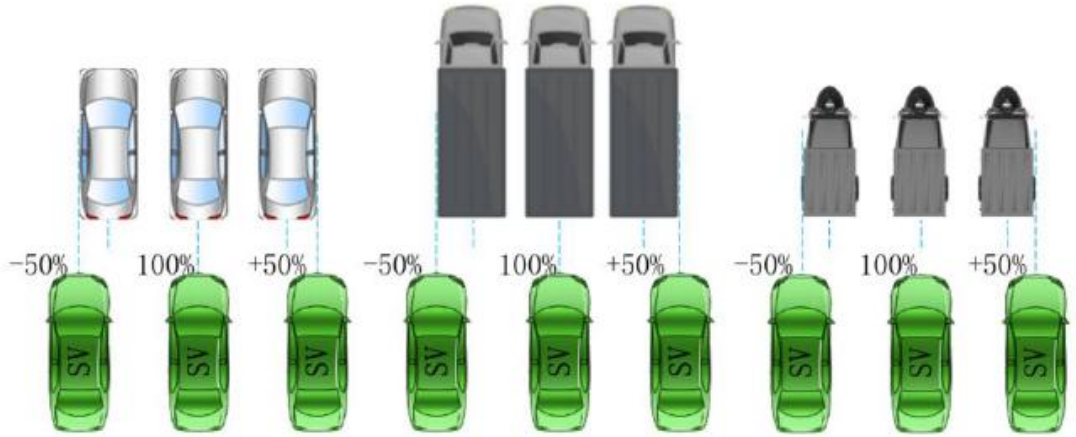


Fig. 3 Lateral Overlap

4 Test Requirements

4.1 Test site and test environment

4.1.1 Requirements for test site

a) The test road surface shall be horizontal and dry without visible moisture, and the adhesion coefficient should be above 0.8;

b) The test road shall be flat without apparent pits, cracks and other defects, with a horizontal flatness of less than 1% and a length of 500 m at least;

c) For AEB car-to-car test and AEB car-to-special-shape-target test, during the test, there shall be no vehicles, obstacles or other objects affecting the test within 3 m on both sides of the test road and 30 m in front of the target vehicle. Overhead signs, bridges and other objects or buildings on the test road shall be 5 m above the ground;

d) For car-to-VRU test, during the pedestrian crossing test, there shall be no vehicles,

obstacles or other objects (excluding the test background vehicle) affecting the test within 6 m on the right and left sides of the SV path and 30 m in front of the SV when the test ends; during the bicyclist crossing test, there shall be no vehicles, obstacles or other objects affecting the test within 21 m on the right side and 6 m on the left side of the SV path and 30 m in front of the SV when the test ends; during the scooter crossing test, there shall be no vehicles, obstacles or other objects affecting the test within 30 m on the left side and 6 m on the right side of the SV path and 30 m in front of the SV when the test ends; during the car to express tricycle longitudinal test, there shall be no vehicles, obstacles or other objects affecting the test within 3 m on both sides of the test road and 30 m in front of the target vehicle. Overhead signs, bridges and other objects or buildings on the test road shall be 5 m above the ground.

4.1.2 Requirements for test environment

a) The weather shall be good, without any bad weather such as rain, snow and dust except for special scenarios;

b) The temperature shall be 0 °C ~ 45 °C, and the wind velocity shall be less than 5 m/s;

c) Except for nighttime and rainy day scenarios, the test shall be conducted under uniform natural illumination conditions. The illuminance shall not be lower than 2000 lux, unless any other lower illuminance limit is specified by the SV manufacturer.

4.2 Test Equipment

4.2.1 Target

4.2.1.1 Target vehicle

a) The passenger car target vehicle shall be a mass-produced M1 passenger car, or a flexible target that has surface characteristic parameters representative of M1 passenger cars and can adapt to the sensor system. Refer to ISO 19206-3 for specific requirements.

Fig. 4 Appearance of Flexible Passenger Car Target

b) The truck target vehicle shall be a mass-produced N3 vehicle for the carriage of goods, or a flexible target that has surface characteristic parameters representative of N3 vehicles for the carriage of goods and can adapt to the sensor system. The current main dimensional requirements are given in Table 1.

Fig. 5 Appearance of Flexible Truck Target

Table 1 Main Dimensions of Flexible Truck Target

Dimensions	Value (mm)
Compartment width	2530
Compartment height	2700
Total height	3900
Bumper height above ground	480
Bumper length	2300
Bumper width	120

c) The express tricycle target vehicle shall be a mass-produced express tricycle, or a flexible target that has surface characteristic parameters representative of express tricycles and can adapt to the sensor system. The current main dimensional requirements are given in Table 2.

Fig. 6 Appearance of Flexible Express Tricycle Target

Table 2 Main Dimensions of Flexible Express Tricycle Target

Dimensions	Value (mm)
Total vehicle length	2905
Total vehicle width	1100
Total vehicle height	1490
Wheel track	1950
Compartment height	1150
Compartment width	1000

4.2.1.2 Vulnerable road user

a) The APT and CPT shall be swingable flexible targets that have surface characteristic parameters representative of the adult and child pedestrians above and can adapt to the sensor system. Refer to ISO 19206-2 for specific requirements.

Fig. 7 Appearance of APT and CPT

b) The ABT shall be a flexible target that has surface characteristic parameters representative of the adult bicyclist above and can adapt to the sensor system. Refer to ISO 19206-4 for specific requirements.

Fig. 8 Appearance of ABT

c) The STA shall be a flexible target that has surface characteristic parameters representative of the scooter above and can adapt to the sensor system. The current main dimensional requirements are given in Table 3.

Fig. 9 Appearance of STA

Table 3 Main Dimensions of STA

Dimensions	Value (mm)
Total vehicle length	1720
Total vehicle width	630
Total vehicle height	1000
Wheel track	1230
Seat height	730
Seat width	280
Pedal height	300
Pedal width	300

Note 1: For flexible targets, after relevant national standards are published, the requirements of those national standards will prevail.

Note 2: If the manufacturer of the VUT believes that the flexible target does not meet the requirements of the VUT sensor for the target, please contact the IVISTA Management Center.

4.2.2 Data acquisition equipment

The closed field test equipment shall meet the following requirements:

a) The sampling and storage frequency for dynamic data shall not be less than 100 Hz, and DGPS time shall be used for data synchronization between the SV and target;

b) Speed accuracy of SV and target: ± 0.1 km/h;

c) Longitudinal acceleration accuracy of SV and target: ± 0.1 m/s^2;

d) Lateral and longitudinal position accuracy of SV and target: ± 0.03 m;

e) Yaw rate accuracy of SV and target: ± 0.1°/s;

f) Angular velocity accuracy of the steering wheel of SV and target: ± 1.0°/s.

4.3 Vehicle preparation

4.3.1 System initialization

If necessary, the AEB system can be initialized prior to the test, including the calibration of sensors such as radars and cameras.

4.3.2 Vehicle condition confirmation

a) The VUT shall be new with a traveled mileage of not more than 5000 km;

b) The VUT shall be equipped with the original new tires designated by the VUT manufacturer. The tires shall be inflated to the standard cold tire pressure recommended by the VUT manufacturer, or to the pressure corresponding to the least loading condition if more than one tire pressure value is recommended;

c) The VUT shall be refueled to not less than 90% of the fuel tank capacity, with other fluids such as oil and water (e.g. coolant, brake fluid, and engine oil) added at least to the minimum indicated position. During the test, the fuel may decrease but shall not be lower than 50% of the fuel tank capacity;

d) The active hood system of VUT, if equipped, shall be disabled before the test equipment is installed;

e) The test equipment shall be installed and stowed so that the following requirements can be met:

$$\text{Curb weight + driver + test equipment + stowage} = (\text{curb weight + 200 kg}) \cdot (1 \pm 1\%)$$

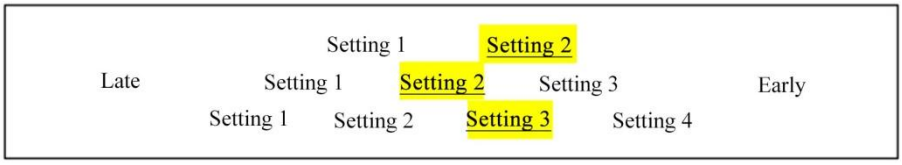
f) For off-vehicle-chargeable new energy vehicles, the traction battery shall be fully charged according to 5.1 of GB/T 18385-2005. For non-off-vehicle-chargeable new energy vehicles, the test shall be prepared in their normal operation states. During the test, the power of the vehicle may decrease, but it shall not be less than 50% SOC.

4.3.3 Functional check

Prior to the test, 3 tests shall be carried out at the minimum speed at which the system will be triggered, to ensure normal operation of the system.

4.3.4 Function settings

For AEB and/or FCW systems with several settings for the alarm level, the braking and/or alarm level shall be set to the middle level before the test, or to the next earlier level if there is an even number of alarm levels.



4.3.5 Warm-up of braking system

Prior to the test, the braking system shall be warmed up, including:

a) Perform 10 stops of the SV from a speed of 56 km/h at an average deceleration of about 5 m/s^2 - 6 m/s^2;

b) Perform 3 stops of the SV from a speed of 72 km/h with sufficient brake pedal force (sufficient to activate the ABS);

c) Drive the SV at 72 km/h for 5 min to cool the braking system;

d) The interval between two formal tests shall at least be 3 min. During the test, if the SV remains stationary for more than 15 min, perform 3 stops of the SV from a speed of 72 km/h at an average deceleration of not less than 7 m/s^2 to warm the braking system;

e) The interval between the last warm-up stop of the braking system and a formal test shall at least be 3 min.

4.4 Data recording and processing

a) For the SV accelerator pedal position, original test data shall be adopted and shall be expressed as the percentage of the accelerator pedal travel;

b) For the lateral and longitudinal positions (in m) of SV, original data shall be used;

c) The SV speed shall be GPS speed (in km/h), and original data shall be used;

d) The longitudinal deceleration data (in m/s^2) of the SV shall be filtered by a 12-pole phaseless Butterworth filter with a cutoff frequency of 6 Hz;

e) The yaw rate data of the SV (in °/s) shall be filtered by a 12-pole phaseless Butterworth filter with a cutoff frequency of 6 Hz;

f) The angular velocity data of the steering wheel (in °/s) shall be filtered by a 12-pole phaseless Butterworth filter with a cutoff frequency of 6 Hz.

4.5 Test photos

a) Before the test equipment is installed, photos shall be taken of the SV at front left 45° and of the vehicle nameplate;

b) After the test equipment is installed, photos shall be taken of the test equipment inside and outside the SV.

5 Test Methods

5.1 The SV manufacturer may provide a pre-test report issued by a qualified third-party testing organization before the formal test. In the absence of such a pre-test report, the vehicle shall be tested once in each test cycle. If pre-test results are provided by the SV manufacturer, the test shall be performed according to the following rules:

a) The first test:

- The first test result is taken as the final result under the specific test cycle if it is the same as the pre-test result;
- If the first test result deviates much from the pre-test result, the second test is conducted.

b) The second test:

- The second test result is taken as the final result under the specific test cycle if it is the same as the pre-test result;
- The average of the first and second test results is taken as the final result in the specific test cycle if the second test result still deviates much from the pre-test result, but it is the same as the first test result;
- If the second test result deviates much from both the first test result and the pre-test result, the third test is conducted.

c) The third test:

- If the third test result is the same as either the first or the second test result, the average of the two test results is taken as the final result under the specific test cycle;
- If the third test result still deviates much from those of the previous two tests, stop the test, and conduct the test again after the reason is analyzed.

Note 1: For a single test cycle, in the formal test of AEB function, if the score of single test result is the same as that of the pre-test and the absolute value of the impact velocity deviation is ≤ 5 km/h, it is considered that the result of formal test is the same as the pre-test result; otherwise, it is considered that there is a sharp deviation between them. In the formal test of FCW function, if the score of single test result is the same as that of pre-test, it is considered that the result of formal test is the same as the pre-test result; otherwise, it is considered that there is a large deviation between them.

