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Intelligent Safety Index
Passive Safety Test Protocol

(Version 2023)

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Table of Contents

Passive Safety Test Protocol

1 Scope

This document specifies the test method for IVISTA China Intelligent Vehicle Index - Intelligent Safety Index - Passive Safety.

2 Introduction

The test items of passive safety for the intelligent safety index are optional, including frontal crash (small overlap frontal driver-side crash, small overlap frontal passenger-side crash and moderate overlap frontal crash), side impact crash.

3 Test Methods

The test method for each passive safety item is shown in Table 1 below.

Table 1 List of Passive Safety Test Methods

S/N	Item Name		Test Method
1	Frontal crash	Small overlap frontal driver-side crash	See Annex A for details.
2		Small overlap frontal passenger-side crash	See Annex B for details.
3		Moderate overlap frontal crash	See Annex C for details.
4	Side impact crash		See Annex D for details.

Annex A
Test Method for Small Overlap Frontal Driver-side Crash

A.1 Introduction

The small overlap frontal driver-side crash test is conducted under the condition of frontal crash of the vehicle with the fixed rigid barrier at a speed of 64.4 km/h ± 1 km/h and an overlap of 25%±1%. A Hybrid III 50th ATD is placed in the driver's position of the VUT, and a Hybrid III 5th female ATD is placed on the impact side of the second row, to measure the damage to the driver and the second-row passenger during the crash and observe the kinematics of the ATDs.

A.2 Vehicle preparation

A.2.1 Vehicle inspection

After the vehicle arrives at the laboratory, first check and confirm whether the vehicle is in good condition (such as whether vehicle parts are complete, whether there is oil leakage, and whether vehicle state indicators are normal). In case of any abnormalities, record the abnormal states and positions in detail. If such abnormalities are directly related to the test, the vehicle shall be repaired or replaced.

A.2.2 Vehicle preparation

A.2.2.1 Adjust the vehicle to normal running state: there is no driver, passenger, or goods, the fuel in the fuel tank is drained, the fuel tank is filled with Stoddard solution or other fuel substitutes of equal weight accounting for 90% ~ 95% of the total capacity, the whole fuel pipeline is filled up, and the on-board tools and spare tires are carried (if provided as standard equipment by the vehicle manufacturer). If the vehicle suspension is adjustable, adjust it to the position recommended by the manufacturer for urban working conditions or the default position (which shall be specified in the vehicle manual or instruction). Measure and record the vehicle mass and front and rear axle loads in this condition. This is the curb mass.

A.2.2.2 Drain the fluid in engine and transmission, the refrigerant of air conditioning system, and the windshield cleaner and other fluids in the engine compartment on the crash side, and remove the left front axle sleeve and internal grease.

A.2.2.3 For a hybrid or battery electric vehicle used as the VUT, test the high voltage system of the hybrid or battery electric vehicle in the maximum charging state recommended by the manufacturer. If there is no manufacturer's recommendation, the high voltage system shall be tested under the live state of not less than 50% of the maximum capacity. The fuse of the high voltage system shall not be removed, and the precautions before and after the crash specified by the vehicle manufacturer shall be followed. In addition, relevant devices shall be prepared and installed according to the technical requirements in GB/T31498-2021 *Safety Requirement for Rear Crash of Electric Vehicles*. The device parameters required in the technical requirements shall be tested.

A.2.2.4 Three high-speed cameras are installed on the vehicle.

A.2.2.5 The traction lanyard is installed at an appropriate position at the front end of the vehicle (such as the subframe or engine bracket).

A.2.2.6 A bracket for test equipment fixing is installed in the rear area of the vehicle. If necessary, the carpet, spare tire, jack, on-board tools and third-row seats in this area may be removed. The following test equipment is installed on the bracket in the rear area:

- On-board emergency brake system: After the system is started, it acts on the rear wheels of the vehicle. The on-board emergency brake system needs to be activated 1.0 s after the crash.
- Dynamic displacement measurement system: The system is used to measure the dynamic displacement of the characteristic position in each direction during the crash.

- Data acquisition system: The system acquires data from sensors during the test.
- Power supply system for on-board high-speed cameras and on-board fill lamps: This system supplies power for on-board high-speed cameras and on-board fill lights.
- Electrical safety measuring equipment: The system collects electrical safety data during the test of hybrid or battery electric vehicles.

A.2.2.7 Remove the foot pad in the vehicle. If it is a standard configuration, keep it there.

A.2.2.8 If necessary, disconnect the fuse or relay of daytime running lamp (if equipped) to reduce the consumption of on-board power supply.

A.2.2.9 Install T0 time point indicators at appropriate positions outside or inside the vehicle, and stick a strip switch at the first contact point with the barrier on the vehicle.

A.2.2.10 Paste photographic marks on the vehicle surface for video analysis (see Fig. A.1 and Fig. A.2). Photographic marks are located as follows:

- Four 61 cm marks: the hood surface, the left front door surface, the right front door surface, and the vertical plane passing through the centerline of driver seat.
- The position of roof surface corresponding to the acceleration sensor on the vehicle body
- The position of the roof surface corresponding to the center of gravity of the vehicle
- Surface positions on the vehicle body side corresponding to the front and rear door locks (the left and right sides of the vehicle) and the upper anchorage of driver seat belt
- Stick a circle mark every 10 cm along the A-pillar from the bottom to top in the X direction
- Mark out the foremost position of the steering wheel center in the longitudinal direction on the driver-side door. If the steering column is adjustable up and down, adjust it to the middle position. If it is telescopic, adjust it to the foremost position.
- Mark out the leading edge of steering wheel and instrument panel with photographic marks, and paint the left front tire white.

A.2.2.11 If necessary, remove the front seat headrest and shield the right front passenger side front airbag, side airbag and center airbag (by connecting a resistor with appropriate resistance and power to the airbag circuit) to avoid airbag deployment affecting camera shooting.

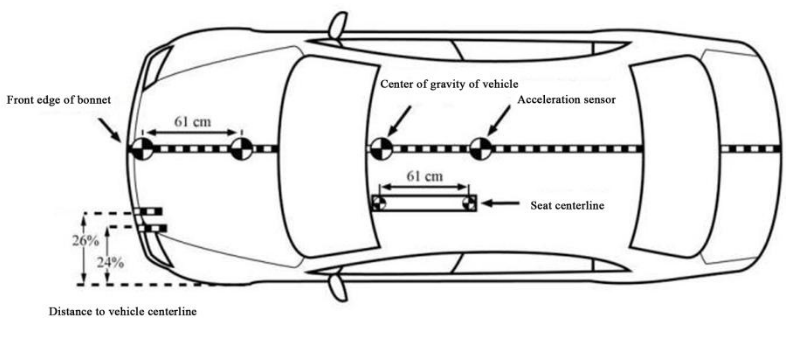


Fig. A.1 Vehicle Outer Surface Marking (Top View)

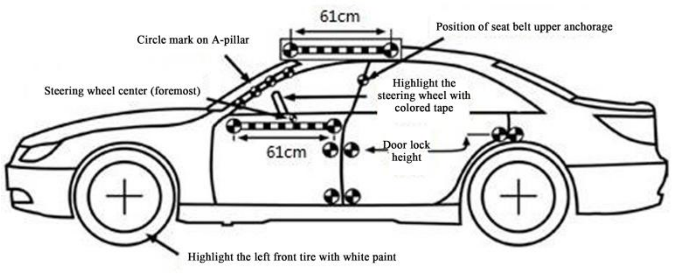


Fig. A.2 Vehicle Outer Surface Marking (Front View)

A.2.3 Adjustment of passenger compartment

A.2.3.1 For detailed procedures of seat and steering column adjustment, see the *ATD and Frontal Seat Positioning Protocol* and the *ATD and Rear Seat Positioning Protocol*.

A.2.3.2 Adjust the front manually adjustable inner armrest to the lowest position, or the multi-stage adjustable armrest to the closest horizontal position. Adjust the armrest of rear independent seats to a horizontal position; keep the central armrest of rear bench seat retracted.

A.2.3.3 Adjust the upper anchorage of the front seat belt to the position recommended by the manufacturer or the uppermost fixing position. Adjust the upper anchorage of the rear seat belt to the position recommended by the manufacturer or the lowest fixing position.

A.2.3.4 Close all doors but do not lock them. If the vehicle has an automatic locking function and this function can be disabled, carry out the test with this function disabled and the doors not locked; if this function cannot be disabled, carry out the test with the doors locked.

A.2.3.5 Before the test, lower all side window glass to the lowest position, turn the ignition switch to ON position, and set the transmission in the neutral position.

A.3 ATD preparation and setting

A.3.1 Place the Hybrid III 50^{th} ATD on the driver seat and position it according to the *ATD and Frontal Seat Positioning Protocol*. Place the Hybrid III 5^{th} female ATD in the second row on the crash side, and position it according to the *ATD and Rear Seat Positioning Protocol*.

A.3.2 Install the neck shield for ATD.

A.3.3 After 5 tests, calibrate the ATD according to 49CFR572 (E). If the measured value of a certain part reaches the "poor" index specified in the rating protocol, for example, HIC15>840 for the driver's head, this part shall be re-calibrated. If damaged parts are found after crash, repair the parts and re-calibrate.

A.3.4 Before the test, put the ATD in an environment with a temperature of 20.0°C ~ 22.2°C and a relative humidity of 10% ~ 70% for at least

5 hours.

A.3.5 Fasten the ATD's seat belt and strain the lap strap. Pull out the shoulder strap from the retractor and rewind it. Repeat that for 4 cycles. When dealing with seat belts with retractors on both shoulder and waist belts, perform the operation 4 times on each retractor.

A.3.6 Paint the ATD's head, knees and calves in different colors to identify the contact position between the ATD and the vehicle interior trim during crash. Mark the position of the center of gravity of the head with photographic marks on both sides of the ATD's head. ATD painting requirements are shown in Table A.1 and Fig. A.3.

Table A.1 ATD Painting Requirements

Part	Hybrid III 50th ATD	Hybrid III 5th ATD
Left face	Yellow	Yellow
Right face	Blue	Blue
Back of head	Red	Red
Left knee	Green	Green
Right knee	Yellow	Yellow
Left tibia	Blue	Blue
Right tibia	Red	Red

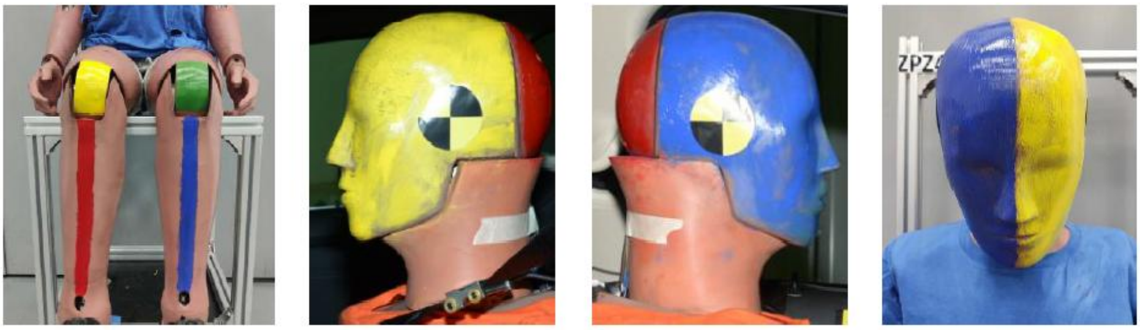


Fig. A.3 Schematic Diagram of ATD Painting

A.4 Test photos

Record the state of the VUT and the position of the ATD before and after the crash. See Table A.2 for detailed shooting angles.

Table A.2 Test Photos

S/N	Shooting Angle	Before Test	After Test
1	Front view photo of the vehicle	√	√
2	Front view photo of the left side of the vehicle	√	√
3	Photo taken at 45° in the left front of the vehicle	√	√
4	Photo of the front left quarter of the vehicle	√	√
5	Photo of the relative position between the vehicle and the barrier	√	√
6	Front-side view photo of driver's position (left and right)	√	√
7	Photo of the driver's leg position	√	√
8	Photo of driver contact	——	√
9	Front view photo of rear passenger	√	√
10	Front-side view photo of rear passenger (left and right)	√	√
11	Photo of rear passenger contact	——	√
12	Photo of the front bottom of the vehicle	√	√

A.5 High-speed photography

Nine high-speed cameras are used in the test, 6 on the ground and 3 on the vehicle. The high-speed cameras record at a speed of not less than 1000 frames per second. Table A.3 lists the shooting angles of the high-speed cameras on the vehicle. Fig. A.4 and Fig. A.5 illustrate the positions of the high-speed cameras on ground and those on the vehicle respectively.

Table A.3 High-speed Cameras on Vehicle - Shooting Angles

Camera Position	I	J	K
Shooting angle	Driver's shoulder	The area behind the driver	The side of the rear passenger

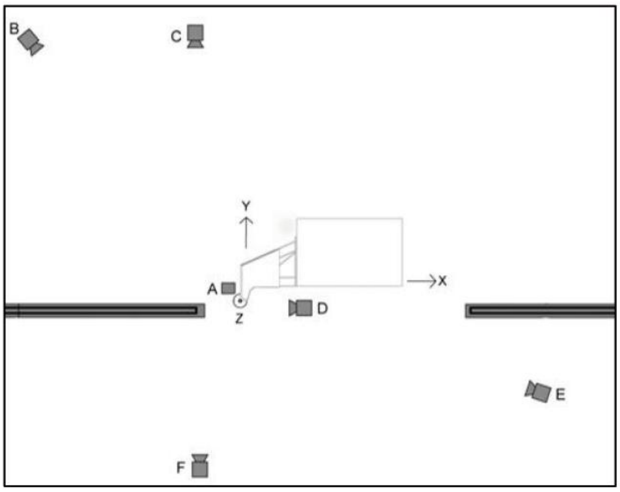


Fig. A.4 Positions of High-speed Cameras on Ground

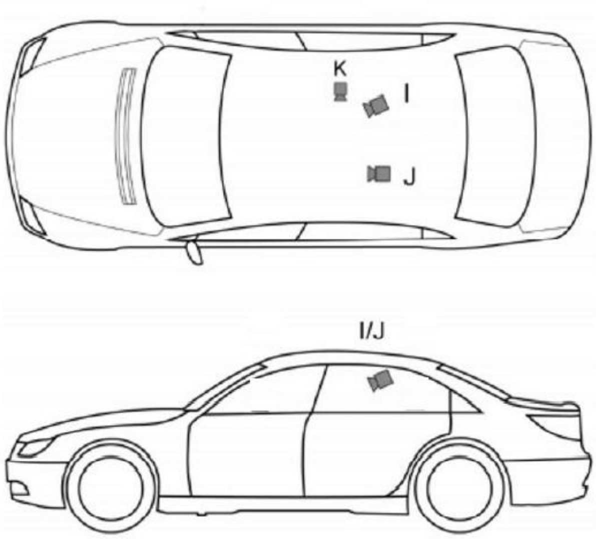


Fig. A.5 Positions of High-speed Cameras on Vehicle

A.6 Test conditions

A.6.1 Test barrier

A rigid barrier is used in the test, and its structural dimensions are shown in Fig. A.6 and Fig. A.7. The barrier is fixed on the ground on the driver's side in the traction direction of the vehicle.

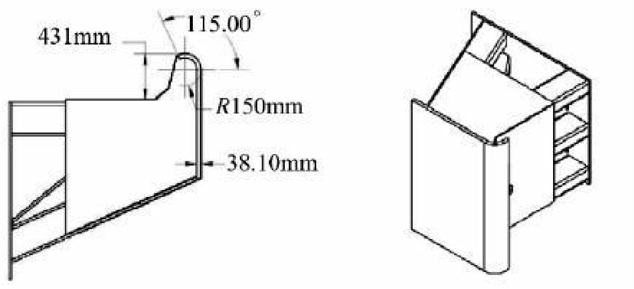


Fig. A.6 Top View and Axial Side View of Barrier

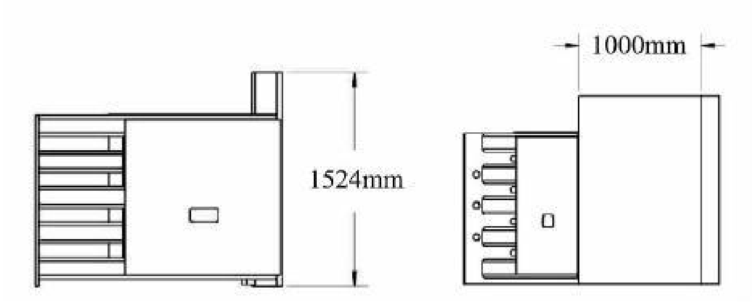


Fig. A.7 Side View and Front View of Barrier

A.6.2 Test mass

The vehicle test mass is measured after all test equipment is installed, and it includes the mass of all test equipment and ATDs. The vehicle test mass shall be 150 kg ~ 200 kg higher than the measured curb mass. If the vehicle test mass does not reach this range, place counterweights in the trunk of the vehicle. If the vehicle test mass exceeds this range, remove some parts at the rear part of the vehicle that do not affect the test results (such as the silencer and the exhaust pipe).

Determine the longitudinal position of the center of gravity of the VUT through the front and rear axle loads.

A.6.3 Vehicle width

The vehicle width is determined and measured according to SAE J1100 *Motor Vehicle Dimensions*. It is defined as the maximum dimension of the widest area of the vehicle, excluding the rearview mirrors, flexible fenders and marker lamps, but including bumpers, body trims, metal panel bulges or double-row wheels (if equipped as standard configuration).

A.6.4 Crash speed

The crash speed of the vehicle is 64.4 km/h ± 1 km/h. The crash speed is measured with a velocimeter, and the measured speed of the traction system itself is used as a backup of the crash speed. The VUT is accelerated by the traction device at an acceleration of ≤ 0.3 g until it reaches the test speed.

A.6.5 Overlap

The VUT is aligned with the rigid barrier, and the overlap on the driver's side accounts for 25%±1% of the vehicle width (see Fig. A.8).

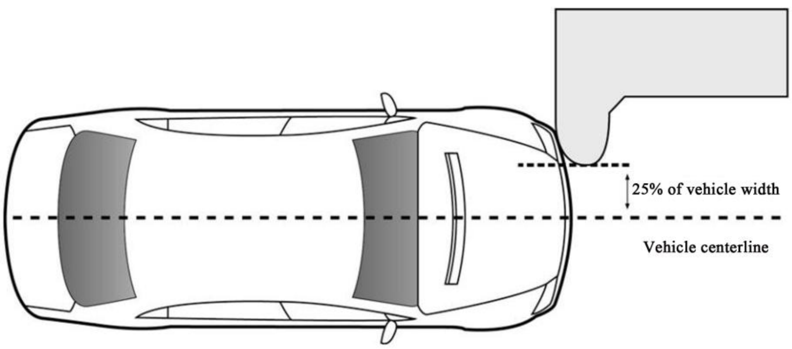


Fig. A.8 Schematic Diagram of Vehicle-Barrier Crash Position

A.7 Test measurement

Test instruments shall be inspected or calibrated regularly, generally, every 12 months. The measured values recorded by all instruments shall conform to SAE J1733 *Sign Convention for Vehicle Crash Testing*.

A.7.1 Test instrument

A.7.1.1 Body test instruments

A.7.1.1.1 Forward tilting amount of driver

The forward tilting amount of driver is measured according to the short-time inertial navigation ranging method. Use the inertial measurement unit (master INS) placed in the fixed connection with the non-deformation structure at the rear of the vehicle body to measure the acceleration and angular velocity of the vehicle body, so as to obtain the attitude information of the vehicle body; use the inertial measurement unit (slave INS) placed at the top bracket of the ATD torso to measure the acceleration and angular velocity of the ATD torso bracket, so as to obtain the attitude information of the upper part of the ATD torso. Obtain the relative displacement between the two by inertial navigation calculation, and take the maximum longitudinal relative displacement in forward moving of ATD during the crash as the forward tilting amount of passenger (see Table A.4).

Table A.4 Inertial Navigation Measurement Sensor

Measuring Parts	Measurement Parameters
Rear non-deformation area of vehicle (master INS)	A_x, A_y, A_z, ω_x, ω_y, ω_z
ATD torso top bracket (slave INS)	A_x, A_y, A_z, ω_x, ω_y, ω_z

A.7.1.1.2 Body acceleration

Install the acceleration sensor horizontally in the rear seat area along the centerline of the vehicle. To facilitate installation, the carpet in this area can be removed, or a sensor installation platform may be welded in this area (see Table A.5).

Table A.5 Body Acceleration Sensor

Measuring Parts	Measurement Parameters	Measuring Channel
Body acceleration	A_x, A_y and A_z	3

A.7.1.1.3 Seat belt force sensor

Install shoulder and lap strap force sensors on the rear seat belts of the vehicle (see Table A.6).

Table A.6 Seat Belt Force Sensor

Measuring Parts	Measurement Parameters	Measuring Channel
Seat belt	Force of shoulder strap and lap belt F	2

A.7.1.2 ATD test instruments

The ATD shall be equipped with sensors at various parts shown below (see Tables A.7 and A.8):

Table A.7 ATD Measurement Parameters and Test Requirements (Hybrid III 50th)

Measuring Parts	Measurement Parameters	Measuring Channel
Head	Acceleration A_x, A_y, A_z	3
	Angular velocity ω_x, ω_y, ω_z	3
Neck	Force F_x, F_y, F_z	4
	Moment M_y	
Chest	Acceleration A_x, A_y, A_z	4
	Compression deformation D	
Thigh and hip	Compression force on thigh (left/right) F_z	4
	Sliding displacement of knee joint (left/right) D	

Measuring Parts	Measurement Parameters	Measuring Channel
Tibia	Force on upper tibia (left/right) F_z	12
	Moment of upper tibia M_x, M_y	
	Force on lower tibia (left/right) F_z	
	Moment of lower tibia M_x, M_y	
Foot	Acceleration (left/right) A_x, A_z	4
Total number of channels of ATD sensor		34

Table A.8 ATD Measurement Parameters and Test Requirements (Hybrid III 5th)

Measuring Parts	Measurement Parameters	Measuring Channel
Head	Acceleration A_x, A_y, A_z	3
Neck	Force F_x, F_y, F_z	4
	Moment M_y	
Chest	Acceleration A_x, A_y, A_z	4
	Compression deformation D	
Thigh	Compression force on thigh (left/right) F_z	4
	Sliding displacement of knee joint (left/right) D	
Pelvis	Force on iliac bone (left/right) F_x	2
	Pelvis acceleration A_x, A_y, A_z	3
Total number of channels of ATD sensor		20

A.7.1.3 Total number of test channels

See Table A.9 for the number of test channels:

Table A.9 Number of Test Channels of Test Instruments

Measuring Parts	Number of Test Channels
Channel for driver Hybrid III 50th ATD	34
Channel for rear passenger Hybrid III 5th ATD	20
Vehicle data channel	3
Inertial navigation measurement sensor channel	12
Seat belt force sensor channel	2
Total	71

A.7.2 Intrusion measurement

Before and after the test, measure the intrusion at the 18 marking points inside and outside the vehicle on the driver's side with a three-coordinate measuring instrument in the same coordinate system.

A.7.2.1 Definition of coordinate system

Define the 3D coordinate system according to the right-hand rule: X direction (positive from front to back), Y direction (positive from left to right) and Z direction (positive from bottom to top).

Before the test, establish a coordinate system using the unloaded vehicle placed on the horizontal ground. The horizontal ground is used for defining the X-Y plane, while the two endpoints of the roof centerline are used for defining the X-axis. The vehicle body coordinate system provided by the enterprise can be used.

Before the crash, measure the coordinates of three reference points marked on the vehicle for restoring the coordinate system of the vehicle after the crash. Generally, the reference points are marked on the vehicle structure of the rear door frame on the non-crash side.

A.7.2.2 Position of measuring points

The vehicle intrusion measuring positions are as follows (see Fig. A.9):

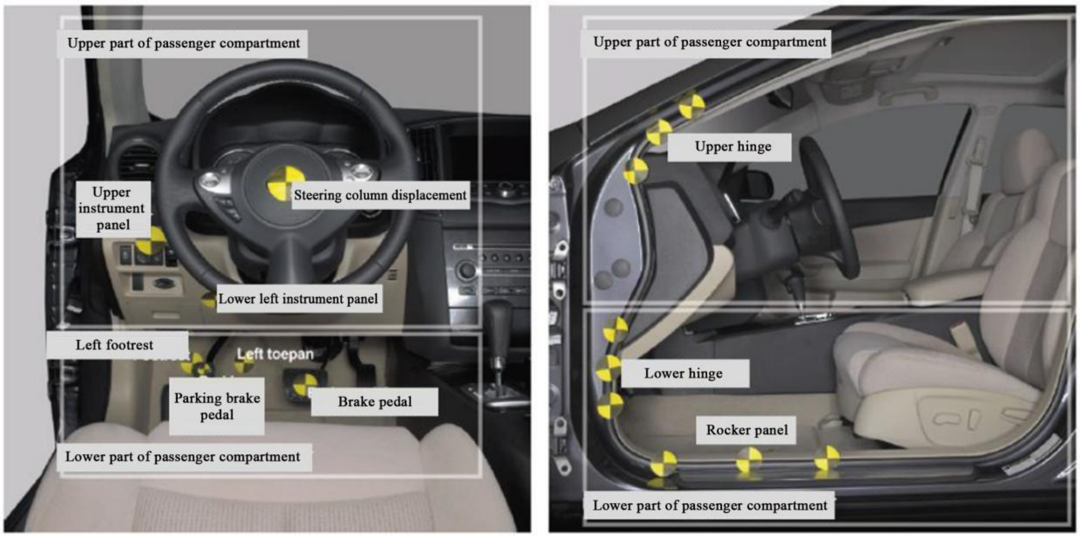


Fig. A.9 Vehicle Intrusion Measuring Positions

A.7.2.2.1 Steering column (one point)

The measuring point is the geometric center of the steering wheel and is usually located on the airbag cover plate. After the crash, it is necessary to restore the airbag cover plate to the non-detonating state. If the steering column is loose or completely separated from the instrument panel during the crash, post and maintain the steering wheel and steering column at their dynamic maximum (upward and forward) positions for measurement, and the steering column position can be determined by high-speed photography.