Note 2: For a single test cycle, if there is a sharp deviation between the final test result and the pre-test result, the test shall be recorded as invalid. After a total of 3 tests are recorded as invalid, the pre-test result shall no longer be used. Only 1 test shall be conducted in each follow-up test cycle.

5.2 Annex A gives the detailed rules for AEB car-to-car test.

5.3 Annex B gives the detailed rules for AEB VRU test.

5.4 Annex C gives the detailed rules for identification and response test of special shape targets.

Annex A
Detailed Rules for AEB Car-to-car Test

A.1 FCW function test

A.1.1 CCRs scenario

A.1.1.1 Test overview

This scenario is used to test the FCW function (i.e., the ability of the SV to identify stationary TV ahead and give a warning). The test cycle is shown in Table A.1.

Table A.1 FCW CCRs Scenario

SV Speed (km/h)	TV Speed (km/h)	Clearance at the Start of Test (m)	Overlap	Target Type
72	0	150	100%	Passenger car target vehicle
72	0	150	100%	Truck target vehicle

A.1.1.2 Test procedure

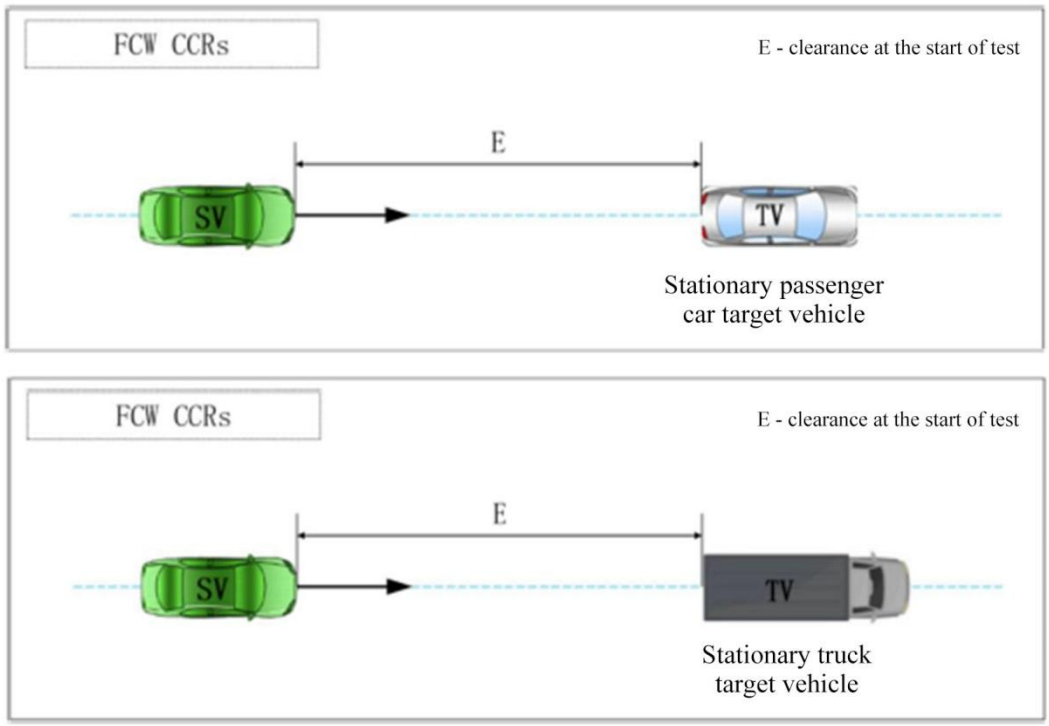


Fig. A.1 FCW CCRs Scenario

a) Park the TV stationary in the running path of the SV, with the TV's central axis coinciding with the SV path and its running direction consistent with that of the SV;

b) Set the rear center of the TV as the impact point for recording the longitudinal and lateral relative positions of the two vehicles. The impact point for each test shall be the same, as shown in Fig. A.1;

c) When the SV reaches 72 km/h and the clearance reaches 150 m, start the formal test and record valid data;

d) After the SV detects the TV, if FCW gives an alarm when TTC is ≥ 2.1 s, or FCW fails to give an alarm when TTC is < 1.9 s (90% of 2.1 s), end the test;

e) After the test, steer or brake the SV to avoid collision with the TV.

A.1.1.3 Test requirements

a) The speed shall be kept stable. After the test starts, the SV speed shall be kept at (72 ± 1) km/h;

b) After the test starts, the angular velocity of the steering wheel of the SV shall not exceed 15°/s, and the lateral offset between SV and TV shall not exceed ± 0.2 m;

c) Before the test ends, the SV shall not suffer from sudden brake or turn and its brake pedal shall not be pressed. After the start of the test, its yaw rate shall not exceed ± 1.0°/s;

d) During the test, the accelerator pedal position change of the SV shall not be greater than ± 5% of the full range.

A.1.2 CCRm scenario

A.1.2.1 Test overview

This scenario is used to test the FCW function (i.e., the ability of the SV to identify low-velocity TV ahead and give a warning). The test cycle is shown in Table A.2.

Table A.2 FCW CCRm Scenario

SV Speed (km/h)	TV Speed (km/h)	Clearance at the Start of Test (m)	Overlap
80	20	150	100%

A.1.2.2 Test procedure

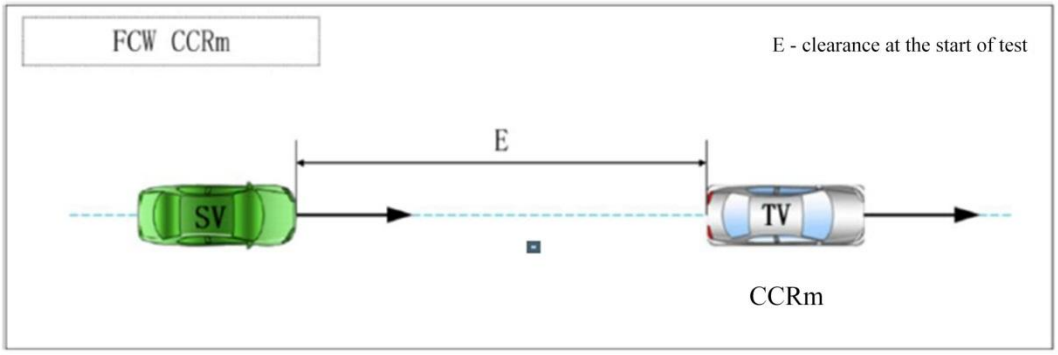


Fig. A.2 FCW CCRm Scenario

a) Accelerate the TV to 20 km/h first, and drive along the path of the SV in front of it, with the TV's central axis coinciding with the SV path and its running direction consistent with that of the SV;

b) Start to accelerate the SV to 80 km/h at an appropriate time and drive it forward, as shown in Fig. A.2;

c) After the two vehicles reach a stable speed, make the SV gradually approach the TV. When the rear clearance between the two vehicles is reduced to 150 m, start the test and record valid data;

d) After the SV detects the TV, if the FCW gives an alarm when TTC is ≥ 2.0 s, or FCW fails to give an alarm when TTC is ≤ 1.8 s (90% of 2.0 s), end the test;

e) After the test, steer or brake the SV to avoid collision with the TV.

A.1.2.3 Test requirements

a) The speed shall be kept stable. After the test starts, the SV speed shall be kept at (80 ± 1) km/h and the TV speed at (20 ± 1) km/h;

b) After the test starts, the angular velocity of the steering wheel of the SV shall not exceed 15°/s, and the lateral offset between SV and TV shall not exceed ± 0.2 m;

c) Before the test ends, the SV shall not suffer from sudden brake or turn and its brake pedal shall not be pressed. After the start of the test, the yaw rate of both the SV and TV shall not be greater than ± 1.0°/s;

d) During the test, the accelerator pedal position change of the SV shall not be greater than ± 5% of the full range.

A.2 AEB function test

A.2.1 CCRs scenario with passenger car target vehicle

A.2.1.1 Test overview

This scenario is used to test the AEB function (i.e., the ability of the SV to identify and avoid collision with the stationary passenger car ahead). The test cycle is shown in Table A.3.

Table A.3 CCRs Scenario with Passenger Car Target Vehicle

SV Speed (km/h)	TV Speed (km/h)	Overlap	Clearance at the Start of Test (m)	Weather
30	0	+50% or -50%	80	Sunny
50	0	+50% or -50%	120	Sunny
30	0	100%	80	Rainy
50	0	100%	120	Rainy

A.2.1.2 Test procedure

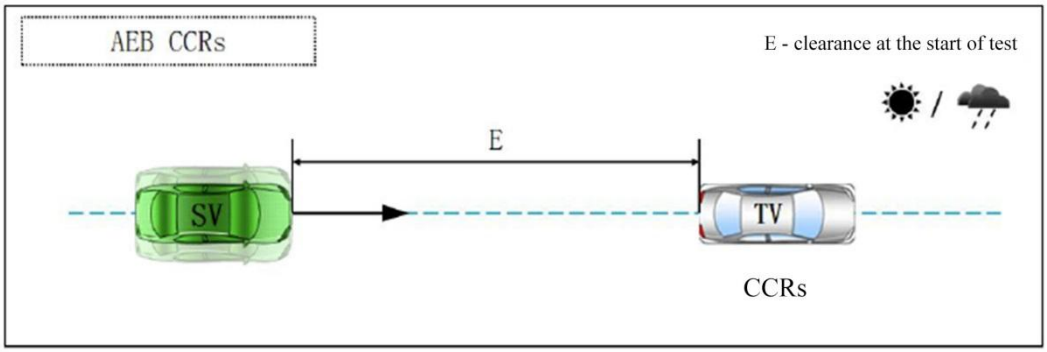


Fig. A.3 CCRs Scenario with Passenger Car Target Vehicle

a) Set the SV path and the longitudinal axis of TV according to the collision overlap specified in Table A.3. Perform the test with +50% or -50% overlap selected randomly at 30 km/h in sunny test cycle, and with -50% or +50% overlap (with the opposite positive/negative value opposite to that for 30 km/h test cycle) at 50 km/h in sunny test cycle;

b) Park the TV stationary ahead of the SV, and set the impact point on its rear for recording the longitudinal and lateral relative positions of the two vehicles. The impact point for each test in sunny test cycle shall be set according to the overlap determined in step a);

c) Accelerate the SV to the speed specified in Table A.3 when it is more than 150 m away from the TV, and make it gradually approach the TV after its speed is stable;

d) When the clearance between the two vehicles is reduced to the clearance at the start of test specified in Table A.3, start the test and record data;

e) If the SV collides with the TV or the collision is avoided, end the test.

A.2.1.3 Test requirements

a) After the test starts, the angular velocity of the steering wheel of the SV shall not exceed 15°/s;

b) During approaching, the lateral offset between the SV and the TV shall not be greater than ± 0.2 m;

c) During approaching, the yaw rate of the SV shall not exceed ± 1.0°/s;

d) The SV speed shall be kept at (30 ± 1) km/h and (50 ± 1) km/h. The brake pedal shall not be pressed before the test ends;

e) The accelerator pedal position change of the SV shall not exceed ± 5% of the full range;

f) For a rainy test cycle, the rainfall shall start 5 min before the start of the test and be stabilized at short-term moderate rain level (short-term rainfall of 3.5 ± 0.3 mm/h), and the illuminance shall not be lower than 180 lux;

g) For a rainy test cycle, during the test, the low beam of the SV shall be turned on, and the wiper shall be set to the middle level, or a high sub-level under the middle level if it is divided into several sub-levels.

Note: Refer to T/CMSA 0013-2019 *The Grade of Rainfall in Short Time Weather Service* for the grade of short-term rainfall.

A.2.2 CCRs scenario with truck target vehicle

A.2.2.1 Test overview

This scenario is used to test the AEB function (i.e., the ability to identify and avoid collision with the stationary truck ahead). The test cycle is shown in Table A.4.

Table A.4 CCRs Scenario with Truck Target Vehicle

SV Speed (km/h)	TV Speed (km/h)	Illumination Condition	Clearance at the Start of Test (m)	Overlap
45	0	Daytime	100	100%, ± 50% *
50	0	Nighttime	120	100%, ± 50% *
55	0	Daytime	140	100%, ± 50% *
60	0	Nighttime	160	100%, ± 50% *

Note: The test cycle with ± 50% overlap is a monitoring item.

A.2.2.2 Test procedure

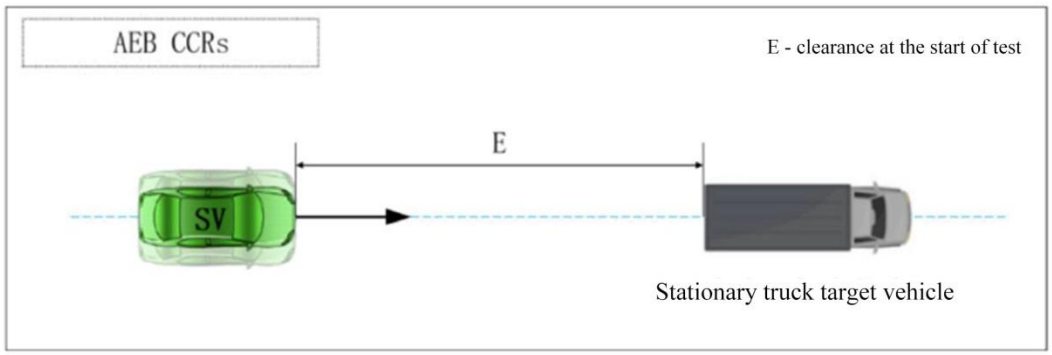


Fig. A.4 CCRs Scenario with Truck Target Vehicle

a) Park the TV stationary ahead of the SV, and set the impact point on its rear for recording the longitudinal and lateral relative positions of the two vehicles. The impact point for each test shall be set according to the overlap set in Table A.4;

b) Start to accelerate the SV to the speed specified in Table A.4 before it is more than 180 m away from the TV, and make it gradually approach the TV after its speed is stable;

c) When the clearance between the two vehicles is reduced to the clearance at the start of test specified in Table A.4, start the test and record data;

d) If the SV collides with the TV or the collision is avoided, end the test.

A.2.2.3 Test requirements

a) After the test starts, the angular velocity of the steering wheel of the SV shall not exceed 15°/s;

b) During approaching, the lateral offset between the SV and the TV shall not be greater than ± 0.2 m;

c) During approaching, the yaw rate of the SV shall not exceed ± 1.0°/s;

d) The SV speed shall be kept at (45 ± 1) km/h, (50 ± 1) km/h, (55 ± 1) km/h and (60 ± 1) km/h. The brake pedal shall not be pressed before the test ends;

e) The accelerator pedal position change of the SV shall not exceed ± 5% of the full range;

f) For a nighttime test cycle, there shall be no background illumination during the test, and the high beam of the SV shall be turned on.

A.2.3 CCRm scenario with passenger car target vehicle

A.2.3.1 Test overview

This scenario is used to test the AEB function (i.e., the ability to identify and avoid collision with the low-speed passenger car target vehicle ahead). The test cycle is shown in Table A.5.

Table A.5 CCRm Scenario with Passenger Car Target Vehicle

SV Speed (km/h)	TV Speed (km/h)	Clearance at the Start of Test (m)	Overlap
60	20	150	100%
70	20	150	100%
80	20	150	100%

A.2.3.2 Test procedure

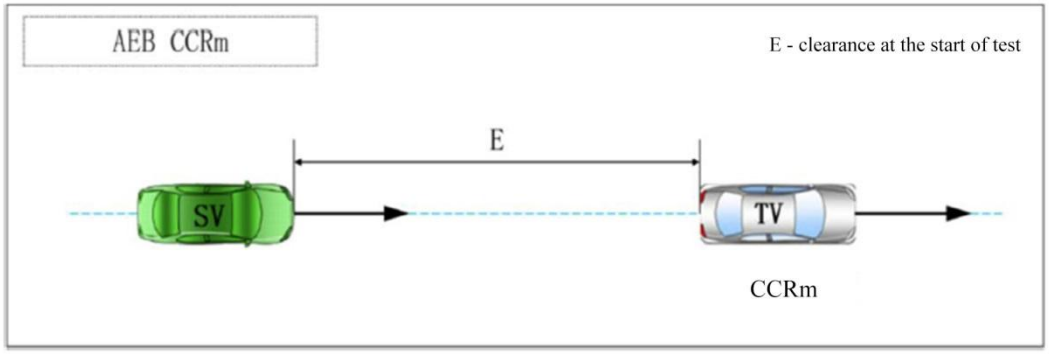


Fig. A.5 CCRm Scenario with Passenger Car Target Vehicle

a) Accelerate the TV to 20 km/h first, and drive along the path of the SV in front of it, with the TV's central axis coinciding with the SV path and its running direction consistent with that of the SV;

b) Start to accelerate the SV to the speed required in Table A.5 at an appropriate time and drive it forward;

c) After the two vehicles reach a stable speed, make the SV gradually approach the TV. When the rear clearance between the two vehicles is reduced to 150 m, start the test and record valid data;

d) If the SV collides with the TV or the collision is avoided, end the test.

A.2.3.3 Test requirements

a) After the test starts, the angular velocity of the steering wheel of the SV shall not exceed 15°/s;

b) During approaching, the lateral offset between the SV and the TV shall not be greater than ± 0.2 m;

c) During approaching, the yaw rate of the SV shall not exceed ± 1.0°/s;

d) The SV speed shall be kept at (60 ± 1) km/h, (70 ± 1) km/h and (80 ± 1) km/h, and the TV speed at (20 ± 1) km/h;

e) The brake pedal of the SV shall not be pressed before the test ends, and the accelerator pedal position change of the SV shall not exceed ± 5% of the full range.

A.2.4 CCRm scenario with express tricycle target vehicle

A.2.4.1 Test overview

This scenario is used to test the AEB function (i.e., the ability to identify and avoid collision with the low-speed express tricycle ahead). The test cycle is shown in Table A.6.

Table A.6 Test Cycle for CCRm Scenario with Express Tricycle Target Vehicle

SV Speed (km/h)	TV Speed (km/h)	Clearance at the Start of Test (m)	Overlap
35	15	150	100%
55	15	150	100%

A.2.4.2 Test procedure

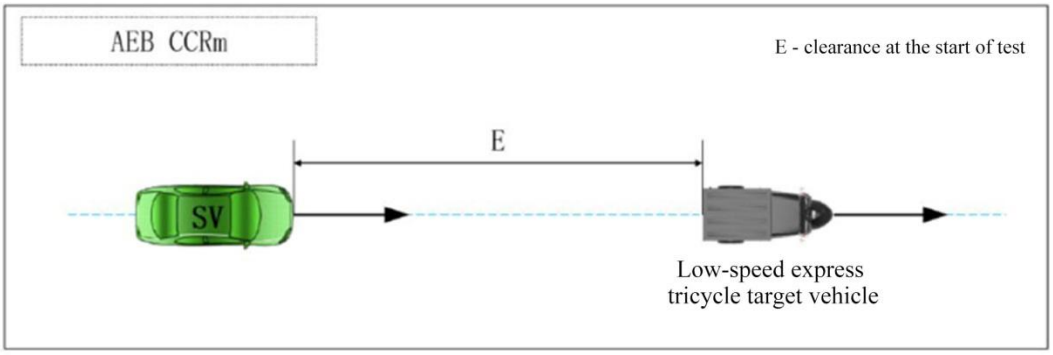


Fig. A.6 CCRm Scenario with Tricycle Target Vehicle

a) Accelerate the TV to 15 km/h first, and drive along the path of the SV in front of it, with the TV's central axis coinciding with the SV path and its running direction consistent with

that of the SV;

b) Start to accelerate the SV to the speed required in Table A.6 at an appropriate time and drive it forward;

c) After the two vehicles reach a stable speed, make the SV gradually approach the TV. When the rear clearance between the two vehicles is reduced to 150 m, start the test and record valid data;

d) If the SV collides with the TV or the collision is avoided, end the test.

A.2.4.3 Test requirements

a) After the test starts, the angular velocity of the steering wheel of the SV shall not exceed 15°/s;

b) During approaching, the lateral offset between the SV and the TV shall not be greater than ± 0.2 m;

c) During approaching, the yaw rate of the SV shall not exceed ± 1.0°/s;

d) The SV speed shall be kept at (35 ± 1) km/h and (55 ± 1) km/h, and the TV speed at (15 ± 1) km/h;

e) The brake pedal of the SV shall not be pressed before the test ends, and the accelerator pedal position change of the SV shall not exceed ± 5% of the full range.

A.2.5 Car-to-car farside car scenario

A.2.5.1 Test overview

This scenario is used to test the AEB function (i.e., the ability to identify and avoid collision with the TV ahead running from the farside). The test cycle is shown in Table A.7.

Table A.7 Car-to-car Farside Car Scenario

SV Speed (km/h)	TV Speed (km/h)	Impact Point
20	30	As per Fig. A.7

A.2.5.2 Test procedure

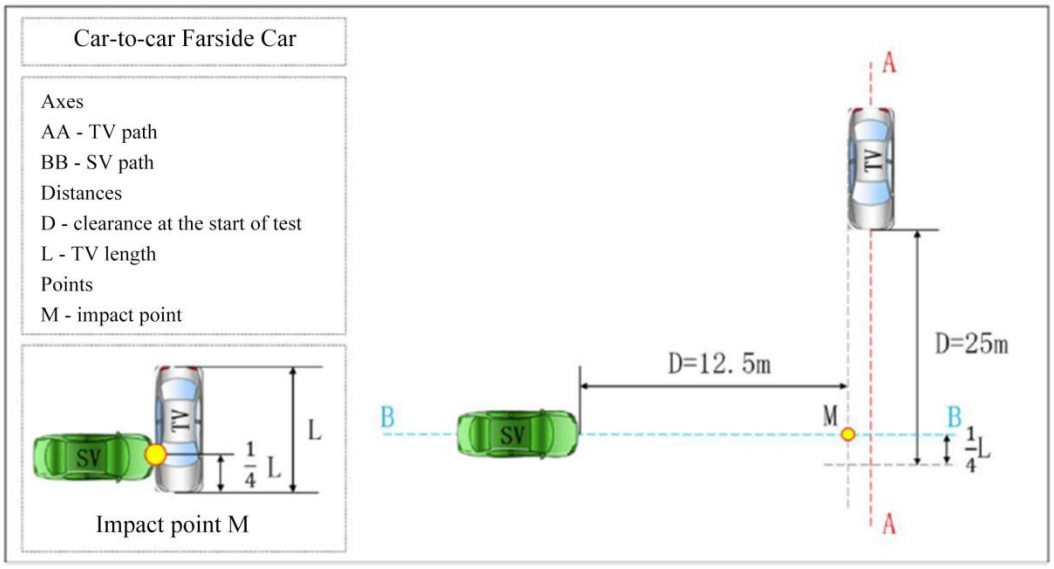


Fig. A.7 Car-to-car Farside Car Scenario

a) Set the SV and TV paths and the impact point as shown in Fig. A.7;

b) Accelerate the SV to the speed required in Table A.7 and drive it along the test path;

c) Keep the TV in pace with the SV and drive it along the test path at the speed required in Table A.7;

d) When the SV and TV run stably to the clearance at the start of test, start the test and record data;

e) If the SV collides with the TV or the collision is avoided, end the test.