A.7.2.2.2 Left lower instrument panel (one point)

The lateral coordinates of the measuring points are obtained by subtracting 15 cm from the lateral coordinates of the measuring points of the steering column, and the vertical coordinates are obtained by adding 45 cm to the floor height inside the vehicle (excluding the foot pad). If the instrument panel or knee pad is loose or damaged during the crash, the post-crash measurement is completed by pressing and holding the instrument panel on the frame structure.

A.7.2.2.3 Brake pedal (one point)

The measuring point is the geometric center of the brake pedal (upper surface). If the brake pedal is loose and shakes after the crash, push the brake pedal directly forward to the toepan or floor, and keep it in this position for post-crash measurement. If the pedal is completely disengaged, no post-crash measurement will be performed.

A.7.2.2.4 Parking brake pedal (one point)

The measuring point is the geometric center of the parking brake pedal (upper surface). If the parking brake is a handbrake or a button on the dashboard or central console, no measurement will be made.

A.7.2.2.5 Left toepan (one point)

The vertical coordinate of the measuring point is consistent with that of the brake pedal measuring point, and the lateral coordinate is obtained by subtracting 15 cm from the lateral coordinate of the brake pedal measuring point. Make a temporary mark on the toepan. Draw a small "v" shape on the carpet and the floor mat on the toepan with tools and peel them off, and then mark and measure on the exposed floor. Restore the carpet and the mat before the crash.

A.7.2.2.6 Left footrest (one point)

The vertical coordinate of the measuring point is consistent with that of the brake pedal measuring point, and the lateral coordinate is obtained by subtracting 25 cm from the lateral coordinate of the brake pedal measuring point. Mark and measure the floor structure with reference to A.7.2.2.5. If there is a special structure at the footrest measuring point, remove the structure, and then mark and measure on the floor. Restore the structure before the crash.

A.7.2.2.7 Seat bolts (two points)

The measuring points are two rear bolts that fix the driver's seat on the floor.

A.7.2.2.8 Upper dashboard (one point)

A row of reference points at the edge of the upper dashboard is determined by subtracting 25 cm from the lateral coordinates of the measuring points of the steering column. The measuring point of the upper dashboard is located at the rearmost position of this row of reference points (towards the rear of the vehicle). This point must be at least 30 cm above the brake pedal measuring point to ensure that the vertical position is high enough to represent the position where the upper part of the driver's body or head may touch. If the rearmost point is less than 30 cm above the brake pedal measuring point, the measuring point of the upper dashboard is located at this 30 cm reference point.

If the measuring point of the upper dashboard is located on a "soft part", such as a vent or a control button (see Fig. A.10), determine two hard reference points by moving inward/outward to a position just outside the soft part, and use the weighted average of the coordinates of these two reference points to represent the coordinates of the measuring point at the original position, as shown in the following equation:

Simulate the position of the upper measuring point = $\frac{l_I}{l_0 + l_I} \times [X_{P_O}, Y_{P_O}, Z_{P_O}] + \frac{l_O}{l_0 + l_I} \times [X_{P_I}, Y_{P_I}, Z_{P_I}]$

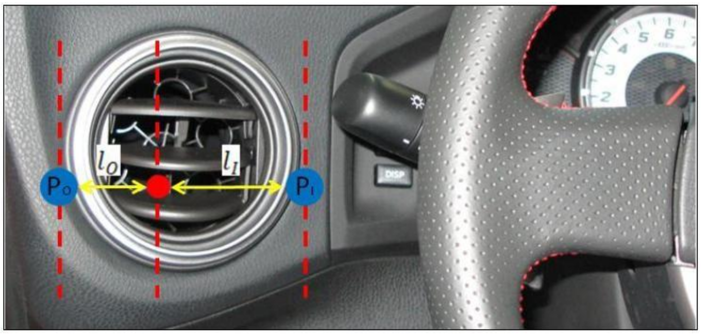


Fig. A.10 Diagram for Measuring Points on Soft Parts

A.7.2.2.9 A-pillar lower hinge (three points) and A-pillar upper hinge (three points)

Measure on the innermost surface of the door frame, usually at the welding edge. The vertical coordinates of the three measuring points of the lower hinge are obtained by adding 0 cm (A-pillar lower hinge point 1), 7.5 cm (A-pillar lower hinge point 2) and 15 cm (A-pillar lower hinge point 3) to the vertical coordinate of the brake pedal measuring point. The vertical coordinates of the three measuring points of the A-pillar upper hinge are obtained by adding 45 cm (A-pillar upper hinge point 1), 52.5 cm (A-pillar upper hinge point 2) and 60 cm (A-pillar upper hinge point 3) to the vertical coordinate of the brake pedal measuring point.

A.7.2.2.10 Rocker panel (three points)

The rocker panel measuring points are located on the innermost surface of the door frame, usually at the welding edge. The longitudinal coordinates are obtained by adding 20 cm (rocker panel point 1), 35 cm (rocker panel point 2) and 50 cm (rocker panel point 3) to the longitudinal coordinate of the brake pedal measuring point. If the rocker panel point 1 is beyond the range of the door frame, the point is located 5 cm behind the measuring point of the A-pillar lower hinge.

A.7.3 Measurement of ATD space position

The measurement of ATD space position is performed after the ATD is installed and positioned, and the measurement contents are shown in Fig. A.11, Table A.10 and Table A.11.

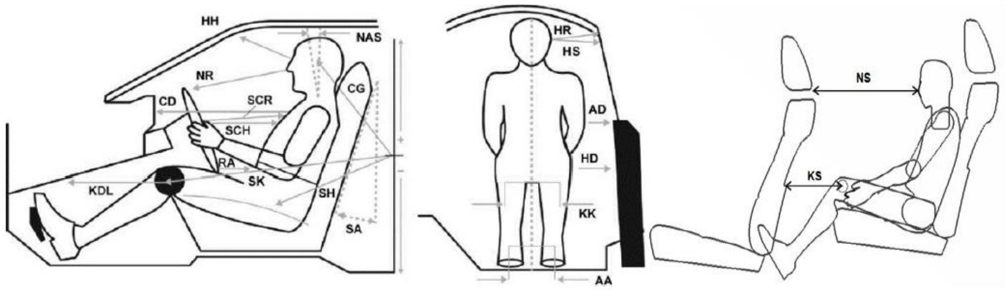


Fig. A.11 Schematic Diagram of Measuring Position

Table A.10 Description of ATD Space Position Measurement (Driver)

Position	Code	Measurement Description
Ankle - ankle	AA	Distance between the centers of both ankles
Arm - door	AD	Horizontal distance between the elbow center and the initial contact point of the door panel
Chest - dashboard	CD	Horizontal distance between the marking point of the clavicle adjusting hole in the chest and the dashboard
Head - A-pillar	HA	Horizontal distance between the marking point of the gravity center of head and the A-pillar (not marked in the figure)
Steering wheel - chest (minimum distance)	HCM	Minimum horizontal distance between the central point of the steering wheel and the ATD's chest (not marked in the figure)
H-point - door	HD	Horizontal distance between the H-point and the initial contact point of door panel
Head - headliner	HH	Distance between the middle of eyes and the upper edge of the front windshield of vehicle
Head - roof	HR	Distance between the marking point of the gravity center of head and the roof (other than the top edge of the door), perpendicular to the longitudinal axis of the vehicle
Head - side window	HS	Distance between the marking point of the gravity center of head and the side window, measured horizontally and perpendicular to the longitudinal axis of the vehicle
Knee - dashboard (left)	KDL	Horizontal distance between the center point of the left knee joint and the dashboard
Knee - dashboard (right)	KDR	Horizontal distance between the center point of the right knee joint and the dashboard
Knee - knee	KK	Distance between outer sides of flanges of knees
Neck angle (sitting/standing position)	NAS	Angle between the neck centerline and the vertical line
Nose - steering wheel rim	NR	Distance from the top of the nose to the upper rim of the steering wheel
Pelvic angle	PA	Angle measured by placing a T-bar on the H-point of ATD
Steering wheel lower rim - abdomen	RA	Distance from the joint between the bottom of the ATD's chest jacket and the ATD's abdomen filler to the lower rim of the steering wheel
Seat backrest angle	SA	Head restraint rod angle
Steering wheel - chest	SCH	Horizontal distance between the steering wheel center and the ATD's chest

Position	Code	Measurement Description
(horizontal)		
Steering wheel - chest (reference)	SCR	Distance between the steering wheel center and the marking point of the clavicle adjusting hole in the chest
Lock catch - center of gravity of head (horizontal)	CGH	Horizontal distance between the marking point of the center of gravity of head and the driver's door lock catch
Lock catch - center of gravity of head (lateral)	CGL	Lateral offset between the marking point of the center of gravity of head and the driver's door lock catch
Lock catch - center of gravity of head (vertical)	CGV	Vertical distance between the marking point of the center of gravity of head and the driver's door lock catch
Lock catch - H-point (horizontal)	SHH	Horizontal distance between the H-point and the driver's door lock catch
Lock catch - H-point (vertical)	SHV	Vertical distance between the H-point and the driver's door lock catch
Lock catch - knee	SK	Distance between the knee center and the driver's door lock catch
Lock catch - knee angle	SKA	Angle between the knee center and the driver's door lock catch
Torso recline angle	TRA	Angle between the H-point and the center of gravity of head

Table A.11 Description of ATD Space Position Measurement (Rear Passenger)

Position	Code	Measurement Description
H-point - door	HD	Horizontal distance between the H-point and the initial contact point of door panel
Head - side window	HS	Distance between the marking point of the gravity center of head and the side window, measured horizontally and perpendicular to the longitudinal axis of the vehicle
Nose - front seat	NS	Horizontal distance between the nose and the backrest of front seat
Abdomen - front seat	AS	Horizontal distance between the abdomen and the backrest of front seat
Chin - front seat	CS	Horizontal distance between the chin and the backrest of front seat
H-point - rocker panel	HS	Vertical distance between the H-point and the upper edge of rocker panel
Head - roof	HR	Vertical distance between the head and the roof
Nose - seat belt	NW	Vertical distance between the nose and the seat belt
Seat belt - door	WD	Horizontal distance between the seat belt and the door
Knee - front seat (left)	KSL	Horizontal distance between the center point of left knee joint and the backrest of front seat
Knee - front seat (right)	KSR	Horizontal distance between the center point of right knee joint and the backrest of front seat
Knee - knee	KK	Distance between the longitudinal centerlines of knees
Neck angle (sitting/standing position)	NAS	Angle between the neck centerline and the vertical line
Pelvic angle	PA	Angle measured by placing a T-bar on the H-point of ATD
Seat backrest angle	SA	Head restraint rod angle

A.7.4 ATD motion and contact position

A.7.4.1 The motion of ATD is analyzed by using high-speed photography. Check and record the contact of the ATD's head and knees with the vehicle interior based on the adhesion of paint after the crash.

A.7.4.2 After the crash, check the ATD while keeping it as it is. Record any damage or abnormal posture of the ATD.

A.7.4.3 The time point when a crash starts and the time points of occurrence of various events during the crash are determined according to high-speed photography. The crash starts at the time point when the T0 indicator lights up. The starting time point of each event is determined based on the number of images played since the crash starts and the number of frames taken by cameras. For a camera with a shooting rate of 1000 frames/second, the starting time point of crash may be delayed by 2 ms, and it can be advanced or delayed by 2 ms according to the time point of event occurrence determined based on high-speed photography. Record the time points when the driver's airbag is initially deployed, the airbag is fully deployed, the initial contact with the ATD is made, and other important events happen.