A.2.5.3 Test requirements

a) After the test starts, the angular velocity of the steering wheel of the SV shall not exceed 15°/s;

b) During approaching, the yaw rate of the SV shall not exceed ± 1°/s;

c) The SV speed shall be kept at (20 ± 1) km/h, and the TV speed at (30 ± 1) km/h;

d) The brake pedal of the SV shall not be pressed before the test ends, and the accelerator pedal position change of the SV shall not exceed ± 5% of the full range.

A.2.6 Car-to-car front turn-across-path (CCFtap) scenario

A.2.6.1 Test overview

This scenario is used to test the AEB function (i.e., the ability of the SV to identify and avoid collision with the TV running in the opposite direction in a turning scenario). The test cycle is shown in Table A.8.

Table A.8 CCFtap Scenario

SV Speed (km/h)	TV Speed (km/h)	Impact Point
15	30	As per Fig. A.8

A.2.6.2 Test procedure

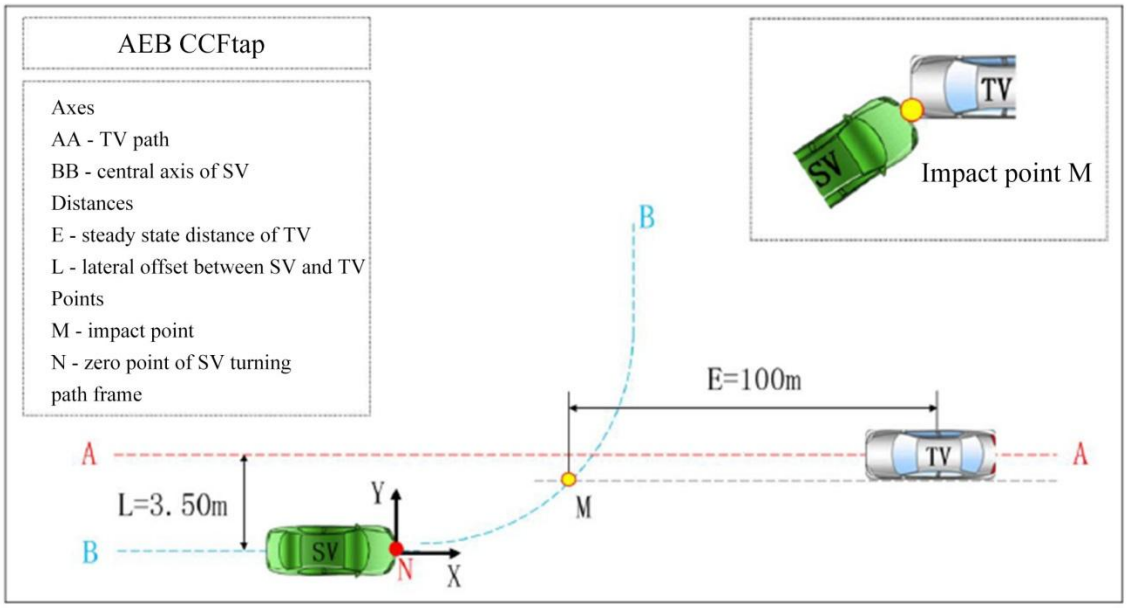


Fig. A.8 CCFtap Scenario

a) Accelerate the SV to 15 km/h at an appropriate position and drive it along the path required in Fig. A.9 and Table A.9;

b) Place the TV as specified in Fig. A.8 and keep it in pace with the SV. Accelerate the TV to

30 km/h at an appropriate position and drive it at the constant speed along the test path. Set the impact point with the SV as M;

c) When the SV speed becomes stable before point N, start the test and record valid data;

d) If the SV collides with the TV or the collision is avoided, end the test.

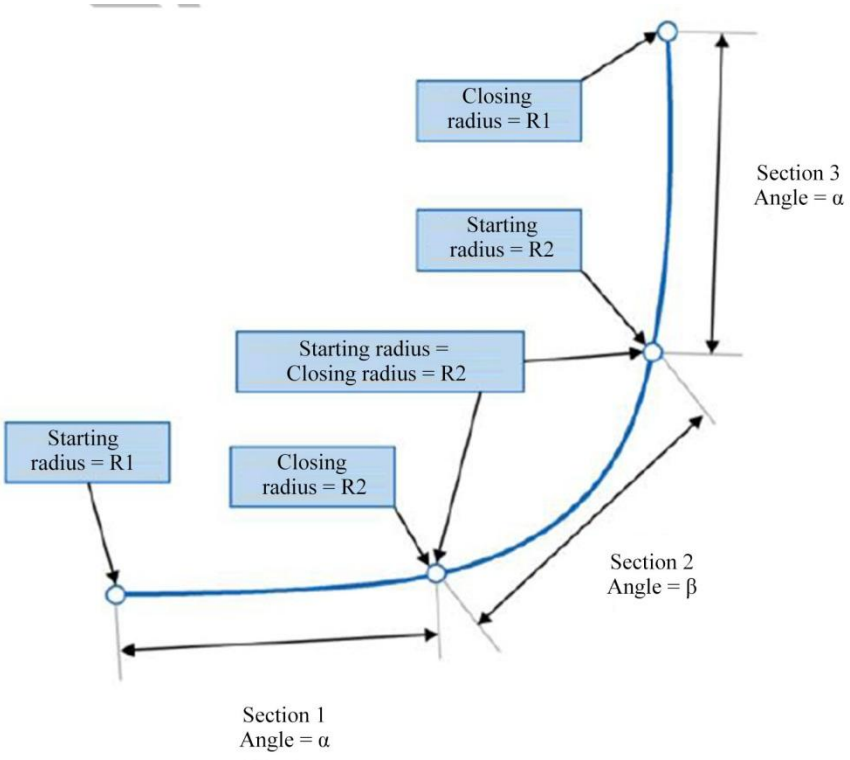


Fig. A.9 Requirements for Left-turn Path of SV

Table A.9 Requirements for Left-turn Path of SV

Speed of SV (km/h)	Section 1 (Variable Curvature)			Section 2 (Constant Curvature)			Section 3 (Variable Curvature)		
	Starting radius R1 (m)	Closing radius R2 (m)	Angle α (deg)	Starting radius R2 (m)	Closing radius R2 (m)	Angle β (deg)	Starting radius R2 (m)	Closing radius R1 (m)	Angle α (deg)
15	1500	11.75	20.93	11.75	11.75	48.14	11.75	1500	20.93

A.2.6.3 Test requirements

a) The SV speed shall be kept at (15 ± 1) km/h, and the TV speed at (30 ± 1) km/h;

b) The brake pedal of the SV shall not be pressed before the test ends;

c) The accelerator pedal position change of the SV shall not exceed ± 5% of the full range;

d) The turn signal lamp of the SV shall be turned on at least 10 s before the turn.

A.3 Advanced assistance function verification test

A.3.1 FCW auxiliary warning form

Determine the FCW auxiliary warning form with the SV at 80 km/h and TV at 20 km/h in the CCRm scenario as described in A.2.3.

A.3.2 Active seat belt pre-tensioning function

Determine whether the active seat belt pre-tensioning function is available (reusable) with the SV at 80 km/h and TV at 20 km/h in the CCRm scenario as described in A.2.3.

A.3.3 Emergency steering collision avoidance function

The SV provided with emergency steering collision avoidance functions (such as AES and ESA) is verified as per the verification scheme provided by the vehicle manufacturer.

A.3.4 V2X function

The SV provided with V2X function is verified as per the verification scheme provided by the vehicle manufacturer.

Annex B
Detailed Rules for AEB VRU Test

B.1 AEB car-to-pedestrian test

B.1.1 Car-to-pedestrian longitudinal adult 25% (CPLA-25)

a) The centerline of APT is parallel to that of the SV, with the distance from the centerline of the SV being 25% of the vehicle width. The test is performed with the pedestrian moving forward at a constant speed of 5 km/h and the SV running at 35 km/h and 55 km/h, respectively. The impact point is located at 25% of the vehicle width, i.e. point M in Fig. B.1. Data recording starts when the SV is 150 m away from the pedestrian's path. This test cycle is performed in sunny daytime.

b) The centerline of APT with an umbrella is parallel to that of the SV, with the distance from the centerline of the SV being 25% of the vehicle width. The test is performed with the pedestrian moving forward at a constant speed of 5 km/h and the SV running at 35 km/h and 55 km/h, respectively. The impact point is located at 25% of the vehicle width, i.e. point M in Fig. B.1. Data recording starts when the SV is 150 m away from the pedestrian's path. This test cycle is performed in rainy condition. The rainfall shall start 5 min before the start of the test and be stabilized at short-term moderate rain level (short-term rainfall of 3.5 ± 0.3 mm/h), and the illuminance shall not be lower than 180 lux. During the test, the low beam of the SV shall be turned on, and the wiper shall be set to the middle level, or a high sub-level under the middle level if it is divided into several sub-levels.

For an APT with an umbrella, the umbrella is fixed to the APT with a flexible bracket. The umbrella used is black 3-fold umbrella with its umbrella cloth made of pongee or coated with vinyl and a radius of 55 cm, as shown in Fig. B.2.

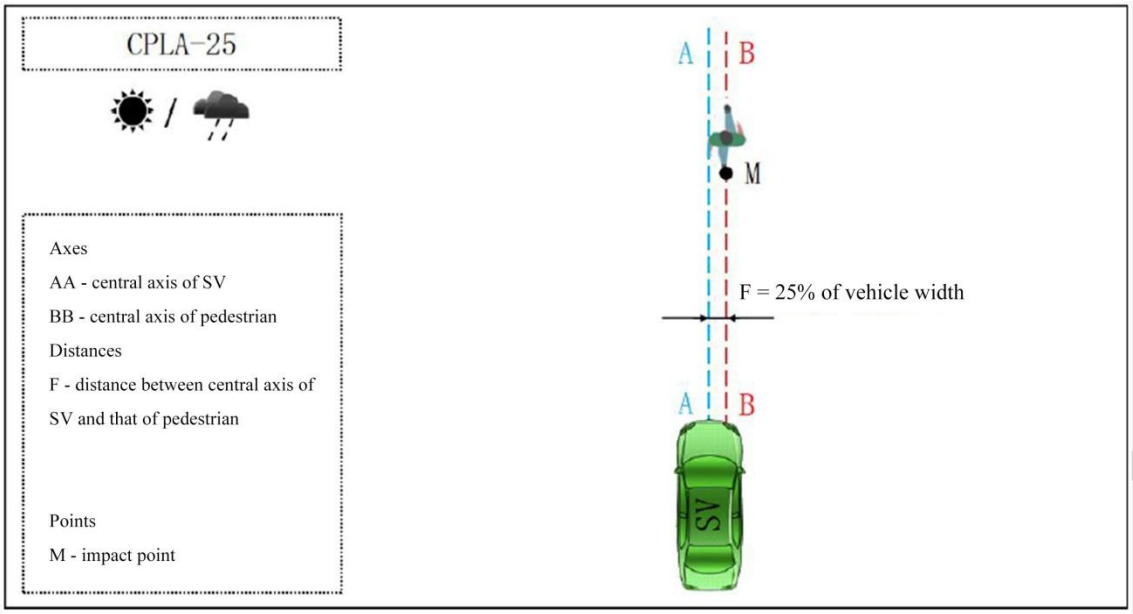


Fig. B.1 CPLA-25 Scenario

Fig. B.2 Appearance of APT with an Umbrella

B.1.2 Car-to-pedestrian nearside adult 25% (CPNA-25)

The path of APT is perpendicular to that of the SV. The pedestrian accelerates to 5 km/h through a 1 m long acceleration section and then moves at a constant speed. The test is performed with the SV running at 20 km/h, 40 km/h and 60 km/h, respectively. The impact point is located at 25% of the vehicle width, i.e. point M in Fig. B.3. Data recording starts when the SV is 150 m away from the pedestrian's path. This test cycle is performed in the nighttime.

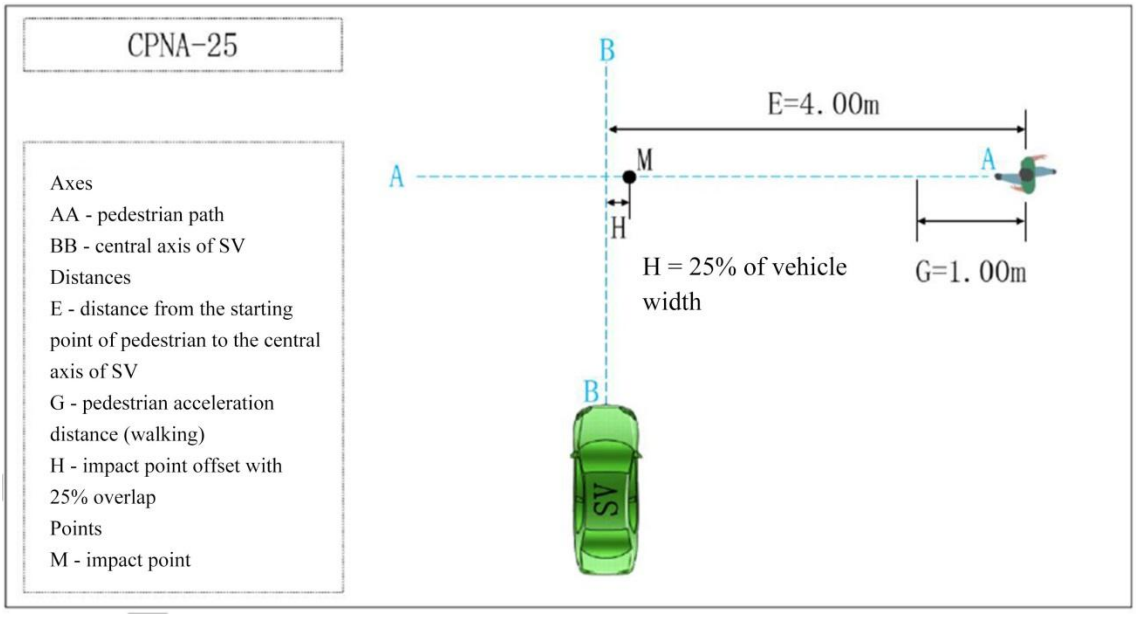


Fig. B.3 CPNA-25 Scenario

B.1.3 Car-to-pedestrian farside obstruction adult 50% (CPFOA-50)

The path of APT is perpendicular to that of the SV. The pedestrian accelerates to 5 km/h through a 1 m long acceleration section and then moves at a constant speed. The test is carried out with the SV running at 20 km/h and 40 km/h, respectively. The impact point is located at 50% of the vehicle width, i.e. point M in Fig. B.4. Data recording starts when the SV is 150 m away from the pedestrian's path. This test cycle is performed in the nighttime, with the low beam of the obstruction vehicle turned on.

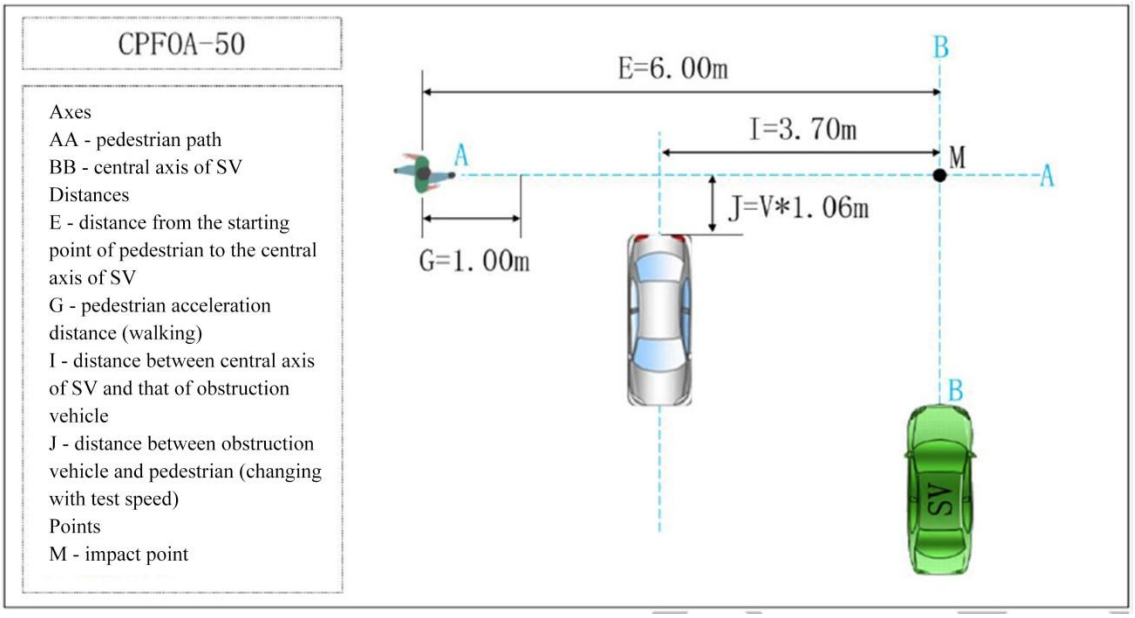


Fig. B.4 CPFOA-50 Scenario

B.1.4 Car-to-pedestrian nearside single obstruction child 50% (CPNSOC-50)

The path of CPT is perpendicular to that of the SV. The pedestrian accelerates to 5 km/h through a 1 m long acceleration section and then moves at a constant speed. The test is carried out with the SV running at 40 km/h and 60 km/h, respectively. The impact point is located at 50% of the vehicle width, i.e. point M in Fig. B.5. Data recording starts when the SV is 150 m away from the pedestrian's path. This test cycle is performed in the daytime.

In this scenario, there are 2 obstruction vehicles. Obstruction vehicle A with its right front end close to the pedestrian is a 4.5 m - 4.95 m long light-colored car. Obstruction vehicle B behind obstruction vehicle A is a 4.4 m - 4.8 m long multi-purpose passenger car in any color.

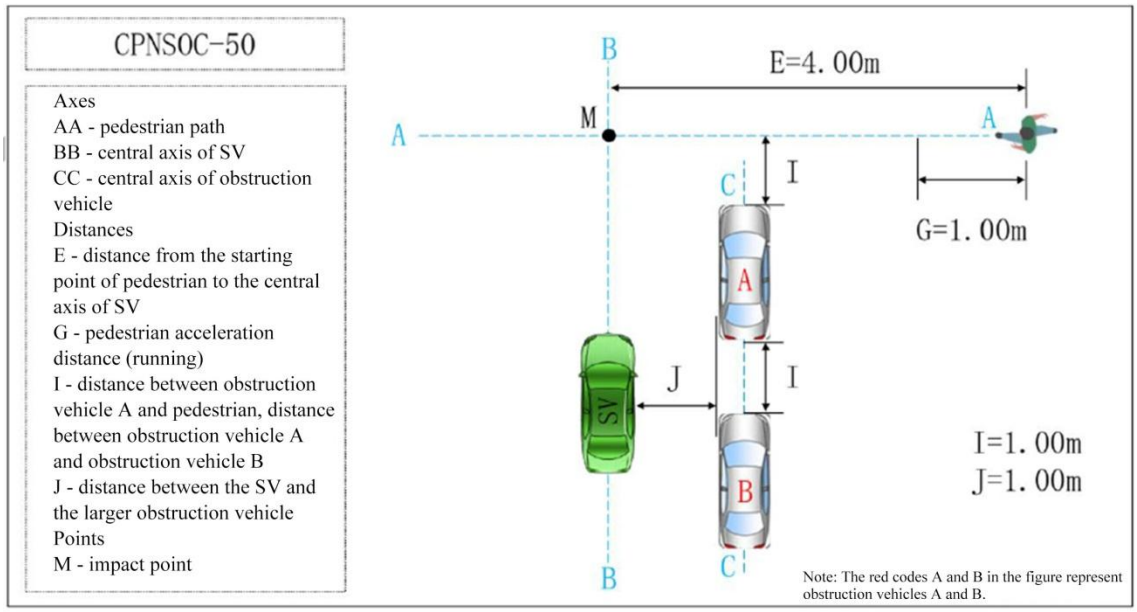


Fig. B.5 CPNSOC-50 Scenario

B.1.5 Car-to-pedestrian nearside double obstruction child 50% (CPNDOC-50)

The path of CPT is perpendicular to that of the SV. The pedestrian accelerates to 5 km/h through a 1 m long acceleration section and then moves at a constant speed. The test is carried out with the SV running at 20 km/h and 30 km/h, respectively. The impact point is located at 50% of

the vehicle width, i.e. point M in Fig. B.6. Data recording starts when the SV is 150 m away from the pedestrian's path. This test cycle is performed in the daytime.

In this scenario, there are 3 obstruction vehicles. Obstruction vehicles A and B are located in consistent with those in CPNSOC-50. Obstruction vehicle C is a 4.4 m - 4.8 m long passenger car in any color.

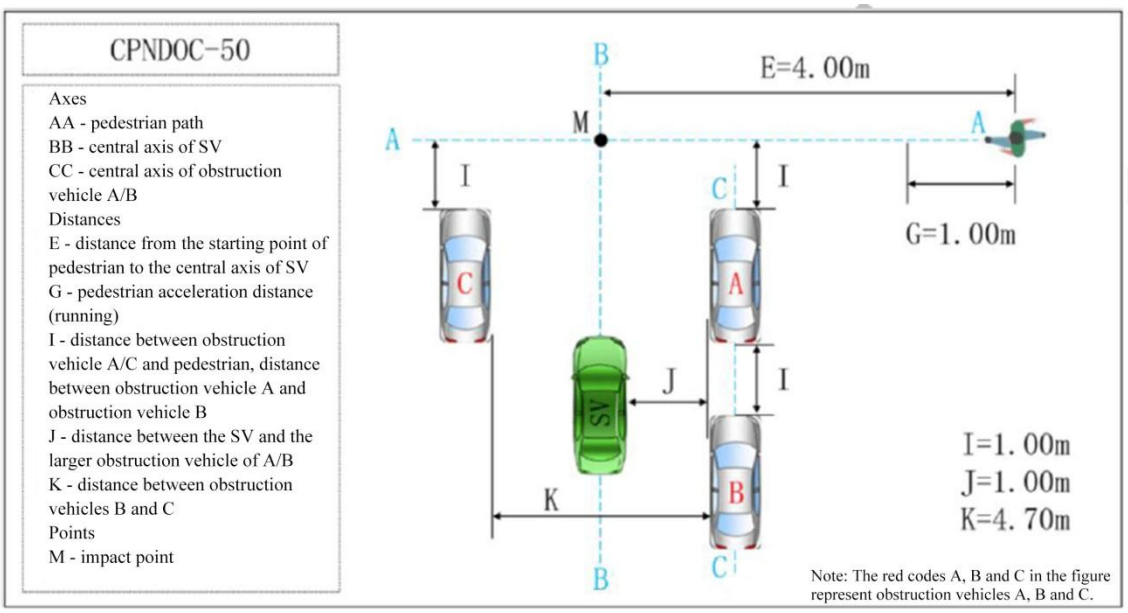


Fig. B.6 CPNDOC-50 Scenario

B.1.6 Car-to-pedestrian turning adult 50% (CPTA-50)

The APT accelerates to 5 km/h and then moves at a constant speed. The SV accelerates to 15 km/h, runs forward along the test path, and then turns left along the path (with the turn signal lamp of the SV turned on at least 10 s before the turn). The SV is kept in pace with the pedestrian (in the absence of intervention of any driver assistance function, the SV collides with the pedestrian at the impact point at 50% of the vehicle width, as shown in Fig. B.7). Data recording starts when the rear clearance between SV and pedestrian is 150 m. This test cycle is performed in the daytime.