A.7.5 Forward coverage of side head protection airbag

Use the images of the high-speed photography to determine whether the side head protection airbag extends forward to an area of 12 cm - 22 cm above the center point of the steering wheel (this point is determined according to A.2.2.10). This area is an orthogonal vertical plane passing through the center of the steering wheel. Detailed procedures are given in normative Annex I.

A.7.6 Fuel system integrity

Record the results of fuel system integrity observed after the crash test. Collect all the liquid leaked from the fuel system within 1 min after the crash. The first sample is usually collected by absorbing the leaked liquid with a water absorption pad of known quality. The second sample is collected within 5 min immediately after the first sample is collected, and it is generally the liquid collected in the tray below the identified leakage source. The third sample is collected within 25 min immediately after the second sample is collected. The tray for every sample collection shall be clean and empty. The volume of each sample is obtained by dividing the sample mass by the liquid density. Record the time taken with a stopwatch, and record the whole process with a camera with an internal timer.

A.7.7 High voltage system integrity

After the test, monitor the hybrid or battery electric vehicle to check whether the high voltage system is damaged. According to GB/T 31498-2021 *Post Crash Safety Requirement for Electric Vehicle*, post-test observation items include electrolyte leakage, REESS safety, movement, and electric shock protection.

Immediately after the test, monitor the temperature of REESS to check whether there is a rapid temperature rise, so as to prevent thermal runaway. REESS temperature shall be monitored for at least 4 hours. After the test, the electric energy can be completely discharged from the high voltage system in the way specified by the manufacturer.

A.7.8 Inspection of E-call function

In the automatic triggering mode of E-call, check and review the communication function of the VUT.

A.7.9 Inspection of other functions

A.7.9.1 After the test, check whether the door on the crash side is opened from outside the vehicle. The door shall not be opened when it is pulled vertically outward with a tension meter reading not more than 400 N at the position shown in the figure (except for the door handle), as shown in Fig. A.12. After the test, the door on the non-crash side shall be unlocked. Check whether the door can be opened normally from outside the vehicle without using tools.

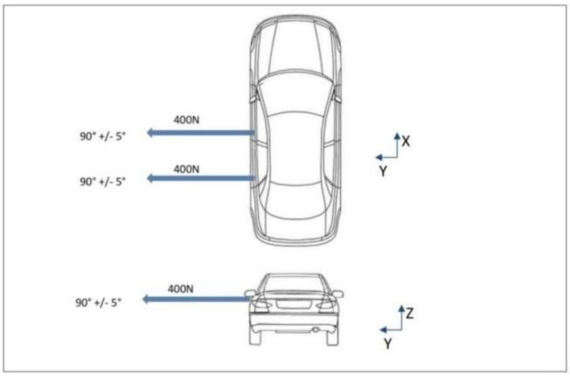


Fig. A.12 Schematic Diagram of Door Opening Measurement

A.7.9.2 After the test, measure the opening force of the seat belt buckle with a seat belt release device.

Annex B
Test Method for Small Overlap Frontal Passenger-side Crash

B.1 Introduction

The small overlap frontal passenger-side crash test is conducted under the condition of frontal crash of the vehicle with the fixed rigid barrier at a speed of 64.4 km/h ± 1 km/h and an overlap of 25%±1%. A Hybrid III 50th ATD is placed in the driver's position and the front passenger seat of the VUT respectively, and a Hybrid III 5th female ATD is placed on the impact side of the second row, to measure the damage to the driver and the second-row passenger during the crash and observe the kinematics of the ATDs.

B.2 Vehicle preparation

B.2.1 Vehicle inspection

After the vehicle arrives at the laboratory, first check and confirm whether the vehicle is in good condition (such as whether vehicle parts are complete, whether there is oil leakage, and whether vehicle state indicators are normal). In case of any abnormalities, record the abnormal states and positions in detail. If such abnormalities are directly related to the test, the vehicle shall be repaired or replaced.

B.2.2 Vehicle preparation

B.2.2.1 Adjust the vehicle to normal running state: there is no driver, passenger, or goods, the fuel in the fuel tank is drained, the fuel tank is filled with Stoddard solution or other fuel substitutes of equal weight accounting for 90% ~ 95% of the total capacity, the whole fuel pipeline is filled up, and the on-board tools and spare tires are carried (if provided as standard equipment by the vehicle manufacturer). If the vehicle suspension is adjustable, adjust it to the position recommended by the manufacturer for urban working conditions or the default position (which shall be specified in the vehicle manual or instruction). Measure and record the vehicle mass and front and rear axle loads in this condition. This is the curb mass.

B.2.2.2 Drain the fluid in engine and transmission, the refrigerant of air conditioning system, and the windshield cleaner and other fluids in the engine compartment on the crash side, and remove the right front axle sleeve and internal grease.

B.2.2.3 For a hybrid or battery electric vehicle used as the VUT, test the high voltage system of the hybrid or battery electric vehicle in the maximum charging state recommended by the manufacturer. If there is no manufacturer's recommendation, the high voltage system shall be tested under the live state of not less than 50% of the maximum capacity. The fuse of the high voltage system shall not be removed, and the precautions before and after the crash specified by the vehicle manufacturer shall be followed. In addition, relevant devices shall be prepared and installed according to the technical requirements in GB/T31498-2021 *Safety Requirement for Rear Crash of Electric Vehicles*. The device parameters required in the technical requirements shall be tested.

B.2.2.4 Three high-speed cameras are installed on the vehicle.

B.2.2.5 The traction lanyard is installed at an appropriate position at the front end of the vehicle (such as the subframe or engine bracket).

B.2.2.6 A bracket for test equipment fixing is installed in the rear area of the vehicle. If necessary, the carpet, spare tire, jack, on-board tools and third-row seats in this area may be removed. The following test equipment is installed on the bracket in the rear area:

- On-board emergency brake system: After the system is started, it acts on the rear wheels of the vehicle. The on-board emergency brake system needs to be activated 1.0 s after the crash.
- Data acquisition system: The system acquires data from sensors during the test.

- Power supply system for on-board high-speed cameras and on-board fill lamps: This system supplies power for on-board high-speed cameras and on-board fill lights.

- Electrical safety measuring equipment: The system collects electrical safety data during the test of hybrid or battery electric vehicles.

B.2.2.7 Remove the foot pad in the vehicle. If it is a standard configuration, keep it there.

B.2.2.8 If necessary, disconnect the fuse or relay of daytime running lamp (if equipped) to reduce the consumption of on-board power supply.

B.2.2.9 Install T0 time point indicators at appropriate positions outside or inside the vehicle, and stick a strip switch at the first contact point with the barrier on the vehicle.

B.2.2.10 Paste photographic marks on the vehicle surface for video analysis (see Fig. B.1 and Fig. B.2). Photographic marks are located as follows:

- Four 61 cm marks: the hood surface, the left front door surface, the right front door surface, and the vertical plane passing through the centerline of front passenger seat.

- The position of roof surface corresponding to the acceleration sensor on the vehicle body

- The position of the roof surface corresponding to the center of gravity of the vehicle

- Surface positions on the vehicle body side corresponding to the front and rear door locks (the left and right sides of the vehicle) and the upper anchorage of front passenger seat belt

- Stick a circle mark every 10 cm along the A-pillar from the bottom to top in the X direction

- Mark out the foremost position of the steering wheel center in the longitudinal direction on the front passenger door. If the steering column is adjustable up and down, adjust it to the middle position. If it is telescopic, adjust it to the foremost position.

- Mark out the leading edge of steering wheel and dashboard with photographic marks, and paint the right front tire white.

B.2.2.11 Shield the side and middle airbags at the driver side (by connecting resistors with appropriate resistance and power in the airbag circuit), so as to avoid the impact of airbag deployment on camera shooting.

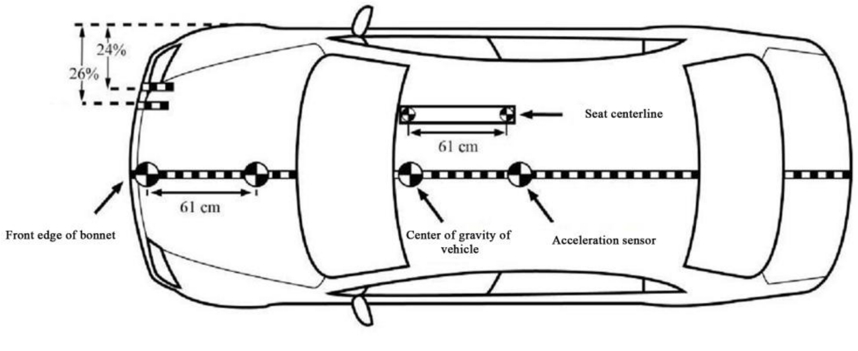


Fig. B.1 Vehicle Outer Surface Marking (Top View)

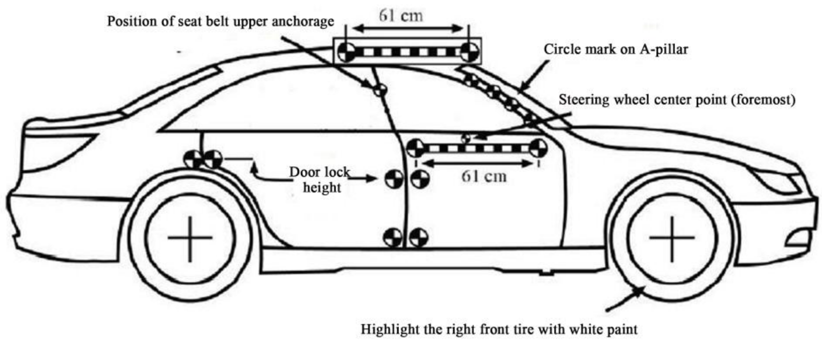


Fig. B.2 Vehicle Outer Surface Marking (Front View)

B.2.3 Adjustment of passenger compartment

B.2.3.1 For detailed procedures of seat and steering column adjustment, see the *ATD and Frontal Seat Positioning Protocol* and the *ATD and Rear Seat Positioning Protocol*.

B.2.3.2 Adjust the front manually adjustable inner armrest to the lowest position, or the multi-stage adjustable armrest to the closest horizontal position. Adjust the armrest of rear independent seats to a horizontal position; keep the central armrest of rear bench seat retracted.

B.2.3.3 Adjust the upper anchorage of the front seat belt to the position recommended by the manufacturer or the uppermost fixing position. Adjust the upper anchorage of the rear seat belt to the position recommended by the manufacturer or the lowest fixing position.

B.2.3.4 Close all doors but do not lock them. If the vehicle has an automatic locking function and this function can be disabled, carry out the test with this function disabled and the doors not locked; if this function cannot be disabled, carry out the test with the doors locked.

B.2.3.5 Before the test, lower all side window glass to the lowest position, turn the ignition switch to ON position, and set the transmission in the neutral position.

B.3 ATD preparation and setting

B.3.1 Place the Hybrid III 50th ATD on the driver and front passenger seats respectively, and position them according to the *ATD and Frontal Seat Positioning Protocol*. Place the Hybrid III 5th female ATD on the impact side of the second row, and position it according to the *ATD and Rear Outboard Seat Positioning Protocol*.

B.3.2 Install the neck shield for ATD.

B.3.3 After 5 tests, calibrate the ATD according to 49 CFR 572 (E). If the measured value of a certain part reaches the "poor" index specified in the rating protocol, for example, HIC15>840 for the driver's head, this part shall be re-calibrated. If damaged parts are found after crash, repair the parts and re-calibrate.

B.3.4 Before the test, put the ATD in an environment with a temperature of 20.0°C ~ 22.2°C and a relative humidity of 10% ~ 70% for at least 5 hours.

B.3.5 Fasten the ATD's seat belt and strain the lap strap. Pull out the shoulder strap from the retractor and rewind it. Repeat that for 4 cycles. When dealing with seat belts with retractors on both shoulder and waist belts, perform the operation 4 times on each retractor.

B.3.6 Paint the ATD's head, knees and calves in different colors to identify the contact position between the ATD and the vehicle interior trim during crash. Mark the position of the center of gravity of the head with photographic marks on both sides of the ATD's head. ATD painting requirements are shown in Table B.1 and Fig. B.3.

Table B.1 ATD Painting Requirements

Part	Hybrid III 50th ATD	Hybrid III 5th ATD
Left face	Yellow	Yellow
Right face	Blue	Blue
Back of head	Red	Red
Left knee	Green	Green
Right knee	Yellow	Yellow
Left tibia	Blue	Blue
Right tibia	Red	Red

Fig. B.3 Schematic Diagram of ATD Painting

B.4 Test photos

Record the state of the VUT and the position of the ATD before and after the crash. See Table B.2 for detailed shooting angles.