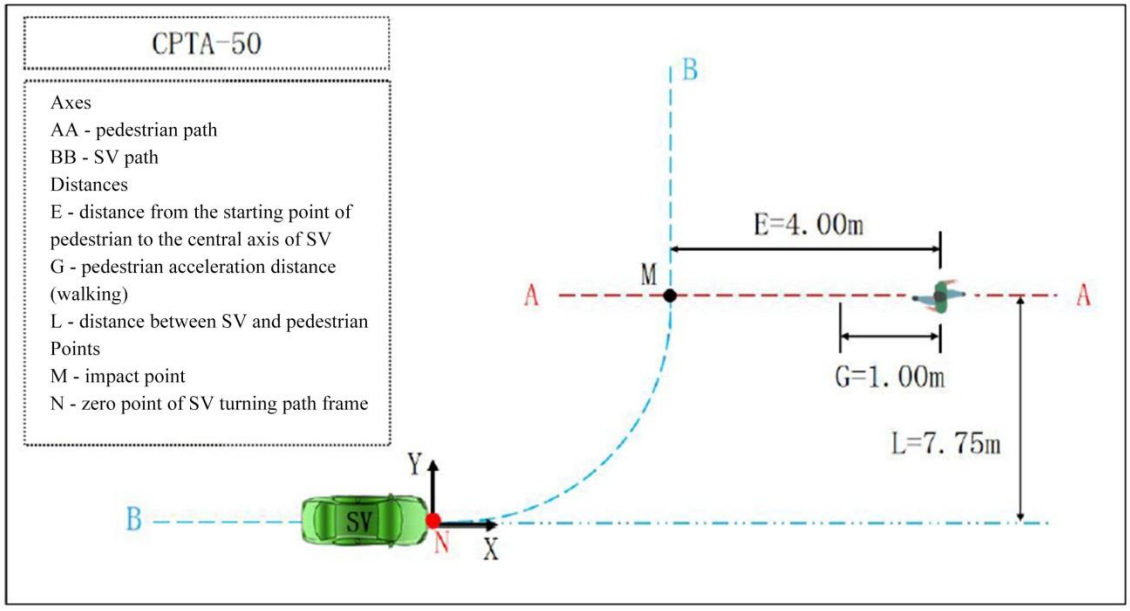


Fig. B.7 CPTA-50 Scenario

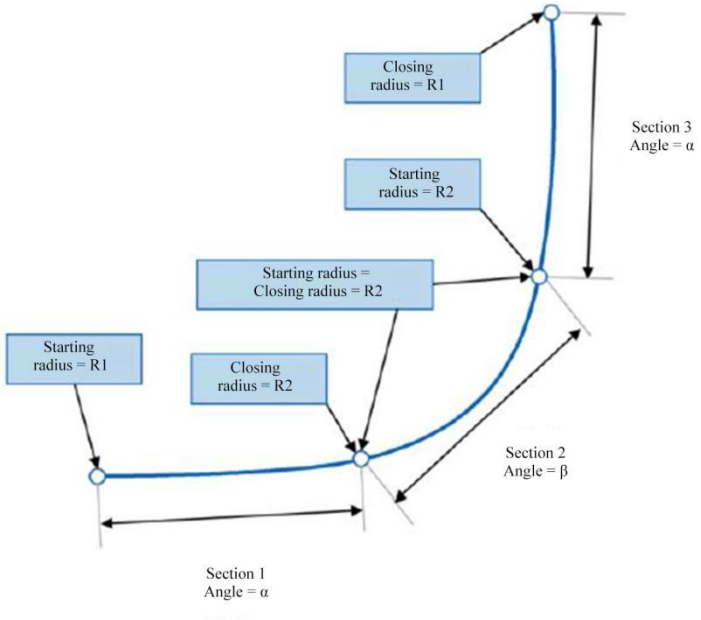


Fig. B.8 Requirements for Left-turn Path of SV

Table B.1 Requirements for Left-turn Path of SV

Speed of SV (km/h)	Section 1 (Variable Curvature)			Section 2 (Constant Curvature)			Section 3 (Variable Curvature)		
	Starting radius R1 (m)	Closing radius R2 (m)	Angle α (deg)	Starting radius R2 (m)	Closing radius R2 (m)	Angle β (deg)	Starting radius R2 (m)	Closing radius R1 (m)	Angle α (deg)
15	1500	11.75	20.93	11.75	11.75	48.14	11.75	1500	20.93

B.1.7 Car-to-pedestrian test requirements

For AEB car-to-pedestrian test, the test requirements include:

a) The SV speed shall be kept at the specified speed ± 1 km/h, and the dummy target speed at (5 ± 0.2) km/h;

b) The lateral offset of the SV shall not exceed the specified path ± 0.1 m;

c) Before the test ends, the SV shall not suffer from sudden brake or turn and its brake pedal shall not be pressed;

d) The accelerator pedal position change of the SV shall not exceed ± 5% of the full range;

e) For CPLA-25, CPNA-25, CPFOA-50, CPNSOC-50 and CPNDOC-50 scenarios, the angular velocity of the steering wheel of the SV shall not exceed 15°/s, and the yaw rate of the SV shall not exceed ± 1°/s.

B.2 AEB car-to-bicyclist/scooter test

B.2.1 Car-to-bicyclist longitudinal adult 50% (CBLA-50)

The path of ABT coincides with that of the SV. The bicycle accelerates to 15 km/h and then moves at a constant speed. The test is performed with the SV running at 45 km/h and 65 km/h, respectively. The impact point is located at 50% of the vehicle width, i.e. point M in Fig. B.9. Data recording starts when the SV is 150 m away from the bicycle. This test cycle is performed in the daytime.

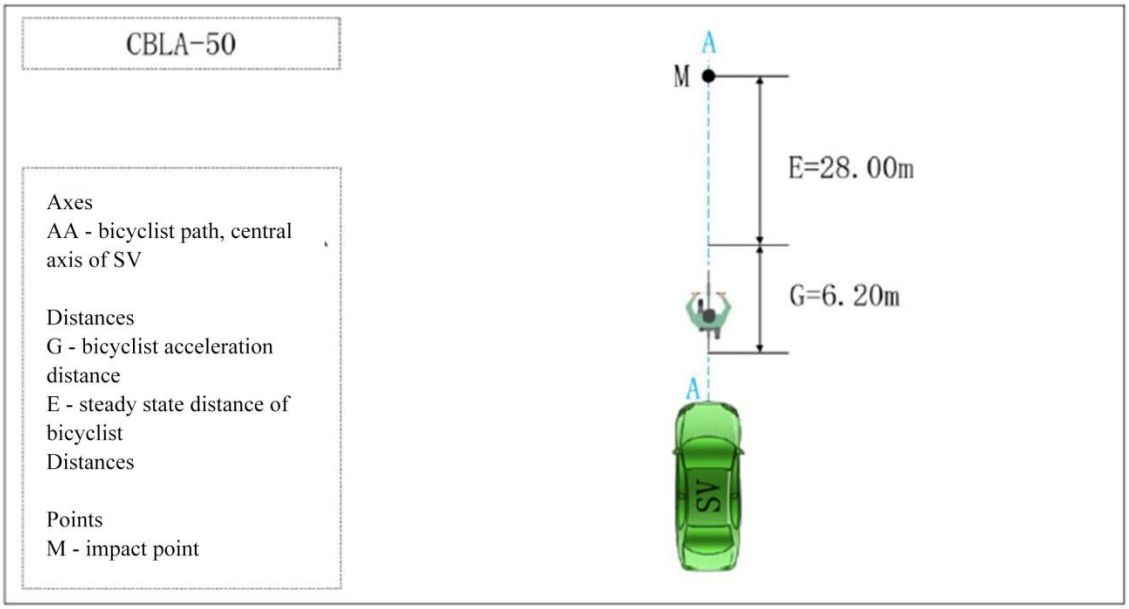


Fig. B.9 CBLA-50 Scenario

B.2.2 Car-to-bicyclist nearside adult 50% (CBNA-50)

The path of ABT is perpendicular to that of the SV. The bicycle accelerates to 15 km/h through a 4 m long acceleration section and then moves at a constant speed. The test is performed with the SV running at 20 km/h, 40 km/h and 60 km/h, respectively. The impact point is located at 50% of the vehicle width, i.e. point M in Fig. B.10. Data recording starts when the SV is 150 m away from the path of the target. This test cycle is performed in the daytime.

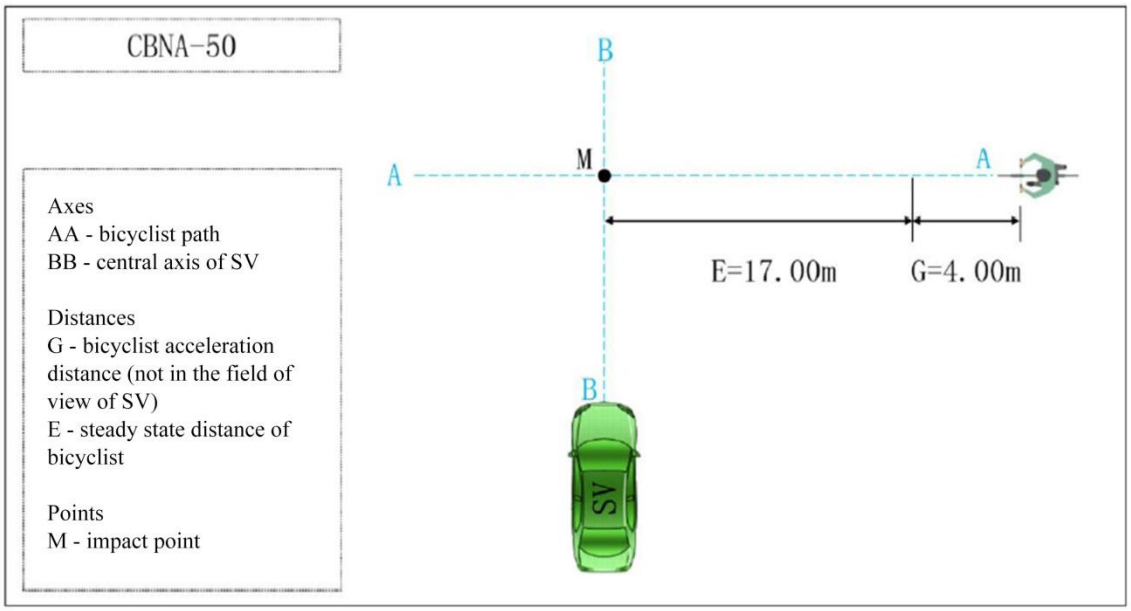


Fig. B.10 CBNA-50 Scenario

B.2.3 Car-to-scooter farside adult 50% (CSFA-50)

The path of STA is perpendicular to that of the SV. The scooter accelerates to 20 km/h and then moves at a constant speed. The test is performed with the SV running at 20 km/h, 40 km/h and 60 km/h, respectively. The impact point is located at 50% of the vehicle width, i.e. point M in Fig. B.11. Data recording starts when the SV is 150 m away from the path of the target. This test cycle is performed in the daytime.

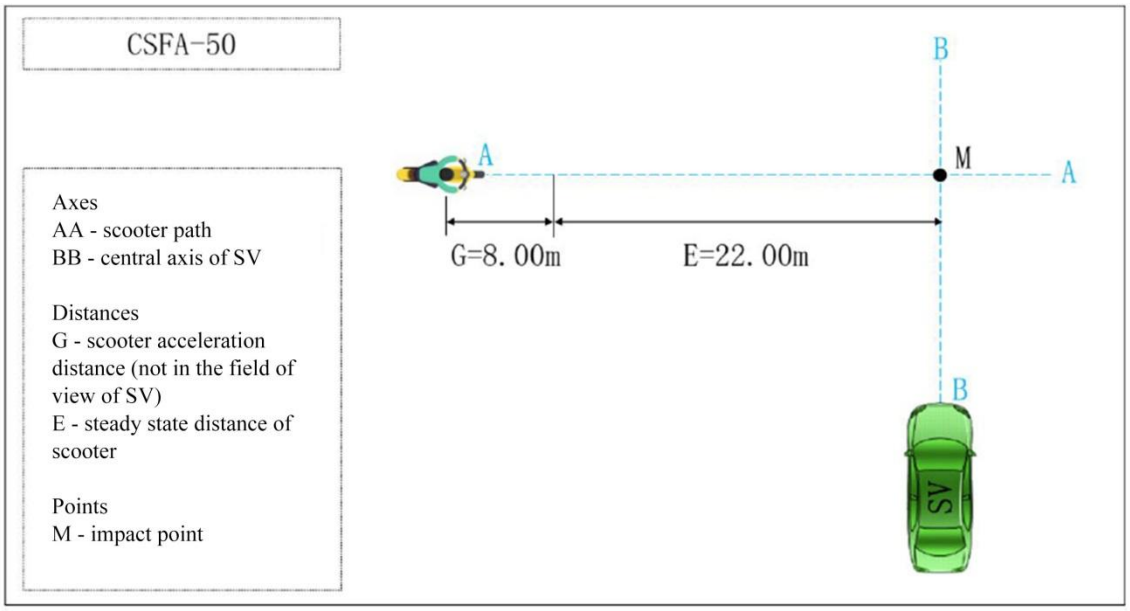


Fig. B.11 CSFA-50 Scenario

B.2.4 Car-to-scooter front turn-across-path 50% (CSFtap-50)

The STA accelerates to 20 km/h and then moves at a constant speed. The SV accelerates to 15 km/h, runs forward along the test path, and then turns left along the path (with the turn signal lamp of the SV turned on at least 10 s before the turn). The SV is kept in pace with the scooter (in the absence of intervention of any driver assistance function, the SV collides with the scooter at the impact point as shown in Fig. B.12). Data recording starts when the rear clearance between SV and scooter is 150 m. This test cycle is performed in the daytime.

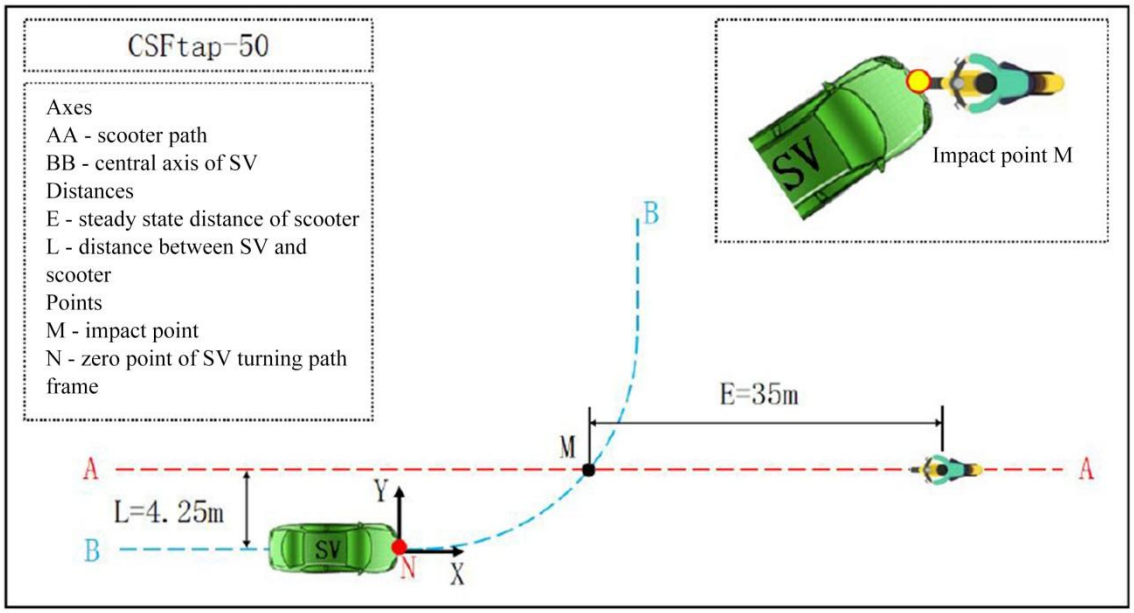


Fig. B.12 CSFtap-50 Scenario

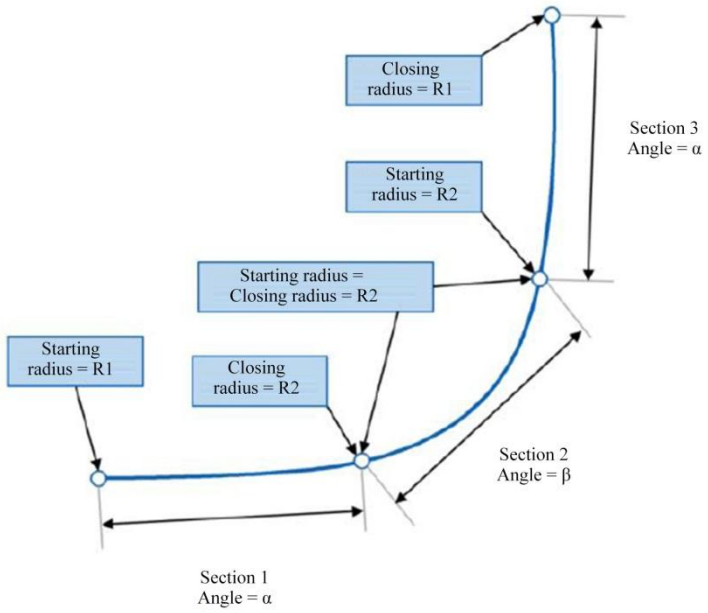


Fig. B.13 Requirements for Left-turn Path of SV

Table B.2 Requirements for Left-turn Path of SV

Speed of SV (km/h)	Section 1 (Variable Curvature)			Section 2 (Constant Curvature)			Section 3 (Variable Curvature)		
	Starting radius R1 (m)	Closing radius R2 (m)	Angle α (deg)	Starting radius R2 (m)	Closing radius R2 (m)	Angle β (deg)	Starting radius R2 (m)	Closing radius R1 (m)	Angle α (deg)
15	1500	11.75	20.93	11.75	11.75	48.14	11.75	1500	20.93

B.2.5 Requirements for car-to-bicyclist/scooter test

For AEB car-to-bicyclist/scooter test, the test requirements include:

a) The SV speed shall be kept at the specified speed ± 1 km/h, the ABT speed at (15 ± 0.5) km/h, and the STA speed at (20 ± 0.5) km/h;

b) The lateral offset of the SV shall not exceed the specified path ± 0.1 m;

c) Before the test ends, the SV shall not suffer from sudden brake or turn and its brake pedal shall not be pressed;

d) The accelerator pedal position change of the SV shall not exceed ± 5% of the full range;

e) For CBLA-50, CBNA-50 and CSFA-50 scenarios, the angular velocity of the steering wheel of the SV shall not exceed 15°/s, and the yaw rate of the SV shall not exceed ± 1°/s.

B.3 Requirements for nighttime test

B.3.1 Background illuminance

The background illuminance is an additive value to the street lamp illumination. All lamps and vehicle light shall be turned off during measurement. The position of measurement is at the impact point, i.e. point M in Fig. B.14. The maximum background illuminance shall be less than 1 lux.

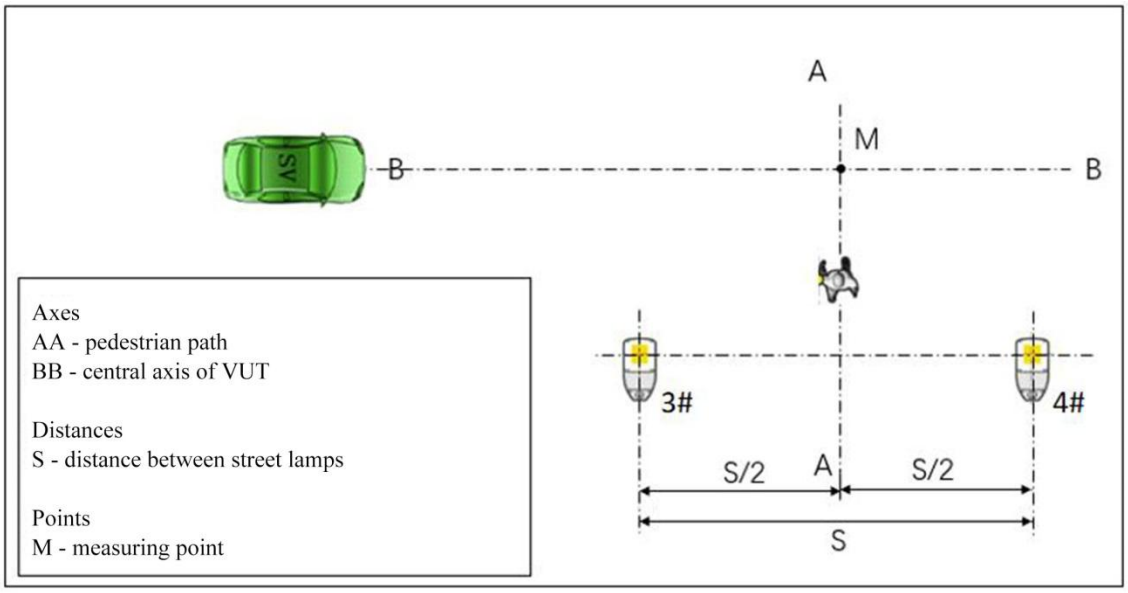


Fig. B.14 Measurement of Background Illuminance

B.3.2 Illuminance on the SV path

The illuminance on the SV path shall be measured at 11 points ($I_1 \ldots I_{11}$) along this path, as shown in Fig. B.15. The average illuminance (I) of these 11 points shall then be calculated according to Formula (1). The street lamps shall be turned on during measurement. The average illuminance shall be within the range of 16 lux < I <22 lux.

$$\bar{I} = \frac{1}{11}\sum_{1}^{n} I_i \qquad \text{(1)}$$

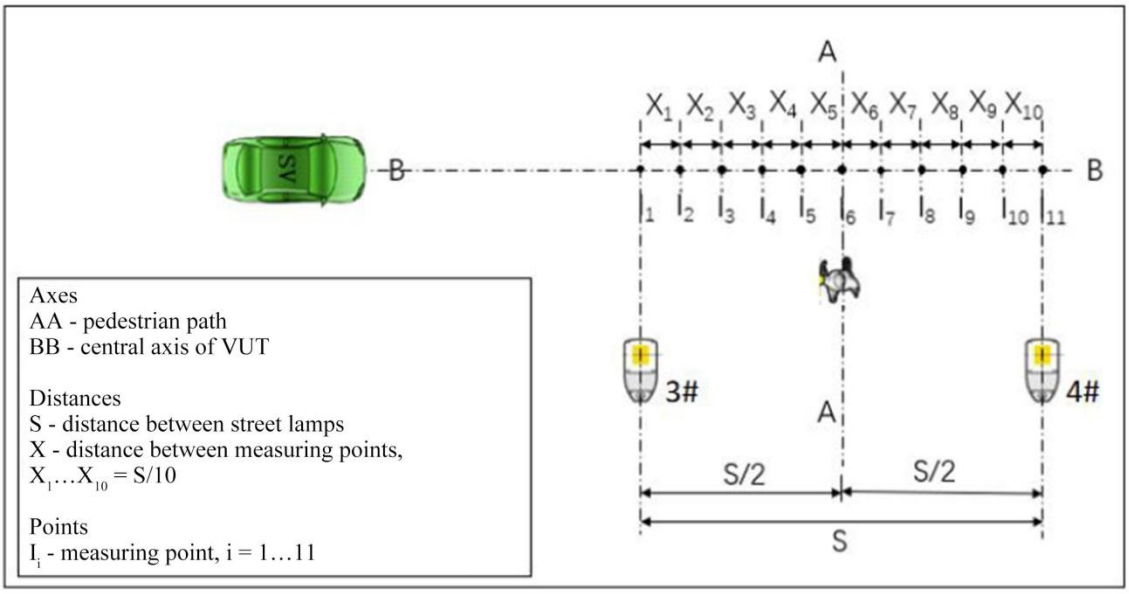


Fig. B.15 Measurement of Illuminance on the SV Path

B.3.3 Illuminance on the pedestrian path

For CPNA-25 scenario, the illuminance on the pedestrian path shall be measured at 6 points ($I_1 \ldots I_6$) along this path, as shown in Fig. B.16. The illuminance at each point shall not be less than 5 lux.