Table B.2 Test Photos

S/N	Shooting Angle	BEFORE Test	After Test
1	Front view photo of the vehicle	√	√
2	Front view photo of the right side of the vehicle	√	√
3	Photo taken at 45° in the right front of the vehicle	√	√
4	Photo of the front right quarter of the vehicle	√	√
5	Photo of the relative position between the vehicle and the barrier	√	√
6	Front-side view photo of driver's position	√	√
7	Photo of the driver's leg position	√	√
8	Photo of driver contact	——	√
9	Front-side view photo of the front passenger	√	√
10	Photo of front passenger's foot position	√	√
11	Photo of front passenger contact	——	√
12	Front-side view photo of rear passenger (left and right)	√	√
13	Photo of rear passenger contact	——	√
14	Photo of the front bottom of the vehicle	√	√

B.5 High-speed photography

Nine high-speed cameras are used in the test, 6 on the ground and 3 on the vehicle. The high-speed cameras record at a speed of not less than 1000 frames per second. Table B.3 lists the shooting angles of the on-board high-speed cameras. Fig. B.4 and Fig. B.5 illustrate the positions of the high-speed cameras on ground and those on the vehicle respectively.

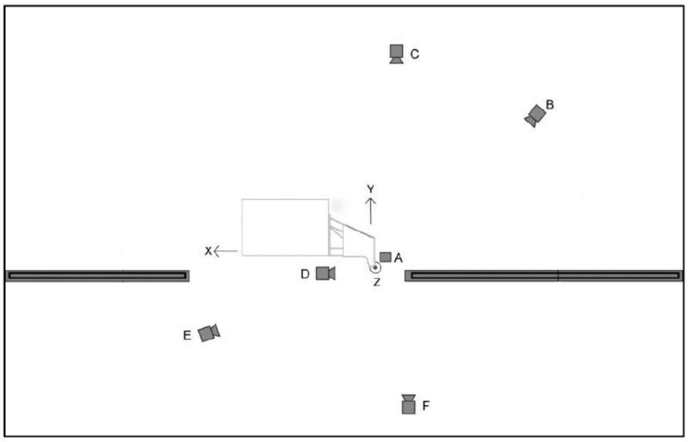


Fig. B.4 Positions of High-speed Cameras on Ground

Table B.3 High-speed Cameras on Vehicle - Shooting Angles

Camera Position	H	I	J
Shooting angle	Rear of front passenger	The side of the rear passenger	Rear of driver and front passenger

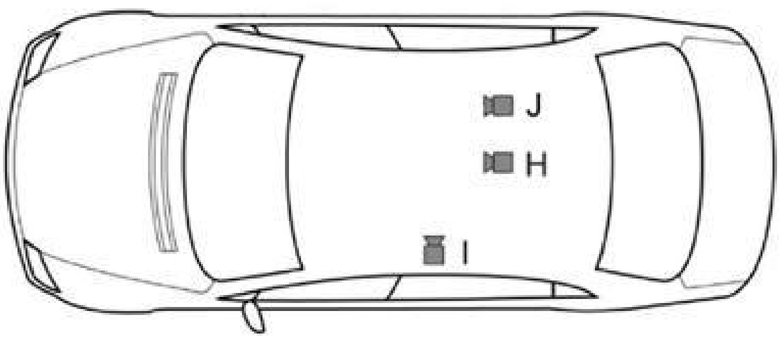


Fig. B.5 Positions of High-speed Cameras on Vehicle

B.6 Test conditions

B.6.1 Test barrier

A rigid barrier is used in the test, and its structural dimensions are shown in Fig. B.6 and Fig. B.7. The barrier is fixed on the ground on the passenger side in the traction direction of the vehicle.

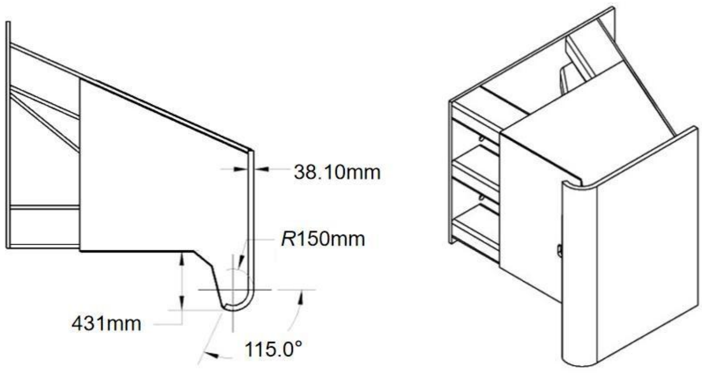


Fig. B.6 Top View and Axial Side View of Barrier

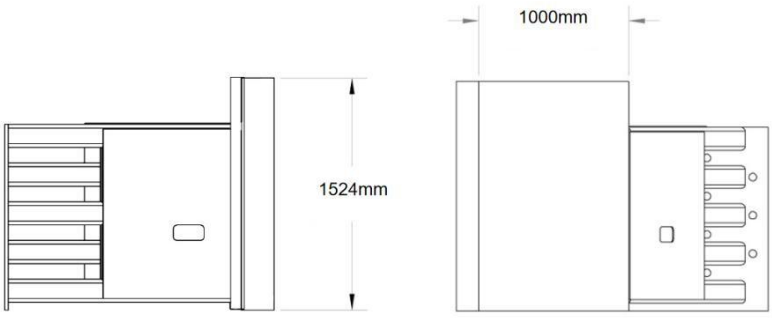


Fig. B.7 Side View and Front View of Barrier

B.6.2 Test mass

The vehicle test mass is measured after all test equipment is installed, and it includes the mass of all test equipment and ATDs. The vehicle test mass shall be 240 kg ~ 290 kg higher than the measured curb mass. If the vehicle test mass does not reach this range, place counterweights in the trunk of the vehicle. If the vehicle test mass exceeds this range, remove some parts at the rear part of the vehicle that do not affect the test results (such as the silencer and the exhaust pipe).

Determine the longitudinal position of the center of gravity of the VUT through the front and rear axle loads.

B.6.3 Vehicle width

The vehicle width is determined and measured according to SAE J1100 *Motor Vehicle Dimensions*. It is defined as the maximum dimension of the widest area of the vehicle, excluding the rearview mirrors, flexible fenders and marker lamps, but including bumpers, body trims, metal panel bulges or double-row wheels (if equipped as standard configuration).

B.6.4 Crash speed

The crash speed of the vehicle is 64.4 km/h ± 1 km/h. The crash speed is measured with a velocimeter, and the measured speed of the traction system itself is used as a backup of the crash speed. The VUT is accelerated by the traction device at an acceleration of ≤ 0.3 g until it reaches the test speed.

B.6.5 Overlap

The VUT is aligned with the rigid barrier, and the overlap on the passenger side accounts for 25%±1% of the vehicle width (see Fig. B.8).

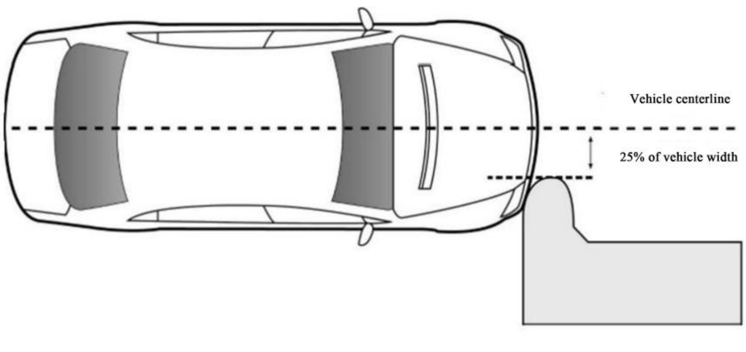


Fig. B.8 Schematic Diagram of Vehicle-Barrier Crash Position

B.7 Test measurement

Test instruments shall be inspected or calibrated regularly, generally, every 12 months. The measured values recorded by all instruments shall conform to SAE J1733 *Sign Convention for Vehicle Crash Testing*.

B.7.1 Test instrument

B.7.1.1 Body test instruments

B.7.1.1.1 Body acceleration

Install the acceleration sensor horizontally in the rear seat area along the centerline of the vehicle. To facilitate installation, the carpet in this area can be removed, or a sensor installation platform may be welded in this area (see Table B.4).

Table B.4 Body Acceleration Sensor

Measuring Parts	Measurement Parameters	Measuring Channel
Body acceleration	A_x, A_y and A_z	3

B.7.1.1.2 Seat belt force sensor

Install shoulder and lap strap force sensors on the rear seat belts of the vehicle (see Table B.5).

Table B.5 Seat Belt Force Sensor

Measuring Parts	Measurement Parameters	Measuring Channel
Seat belt	Force of shoulder strap and lap belt F	2

B.7.1.2 ATD test instruments

The Hybrid III 50th ATD shall be equipped with sensors at various parts shown below (see Table B.6):

Table B.6 ATD Measurement Parameters and Test Requirements (Hybrid III 50th)

Measuring Parts	Measurement Parameters	Measuring Channel
Head	Acceleration A_x, A_y, A_z	3
	Angular velocity ω_x, ω_y, ω_z	3
Neck	Force F_x, F_y, F_z	4
	Moment M_y	
Chest	Acceleration A_x, A_y, A_z	4
	Compression deformation D	
Thigh and hip	Compression force on thigh (left/right) F_z	4
	Sliding displacement of knee joint (left/right) D	
Tibia	Force on upper tibia (left/right) F_z	12
	Moment of upper tibia M_x, M_y	
	Force on lower tibia (left/right) F_z	
	Moment of lower tibia M_x, M_y	
Foot	Acceleration (left/right) A_x, A_z	4
Total number of channels of ATD sensor		34

The Hybrid III 5th ATD shall be equipped with sensors at various parts shown below (see Table B.7):

Table B.7 ATD Measurement Parameters and Test Requirements (Hybrid III 5th)

Measuring Parts	Measurement Parameters	Measuring Channel
Head	Acceleration A_x, A_y, A_z	3
Neck	Force F_x, F_y, F_z	4

Measuring Parts	Measurement Parameters	Measuring Channel
	Moment M_y	
Chest	Acceleration A_x, A_y, A_z	4
Chest	Compression deformation D	4
Thigh	Compression force on thigh (left/right) F_z	4
	Sliding displacement of knee joint (left/right) D	
Pelvis	Force on iliac bone (left/right) F_x	2
	Pelvis acceleration A_x, A_y, A_z	3
Total number of channels of ATD sensor		20

B.7.1.3 Total number of test channels

See Table B.8 for details of test channels:

Table B.8 Number of Test Channels of Test Instruments

Measuring Parts	Number of Test Channels
Channel for Hybrid III 50th ATD in driver and front passenger seats	68
Channel for rear passenger Hybrid III 5th ATD	20
Vehicle data channel	3
Seat belt force sensor channel	2
Total	93

B.7.2 Intrusion measurement

Before and after the test, measure the intrusion at the 19 marking points inside and outside the vehicle on the passenger side with a three-coordinate measuring instrument in the same coordinate system.

B.7.2.1 Definition of coordinate system

Define the 3D coordinate system according to the right-hand rule: X direction (positive from front to back), Y direction (positive from left to right) and Z direction (positive from bottom to top).

Before the test, establish a coordinate system using the unloaded vehicle placed on the horizontal ground. The horizontal ground is used for defining the X-Y plane, while the two endpoints of the roof centerline are used for defining the X-axis. The vehicle body coordinate system provided by the enterprise can be used.

Before the crash, measure the coordinates of three reference points marked on the vehicle for restoring the coordinate system of the vehicle after the crash. Generally, the reference points are marked on the vehicle structure of the rear door frame on the non-crash side.

B.7.2.2 Position of measuring points

The vehicle intrusion measuring positions are as follows (see Fig. B.9):

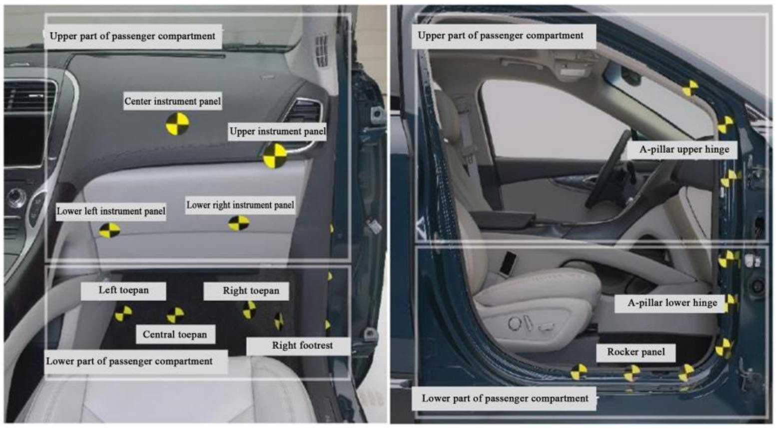


Fig. B.9 Vehicle Intrusion Measuring Positions

B.7.2.2.1 Upper dashboard (one point)

Add 25 cm to the lateral coordinate of the centerline measurement point of the passenger seat. Thereby, a row of reference points at the edge of the upper dashboard is determined. The measuring point of the upper dashboard is located at the rearmost position of this row of reference points (towards the rear of the vehicle). This point must be located at least 30 cm above the brake pedal measuring point to ensure that the vertical position is high enough. If the rearmost point is less than 30 cm above the brake pedal measuring point, the measuring point of the upper dashboard is located at this 30 cm reference point.

If the measuring point of the upper dashboard is located on a "soft part", such as a vent or a control button (see Fig. B.10), determine two hard reference points by moving inward/outward to a position just outside the soft part, and use the weighted average of the coordinates of these two reference points to represent the coordinates of the measuring point at the original position, as shown in the following equation:

Simulate the position of the upper measuring point = $\frac{l_I}{l_0 + l_I} \times [X_{P_O}, Y_{P_O}, Z_{P_O}] + \frac{l_O}{l_0 + l_I} \times [X_{P_I}, Y_{P_I}, Z_{P_I}]$

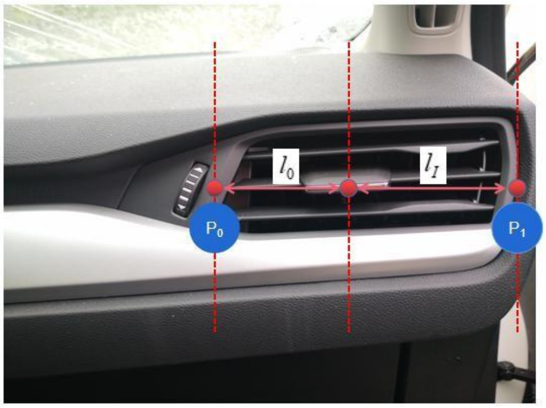


Fig. B.10 Diagram for Measuring Points on Soft Parts

B.7.2.2.2 Center dashboard (one point)

The lateral coordinate of this point is consistent with the lateral coordinate of the centerline of the passenger seat, and the vertical coordinate is 10 cm above the measuring point of the upper dashboard. If this point falls on the airbag cover plate, after the test, it is necessary to restore the airbag cover plate to the undeployed state before measurement.

B.7.2.2.3 Lower left and lower right dashboards (two points)

The lateral coordinate of the lower left dashboard measuring point is obtained by subtracting

15 cm from the lateral coordinate of the centerline measuring point of the right front passenger seat, and the lateral coordinate of the lower right dashboard measuring point is obtained by adding 15 cm to the lateral coordinate of the centerline measuring point of the right front passenger seat. The vertical coordinates of the measuring points of the lower left and lower right dashboards are obtained by adding 45 cm to the floor height of the driver side (excluding the foot pad). If the dashboard is loose or damaged during the crash, the measurement after the crash shall be achieved by pressing and holding the dashboard on the framework structure.

B.7.2.2.4 Right footrest (one point)

The vertical coordinate of the measuring point is consistent with that of the brake pedal, and the lateral coordinate is obtained by adding 25 cm to the lateral coordinate of the centerline of the right front passenger seat. The measurement procedure of floor marking points refers to A.7.2.2.5 in Small Overlap Frontal Driver-side Crash Test Protocol.

B.7.2.2.5 Seat bolts (two points)

The measuring points are two rear bolts that fix the right front passenger seat on the floor.

B.7.2.2.6 Toepan (three points)

The center toepan measuring point is located on the centerline of the right front passenger seat, the lateral coordinate of the left toepan measuring point is obtained by subtracting 15 cm from the lateral coordinate of measuring point of right front passenger seat centerline, and the lateral coordinate of the right toepan measuring point is obtained by adding 15 cm to the lateral coordinate of measuring point of right front passenger seat centerline. The vertical coordinates are consistent with that of the brake pedal measuring points, and the measuring procedure of the floor marking points refers to A.7.2.2.5 in Small Overlap Frontal Driver-side Crash Test Protocol.

B.7.2.2.7 A-pillar lower hinge (three points) and A-pillar upper hinge (three points)

Measure on the innermost surface of the right front door frame, usually at the welding edge. The vertical coordinates of the three measuring points of the A-pillar lower hinge are obtained by adding 0 cm (A-pillar lower hinge point 1), 7.5 cm (A-pillar lower hinge point 2) and 15 cm (A-pillar lower hinge point 3) to the vertical coordinate of the brake pedal measuring point. The vertical coordinates of the three measuring points of the A-pillar upper hinge are obtained by adding 45 cm (A-pillar upper hinge point 1), 52.5 cm (A-pillar upper hinge point 2) and 60 cm (A-pillar upper hinge point 3) to the vertical coordinate of the brake pedal measuring point.

B.7.2.2.8 Rocker panel (three points)

The rocker panel measuring points are located on the innermost surface of the right front door frame, usually at the welding edge. The longitudinal coordinates are obtained by adding 20 cm (rocker panel point 1), 35 cm (rocker panel point 2) and 50 cm (rocker panel point 3) to the longitudinal coordinate of the brake pedal measuring point. If the rocker panel point 1 goes forward beyond the range of the door frame, it is located 5 cm behind the measuring point of the A-pillar lower hinge.

B.7.3 Measurement of ATD space position

The measurement of ATD space position is performed after the ATD is installed and positioned, and the measurement contents are shown in Fig. B.11 and Table B.9 ~ Table B.11.

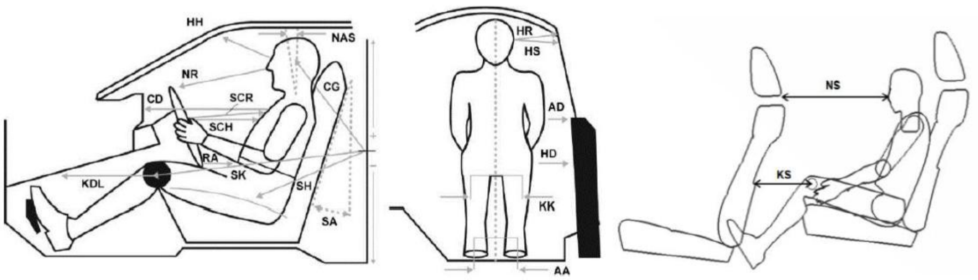


Fig. B.11 Schematic Diagram of Measuring Position

Table B.9 Description of ATD Space Position Measurement (Driver)

Position	Code	Measurement Description
Ankle - ankle	AA	Distance between the centers of both ankles
Arm - door	AD	Horizontal distance between the elbow center and the initial contact point of the door panel
Chest - dashboard	CD	Horizontal distance between the marking point of the clavicle adjusting hole in the chest and the dashboard
Head - A-pillar	HA	Horizontal distance between the left marking point of the center of gravity of the head and the A-pillar (unmarked in the figure)
Steering wheel - chest (minimum distance)	HCM	Minimum horizontal distance between the central point of the steering wheel and the ATD's chest (not marked in the figure)
H-point - door	HD	Horizontal distance between the H-point and the initial contact point of door panel
Head - headliner	HH	Distance between the middle of eyes and the upper edge of the front windshield of vehicle
Head - roof	HR	Distance between the marking point of the gravity center of head and the roof (other than the top edge of the door), perpendicular to the longitudinal axis of the vehicle
Head - side window	HS	Distance between the marking point of the gravity center of head and the side window, measured horizontally and perpendicular to the longitudinal axis of the vehicle
Knee - dashboard (left)	KDL	Horizontal distance between the center point of the left knee joint and the dashboard
Knee - dashboard (right)	KDR	Horizontal distance between the center point of the right knee joint and the dashboard
Knee - knee	KK	Distance between outer sides of flanges of knees
Neck angle (sitting/standing position)	NAS	Angle between the neck centerline and the vertical line
Nose - steering wheel rim	NR	Distance from the top of the nose to the upper rim of the steering wheel
Pelvic angle	PA	Angle measured by placing a T-bar on the H-point of ATD
Steering wheel lower rim - abdomen	RA	Distance from the joint between the bottom of the ATD's chest jacket and the ATD's abdomen filler to the lower rim of the steering wheel
Seat backrest angle	SA	Head restraint rod angle
Steering wheel - chest (horizontal)	SCH	Horizontal distance between the steering wheel center and the ATD's chest
Steering wheel - chest (reference)	SCR	Distance between the steering wheel center and the marking point of the clavicle adjusting hole in the chest
Lock catch - center of gravity of head (horizontal)	CGH	Horizontal distance between the marking point of the center of gravity of head and the driver's door lock catch
Lock catch - center of gravity	CGL	Lateral offset between the marking point of the center of gravity of

Position	Code	Measurement Description
of head (lateral)		head and the driver's door lock catch
Lock catch - center of gravity of head (vertical)	CGV	Vertical distance between the marking point of the center of gravity of head and the driver's door lock catch
Lock catch - H-point (horizontal)	SHH	Horizontal distance between the H-point and the driver's door lock catch
Lock catch - H-point (vertical)	SHV	Vertical distance between the H-point and the driver's door lock catch
Lock catch - knee	SK	Distance between the knee center and the driver's door lock catch
Lock catch - knee angle	SKA	Angle between the knee center and the driver's door lock catch
Torso recline angle	TRA	Angle between the H-point and the center of gravity of head

Table B.10 Description of ATD Space Position Measurement (Front Passenger)

Position	Code	Measurement Description
Ankle - ankle	AA	Distance between the centers of both ankles
Arm - door	AD	Horizontal distance between the elbow center and the initial contact point of the door panel
Chest - the center of the dashboard	CD	Horizontal distance between the marking point of the clavicle adjusting hole in the chest and the dashboard
Chest - dashboard (minimum)	CDM	Minimum horizontal distance between the chest and the dashboard (unmarked in the figure)
Head - A-pillar	HA	Horizontal distance between the marking point of the gravity center of head and the A-pillar (not marked in the figure)
H-point - door	HD	Horizontal distance between the H-point and the initial contact point of door panel
Head - headliner	HH	Distance between the middle of eyes and the upper edge of the front windshield of vehicle
Head - roof	HR	Distance between the marking point of the gravity center of head and the roof (other than the top edge of the door), perpendicular to the longitudinal axis of the vehicle
Head - side window	HS	Distance between the marking point of the gravity center of head and the side window, measured horizontally and perpendicular to the longitudinal axis of the vehicle
Knee - dashboard (left)	KDL	Horizontal distance between the center point of the left knee joint and the dashboard (unmarked in the figure)
Knee - dashboard (right)	KDR	Horizontal distance between the center point of the right knee joint and the dashboard (unmarked in the figure)
Knee - knee	KK	Distance between outer sides of flanges of knees
Neck angle (sitting/standing position)	NAS	Angle between the neck centerline and the vertical line
Nose - the center of the dashboard	ND	Distance from the top of the nose to the center of the dashboard
Pelvic angle	PA	Angle measured by placing a T-bar on the H-point of ATD
Seat backrest angle	SA	Head restraint rod angle
Lock catch - center of gravity of head (horizontal)	CGH	Horizontal distance between the marking point of the center of gravity of the head and the front passenger door lock catch
Lock catch - center of gravity of head (lateral)	CGL	Lateral offset between the marking point of the center of gravity of the head and the front passenger door lock catch
Lock catch - center of gravity of head (vertical)	CGV	Vertical distance between the marking point of the center of gravity of the head and the front passenger door lock catch
Lock catch - H-point (horizontal)	SHH	Horizontal distance between H-point and the front passenger door lock catch

Position	Code	Measurement Description
Lock catch - H-point (vertical)	SHV	Vertical distance between H-point and the front passenger door lock catch
Lock catch - knee	SK	Distance from the knee center to the front passenger door lock catch
Lock catch - knee angle	SKA	Angle between the knee center and the front passenger door lock catch
Torso recline angle	TRA	Angle between the H-point and the center of gravity of head

Table B.11 Description of ATD Space Position Measurement (Rear Passenger)

Position	Code	Measurement Description
H-point - door	HD	Horizontal distance between the H-point and the initial contact point of door panel
Head - side window	HS	Distance between the marking point of the gravity center of head and the side window, measured horizontally and perpendicular to the longitudinal axis of the vehicle
Nose - front seat	NS	Horizontal distance between the nose and the backrest of front seat
Abdomen - front seat	AS	Horizontal distance between the abdomen and the backrest of front seat
Chin - front seat	CS	Horizontal distance between the chin and the backrest of front seat
H-point - rocker panel	HS	Vertical distance between the H-point and the upper edge of rocker panel
Head - roof	HR	Vertical distance between the head and the roof
Nose - seat belt	NW	Vertical distance between the nose and the seat belt
Seat belt - door	WD	Horizontal distance between the seat belt and the door
Knee - front seat (left)	KSL	Horizontal distance between the center point of left knee joint and the backrest of front seat
Knee - front seat (right)	KSR	Horizontal distance between the center point of right knee joint and the backrest of front seat
Knee - knee	KK	Distance between the longitudinal centerlines of knees
Neck angle (sitting/standing position)	NAS	Angle between the neck centerline and the vertical line
Pelvic angle	PA	Angle measured by placing a T-bar on the H-point of ATD
Seat backrest angle	SA	Head restraint rod angle

B.7.4 ATD motion and contact position

B.7.4.1 The motion of ATD is analyzed by using high-speed photography. Check and record the contact of the ATD's head and knees with the vehicle interior based on the adhesion of paint after the crash.