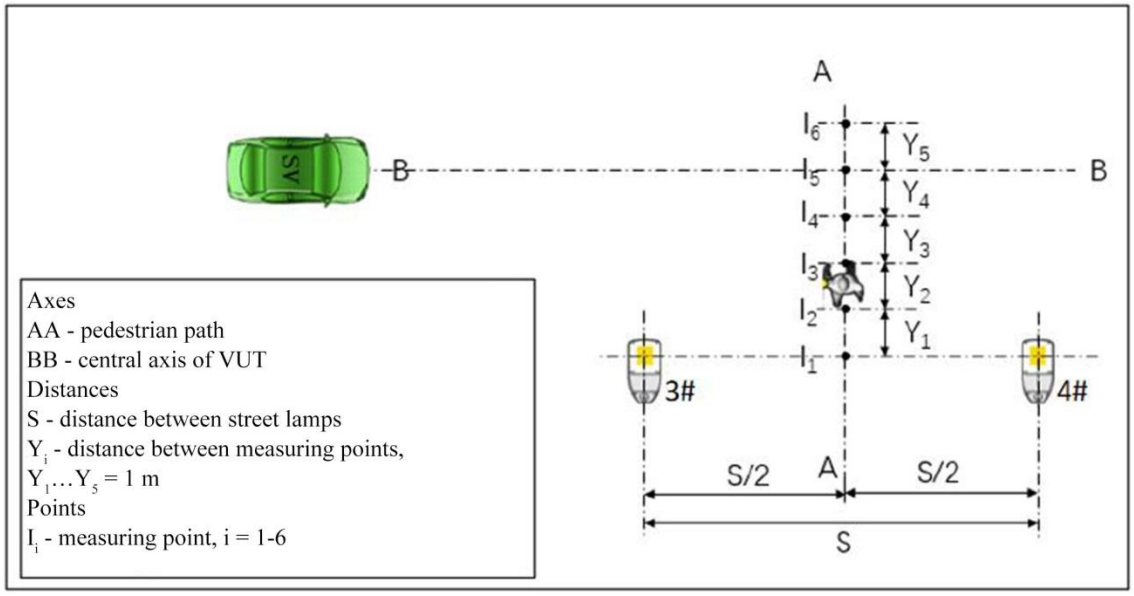


Fig. B.16 Measurement of Illuminance on the Pedestrian Path

B.3.4 Installation of street lamps

The pedestrian path is located between lamps 3 and 4, as shown in Fig. B.17. The distance between street lamps (S) is (25 ± 0.5) m, the distance between the street lamps and the SV path (D) is (4 ± 0.1) m, the height of light source of each street lamp (H) is (5 ± 0.1) m, and the angle between the ground and the lamp pole (a) is (90 ± 0.1)°. The street lamps, when installed, shall ensure no obstacles within 4 m on the right side and 6 m on the left side of the SV path.

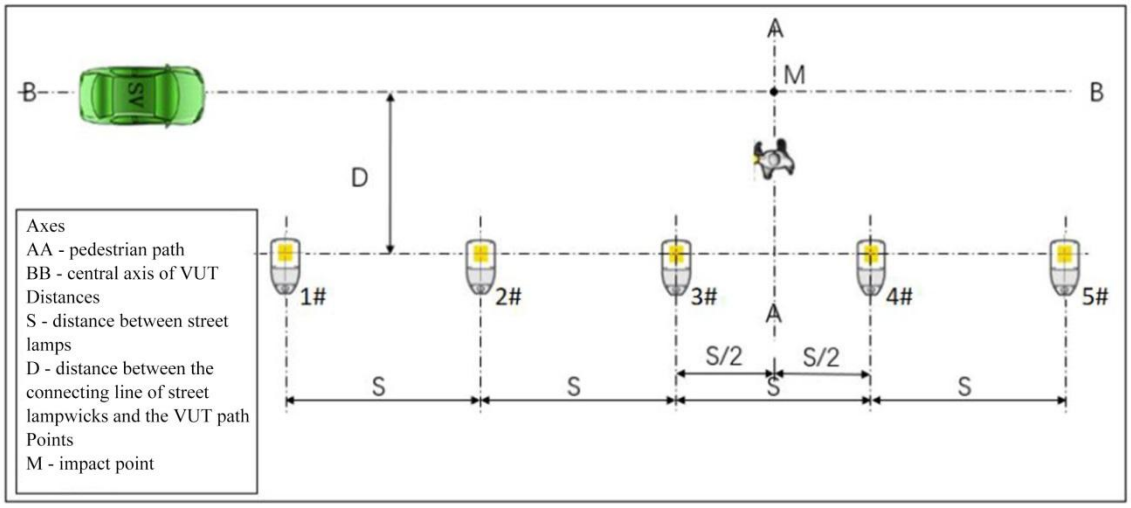


Fig. B.17 Installation Positions of Street Lamps

Annex C
Detailed Rules for Identification and Response Test of Special Shape Targets

C.1 Identification of and response to special shape target

C.1.1 Test overview

This scenario is used to test the AEB function (i.e., the ability of the SV to identify and avoid collision with the stationary special shape target ahead). The test cycle is shown in Table C.1.

Table C.1 Car-to-special-shape-target Rear Stationary Scenario

SV Speed (km/h)	TV Speed (km/h)	Clearance at the Start of Test (m)	Target Type	Time
40	0	80	Corrugated Carton	Daytime
50	0	120	Corrugated Carton	Daytime
40	0	80	White Foam Box	Daytime
50	0	120	White Foam Box	Daytime
40	0	80	White Woven Bag	Daytime
50	0	120	White Woven Bag	Daytime

C.1.2 Test procedure

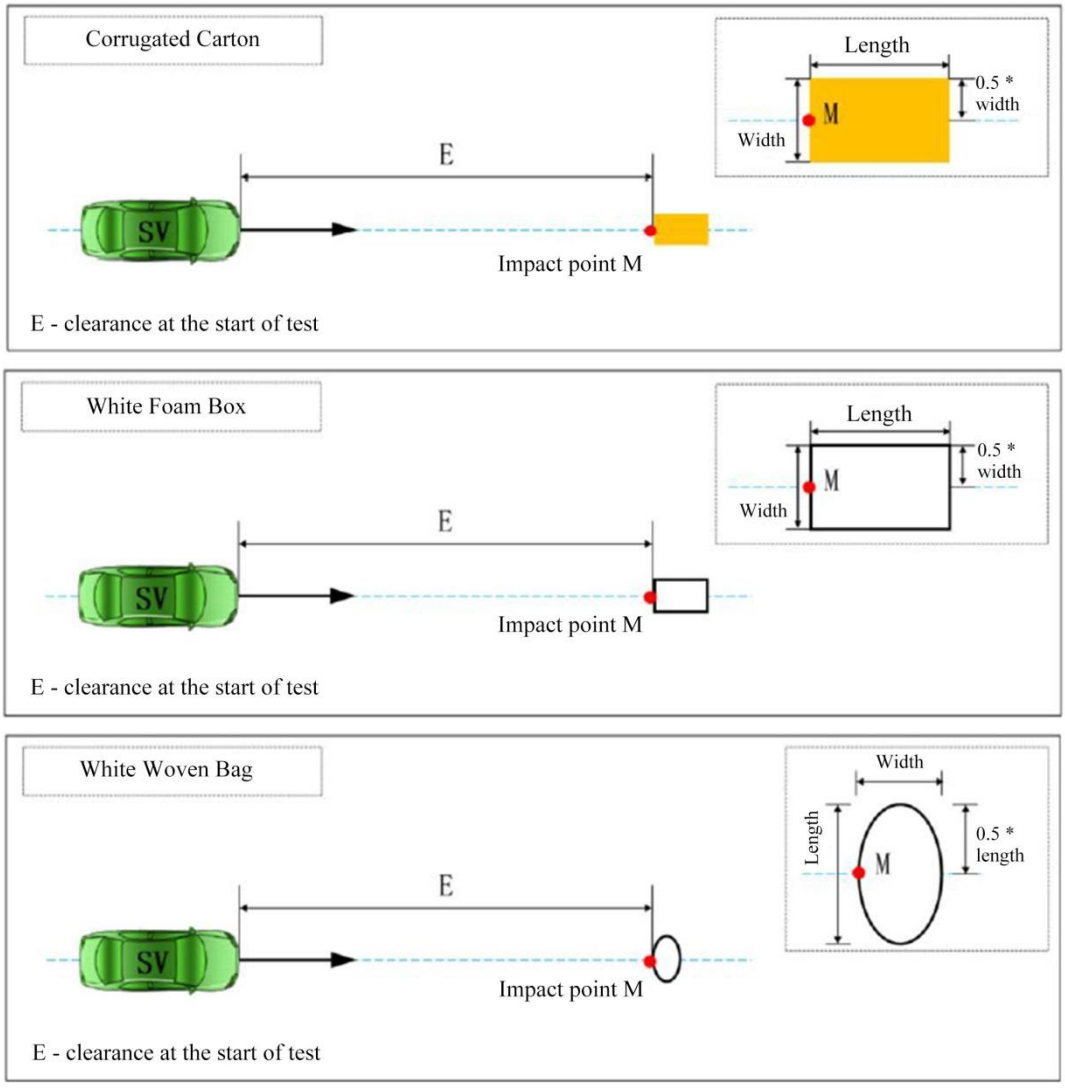


Fig. C.1 Car-to-special-shape-target Rear Stationary Scenario

a) Randomly select one of the three special shape targets (corrugated carton, white foam box and white woven bag) for test;

b) Set the SV path and the longitudinal axis of the target as shown in Fig. C.1;

c) Keep the target stationary in the middle of the test road, with the vehicle's longitudinal axis parallel to the lane marking and its direction consistent with the running direction of the SV;

d) Set the impact point as shown in Fig. C.1 for recording the longitudinal and lateral relative positions between the SV and the target;

e) Accelerate the SV to the speed specified in Table C.1 when it is more than 150 m away from the target, and make it gradually approach the target after its speed is stable;

f) When the rear clearance between the SV and the target is reduced to the clearance at the start of test specified in Table C.1, start the test and record data;

g) If the SV collides with the target or the collision is avoided, end the test.

C.1.3 Test requirements

a) Adjustment of the steering wheel shall be minimized during the test, and the angular velocity of the steering wheel shall not exceed 15°/s;

b) During approaching, the lateral offset between the SV and the target shall not be greater than ± 0.2 m;

c) During approaching, the yaw rate of the SV shall be kept within ± 1.0°/s;

d) The SV speed shall be kept at (40 ± 1) km/h or (50 ± 1) km/h. The brake pedal shall not be pressed before the test ends;

e) The accelerator pedal position change of the SV shall not exceed ± 5% of the full range;

f) The corrugated carton shall be 60 cm long, 40 cm wide and 50 cm high, empty inside, and packed with transparent adhesive tape, as shown in Fig. C.2;

g) The foam box shall be white, 57 cm long, 42.5 cm wide and 30 cm high, empty inside and packed with transparent adhesive tape, as shown in Fig. C.2;

h) The woven bag shall be white, 102 cm long and 60 cm wide, and filled with white sponge sheet to its full capacity, with its opening tightened, as shown in Fig. C.2.

Fig. C.2 Special Shape Targets