B.7.4.2 After the crash, check the ATD while keeping it as it is, and record any damage or abnormal posture on the ATD.

B.7.4.3 The time point when a crash starts and the time points of occurrence of various events during the crash are determined according to high-speed photography. The crash starts at the time point when the T0 indicator lights up. The starting time point of each event is determined based on the number of images played since the crash starts and the number of frames taken by cameras. For a camera with a shooting rate of 1000 frames/second, the starting time point of crash may be delayed by 2 ms, and it can be advanced or delayed by 2 ms according to the time point of event occurrence determined based on high-speed photography. Record the time points when the driver's airbag is initially deployed, the airbag is fully deployed, the initial contact with the ATD is made, and other important events happen.

B.7.5 Forward coverage of side head protection airbag

Use the images of the high-speed photography to determine whether the side head protection airbag extends forward to an area of 12 cm - 22 cm above the center point of the steering wheel (this point is determined according to B.2.2.10). This area is an orthogonal vertical plane passing through the center of the steering wheel. Detailed procedures are given in normative Annex I.

B.7.6 Fuel system integrity

Record the results of fuel system integrity observed after the crash test. Collect all the liquid leaked from the fuel system within 1 min after the crash. The first sample is usually collected by absorbing the leaked liquid with a water absorption pad of known quality. The second sample is collected within 5 min immediately after the first sample is collected, and it is generally the liquid collected in the tray below the identified leakage source. The third sample is collected within 25 min immediately after the second sample is collected. The tray for every sample collection shall be clean and empty. The volume of each sample is obtained by dividing the sample mass by the liquid density. Record the time taken with a stopwatch, and record the whole process with a camera with an internal timer.

B.7.7 High voltage system integrity

After the test, monitor the hybrid or battery electric vehicle to check whether the high voltage system is damaged. According to GB/T 31498-2021 *Post Crash Safety Requirement for Electric Vehicle*, post-test observation items include electrolyte leakage, REESS safety, movement, and electric shock protection.

Immediately after the test, monitor the temperature of REESS to check whether there is a rapid temperature rise, so as to prevent thermal runaway. REESS temperature shall be monitored for at least 4 hours. After the test, the electric energy can be fully released from the high voltage system in the mode specified by the manufacturer.

B.7.8 Inspection of E-call function

In the automatic triggering mode of E-call, check and review the communication function of the VUT.

B.7.9 Inspection of other functions

B.7.9.1 After the test, check whether the door on the crash side is opened from outside the vehicle. The door shall not be opened when it is pulled vertically outward with a tension meter reading not more than 400 N at the position shown in the figure (except for the door handle), as shown in Fig. B.12. After the test, the door on the non-crash side shall be unlocked. Check whether the door can be opened normally from outside the vehicle without using tools.

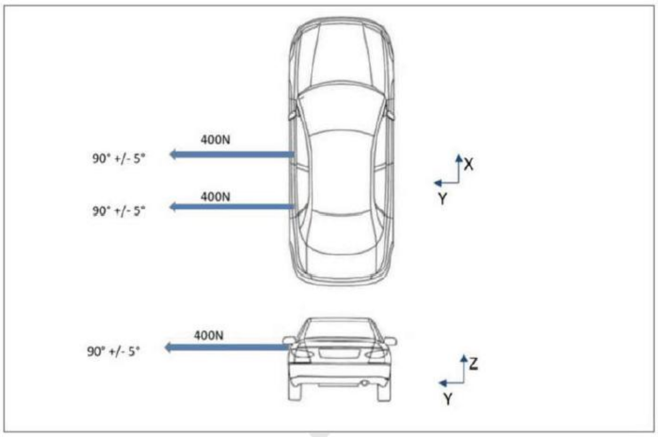


Fig. B.12 Schematic Diagram of Door Opening Measurement

B.7.9.2 After the test, measure the opening force of the seat belt buckle with a seat belt release device.

Annex C
Test Method for Moderate Overlap Frontal Crash

C.1 Introduction

The moderate overlap frontal crash test is conducted under the condition of a frontal crash of the VUT with the barrier vehicle at a speed of 50 km/h ± 1 km/h and an overlap of 50% ± 25 mm (at the driver side). A THOR 50th ATD is placed in the driver's position, a Hybrid III 50th ATD is placed on the front passenger seat and a Q6 child ATD and a Q10 child ATD are placed on the rear passenger seat on the crash side and the non-crash side respectively. They function to measure the injuries of the driver, the front passenger and the rear child occupant during the crash and observe the kinematics of the ATDs.

C.2 Vehicle preparation

C.2.1 Vehicle inspection

After the vehicle arrives at the laboratory, first check and confirm whether the vehicle is in good condition (such as whether vehicle parts are complete, whether there is oil leakage, and whether vehicle state indicators are normal). In case of any abnormalities, record the abnormal states and positions in detail. If such abnormalities are directly related to the test, the vehicle shall be repaired or replaced.

C.2.2 Vehicle preparation

C.2.2.1 Adjust the vehicle to normal running state: there is no driver, passenger, or goods, the fuel in the fuel tank is drained, the fuel tank is filled with Stoddard solution or other fuel substitutes of equal weight accounting for 90% ~ 95% of the total capacity, the whole fuel pipeline is filled up, and the on-board tools and spare tires are carried (if provided as standard equipment by the vehicle manufacturer). If the vehicle suspension is adjustable, adjust it to the position recommended by the manufacturer for urban working conditions or the default position (which shall be specified in the vehicle manual or instruction). Measure and record the vehicle mass and front and rear axle loads in this condition. This is the curb mass.

C.2.2.2 Drain the fluid in engine and transmission, the refrigerant of air conditioning system, and the windshield cleaner and other fluids in the engine compartment on the crash side.

C.2.2.3 If the VUT is a hybrid electric vehicle or battery electric vehicle, test its high voltage system at the maximum charging state recommended by the manufacturer. If there is no manufacturer's recommendation, the high voltage system shall be tested under the live state of not less than 50% of the maximum capacity. The fuse of the high voltage system shall not be removed, and the precautions before and after the crash specified by the vehicle manufacturer shall be followed. In addition, relevant devices shall be prepared and installed according to the technical requirements in GB/T31498-2021 *Safety Requirement for Rear Crash of Electric Vehicles*. The device parameters required in the technical requirements shall be tested.

C.2.2.4 Four high-speed cameras are installed on the vehicle.

C.2.2.5 The traction lanyard is installed at an appropriate position at the front end of the vehicle (such as the subframe or engine bracket).

C.2.2.6 A bracket for test equipment fixing is installed in the rear area of the vehicle. If necessary, the carpet, spare tire, jack, on-board tools and third-row seats in this area may be removed. The following test equipment is installed on the bracket in the rear area:

- On-board emergency brake system: Install it if necessary. After the system is started, it acts on the rear wheels of the vehicle. The on-board emergency brake system needs to be activated

1.0 s after the crash.

- Data acquisition system: The system acquires data from sensors during the test.
- Power supply system for on-board high-speed cameras and on-board fill lamps: This system supplies power for on-board high-speed cameras and on-board fill lights.
- Electrical safety measuring equipment: The system collects electrical safety data during the test of hybrid or battery electric vehicles.

C.2.2.7 Remove the foot pad in the vehicle. If it is a standard configuration, keep it there.

C.2.2.8 If necessary, disconnect the fuse or relay of daytime running lamp (if equipped) to reduce the consumption of on-board power supply.

C.2.2.9 Install T0 time point indicators at appropriate positions outside or inside the vehicle, and stick a strip switch at the first contact point with the barrier on the vehicle.

C.2.3 Adjustment of passenger compartment

C.2.3.1 For detailed procedures of seat and steering column adjustment, refer to *ATD and Frontal Seat Positioning Protocol* and *Child ATD and Rear Seats Positioning Protocol*.

C.2.3.2 For front seats, adjust the manually adjustable inner armrest to the lowest position and the multi-stage adjustable armrest to the closest horizontal position. For rear bucket seats, adjust the armrest to the horizontal position; for rear bucket seats equipped with child seats, keep the armrest folded; for rear bench seats, keep the central armrest folded.

C.2.3.3 Adjust the upper anchorage of the front seat belt to the position recommended by the manufacturer or the uppermost fixing position. Adjust the upper anchorage of the rear seat belt to the position recommended by the manufacturer or the lowest fixing position.

C.2.3.4 Adjust the top of the front passenger seat head restraint to a locking position flush with the ATD head. If the front passenger seat head restraint cannot be locked in the current position, adjust it upward to the nearest locking position. If the tilt of the head restraint is adjustable, adjust the head restraint to the rearmost tilt position.

C.2.3.5 Close all doors but do not lock them. If the vehicle has an automatic locking function and this function can be disabled, carry out the test with this function disabled and the doors not locked; if this function cannot be disabled, carry out the test with the doors locked.

C.2.3.6 Before the test, lower all side window glass to the lowest position, turn the ignition switch to ON position, and set the transmission in the neutral position.

C.3 Preparation and setting of ATD and child restraint system

C.3.1 Place the THOR 50th ATD and the Hybrid III 50th ATD on the driver seat and front passenger seat respectively, and position them according to *ATD and Frontal Seat Positioning Protocol*. Place Q6 and Q10 child ATDs on the rear seats on the crash side and non-crash side respectively, and position them according to *Child ATD and Rear Seats Positioning Protocol*.

C.3.2 Install the neck shield for ATD.

C.3.3 Calibrate the THOR 50th ATD according to the ATD user manual (472-9900 [Rev.F] version) after 3 tests, the Hybrid III 50th ATD according to the 49CFR572 (E) after 5 tests and the Q6 and Q10 ATDs after 20 tests. If the measured value of a certain part reaches the "poor" index in the rating protocol, this part shall be re-calibrated. If damaged parts are found after crash, repair the parts and re-calibrate.

C.3.4 Before the test, put the ATD in an environment with a temperature of 20.0°C ~ 22.2°C and a relative humidity of 10% ~ 70% for at least 5 hours.

C.3.5 Fasten the ATD's seat belt and strain the lap strap. Pull out the shoulder strap from the retractor and rewind it. Repeat that for 4 cycles. When dealing with seat belts with retractors on both shoulder and waist belts, perform the operation 4 times on each retractor.

C.3.6 Paint the ATD's head, knees and calves in different colors to identify the contact position between the ATD and the vehicle interior trim during crash. Mark the position of the center of gravity of the head with photographic marks on both sides of the ATD's head. The requirements for ATD painting are shown in Tables C.1~C.2 and Figs. C.1~C.2.

Table C.1 Requirements for Front-row ATD Painting

Part	THOR 50th ATD	Hybrid III 50th ATD	Remarks
Left face	Yellow	Yellow	——
Right face	Blue	Blue	——
Back of head	Red	Red	——
Left knee	Green	Green	45 x 45 mm square, at knee centerline, with the lower edge flush with the top of the tibia
Right knee	Yellow	Yellow	
Left tibia	Blue	Blue	——
Right tibia	Red	Red	——

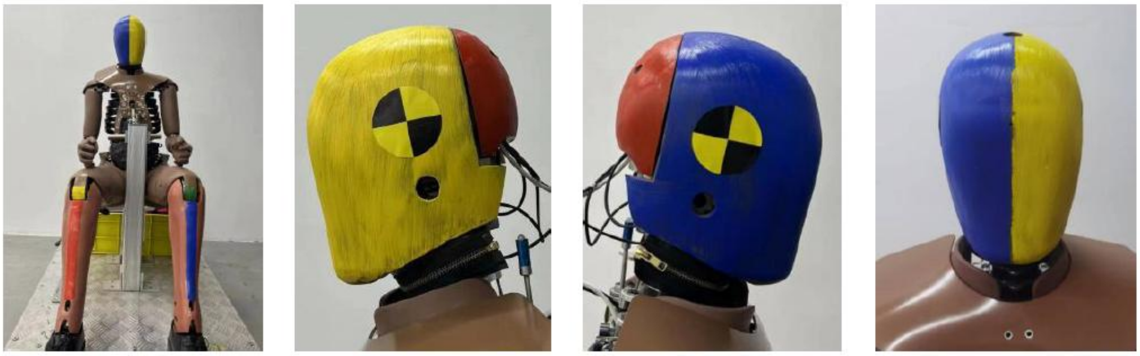


Fig. C.1 Schematic Diagram of ATD Painting (THOR 50th ATD)

Table C.2 Requirements for Child ATD Painting

Part	Color	Remarks
Top of the head	Blue	Dimensions: 75 mm X 75 mm
Hairband	Red, yellow and green (from left to right)	25 mm wide, extend to CG point on both sides

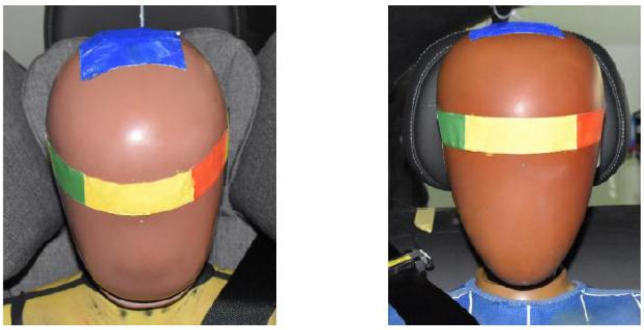


Fig. C.2 Schematic Diagram of Child ATD Painting (Q6 ATD on the Left and Q10 ATD on the Right)

C.3.7 The model of the child restraint system used in the crash test shall be determined according to the following priorities.

C.3.7.1 If the vehicle is equipped with a built-in child restraint system and it applies to Q6 or Q10 ATD, it shall be preferred to be used for the crash test.

C.3.7.2 The model of the child restraint system recommended by the enterprise is used. The model of the child restraint system shall be defined or recommended in the vehicle manual or instruction, and the child restraint system shall have a CCC certificate, meet the requirements of GB27887 *Restraining Devices for Child Occupants of Power-driven Vehicles* and can be purchased through regular sales channels in the domestic market. Enterprises can select relevant products from the "List of Child Restraint System Products for Crash Test" (shown in Table C.3) for tests.

C.3.7.3 If the enterprise does not recommend the model of the child restraint system for tests, the test room shall randomly select relevant products from the "List of Child Restraint System Products for Crash Test" for tests.

Table C.3 List of Child Restraint System Products for Crash Test

Applicable ATD	Installation Type	Product Model
Q6	Child seat (ISOFIX) + adult seat belt	Welldon WD015 Cocoon Journey 2
		Knight i-SIZE
		AVOVAStar-fix
Q10	Booster cushion + adult seat belt	KangoDad Xingzai (V906A)
		Goodbaby GB CS100
		Babycarseat BBC-513 (without backrest during test)

C.4 Test photos

Record the state of the VUT and the position of the ATD before and after the crash. See Table C.4 for detailed shooting angles.

Table C.4 Test photos

S/N	Shooting Angle	Before Test	After Test
1	Front view photo of the vehicle	√	√
2	Front view photo of the left side of the vehicle	√	√
3	Front view photo of the right side of the vehicle	√	√
4	Photo taken at 45° in the left front of the vehicle	√	√
5	Photo taken at 45° in the right front of the vehicle	√	√
6	Front view photo of the front windshield	√	√
7	Photo of the relative position between the vehicle and the barrier	√	√
8	Front-side view photo of driver's position	√	√
9	Photo of the driver's leg position	√	√
10	Photo of driver contact	——	√
11	Front-side view photo of the front passenger	√	√
12	Photo of front passenger's foot position	√	√
13	Photo of front passenger contact	——	√
14	Front-side view photo of rear passenger (left and right)	√	√
15	Photo of rear passenger contact	——	√
16	Photo of the front bottom of the vehicle	√	√
17	The front and side photos of honeycomb aluminum deformation	√	√
18	Photo of the relative position between MPDB and vehicle	——	√

C.5 High-speed photography

Ten high-speed cameras are used in the test, 6 on the ground and 4 on the vehicle. The high-speed cameras record at a speed of not less than 1000 frames per second. Table 5 lists the shooting angles of the high-speed cameras on the vehicle. Fig. C.3 gives the positions of the high-speed cameras on the ground and on the vehicle respectively.

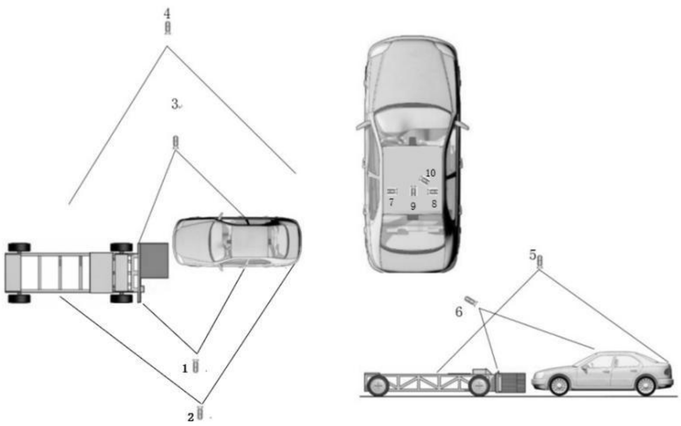


Fig. C.3 Layout of High-speed Cameras

Table C.5 High-speed Cameras on Vehicle - Shooting Angles

Camera Position	7	8	9	10
Shooting angle	The rear right passenger	The rear left passenger	Front passenger	The side of the driver

C.6 Test conditions

C.6.1 Test barrier

The MPDB shall consist of a sled and a progressive deformable barrier on the front end of the sled, as shown in Fig. C.4 below.

C.6.1.1 The total mass of MPDB shall be 1400 kg ± 20 kg.

C.6.1.2 The center of gravity shall be situated in the median longitudinal vertical plane within ±10 mm, 1000 mm ± 30 mm behind the front axle, and 500 mm + 30 mm above the ground.

C.6.1.3 The distance between the front surface of the barrier and the center of gravity of the sled shall be 2290 mm ± 30 mm.

C.6.1.4 The lower surface of the barrier shall be 150 mm ± 5 mm above the ground.

C.6.1.5 The distance between the outer edge of MPDB and the longitudinal centerline shall be 850 mm ± 10 mm.

C.6.1.6 The gap between the front wheels and the rear wheels shall be 1500 mm ± 10 mm.

C.6.1.7 The wheelbase of the sled shall be 3000 mm ± 10 mm.

C.6.1.8 The interface plate between the barrier and the sled shall be 1700 mm wide and 650 mm high.

C.6.1.9 The sled must be equipped with an emergency braking system, and the pressure of all tires shall be adjusted to the same level.

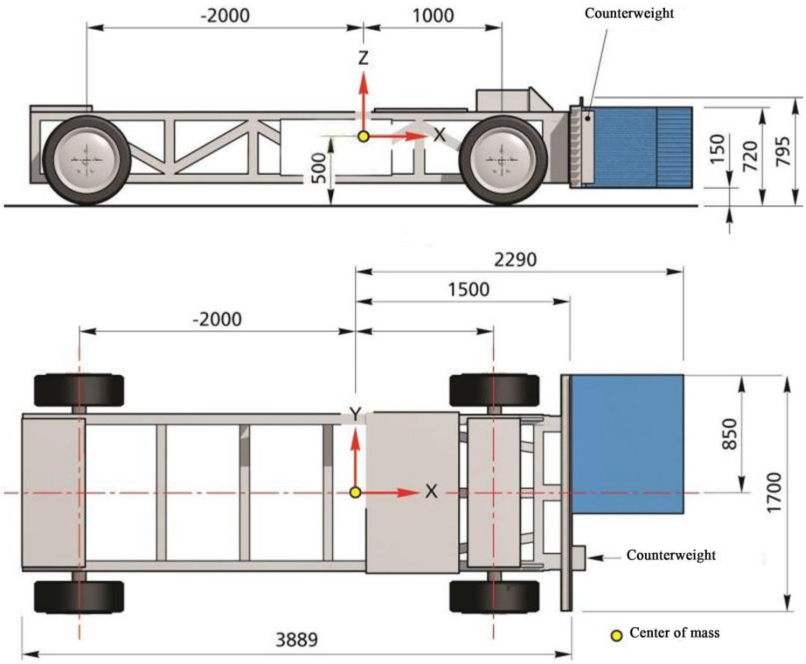


Fig. C.4 Schematic Diagram of Test Barrier Dimensions

C.6.2 Test mass

The vehicle test mass is measured after all test equipment is installed, and it includes the mass of all test equipment and ATDs. The vehicle test mass shall be 250 kg ~ 300 kg larger than the measured curb mass. If the vehicle test mass does not reach this range, place counterweights in the trunk of the vehicle. If the vehicle test mass exceeds this range, remove some parts at the rear part of the vehicle that do not affect the test results (such as the silencer and the exhaust pipe).

Determine the longitudinal position of the center of gravity of the VUT through the front and rear axle loads.

C.6.3 Vehicle width

The vehicle width is determined and measured according to SAE J1100 *Motor Vehicle Dimensions*. It is defined as the maximum dimension of the widest area of the vehicle, excluding the rearview mirrors, flexible fenders and marker lamps, but including bumpers, body trims, metal panel bulges or double-row wheels (if equipped as standard configuration).

C.6.4 Crash speed

The crash speeds of the MPDB and the VUT shall be 50 km/h ± 1 km/h. The crash speed is measured with a velocimeter, and the measured speed of the traction system itself is used as a backup of the crash speed. The MPDB and the VUT shall be accelerated by the traction device at an acceleration of ≤ 0.3 g until they reach the test speed.

C.6.5 Overlap

The VUT shall be aligned with the honeycomb aluminum at the front end of the MPDB, and the overlap at the driver side shall account for 50% ± 25 mm of the vehicle width (shown in Fig. C.5).

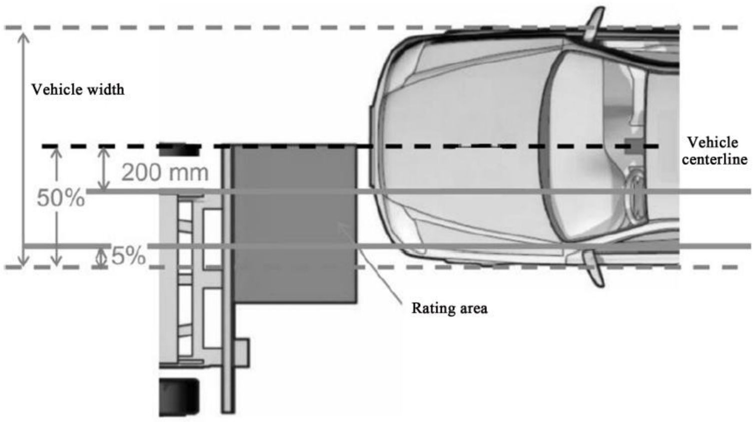


Fig. C.5 Schematic Diagram of Vehicle-Barrier Crash Position

C.7 Test measurement

Test instruments shall be inspected or calibrated regularly, generally, every 12 months. The measured values recorded by all instruments shall conform to SAE J1733 *Sign Convention for Vehicle Crash Testing*.

C.7.1 Test instrument

C.7.1.1 Vehicle test instrument

Vehicle sensors shall include those on the vehicle body, the seat belts and the batteries. The configuration list is shown in Table C.6.

C.7.1.1.1 Remove the carpet and necessary interior trims, and install the acceleration sensor horizontally at the rocker panel at the bottom of the B-pillar. The installation shall not adversely affect the seat belt retractor/pretensioner.

C.7.1.1.2 The sensor arranged on the shoulder strap of the ATD shall be lighter than 100 g and be calibrated according to ISO/TS 17242: 2014.

C.7.1.1.3 When the installation of the sensor arranged on the shoulder strap has a significant impact on the natural wearing position of the seat belt, a soft non-metallic wire can be used to support it from above.

C.7.1.1.4 For seat belts equipped with pretensioners, there shall be sufficient distance between the sensor arranged on the shoulder strap of the ATD and the D-ring to avoid interference between the sensor and the D-ring when the seat belt is pretensioned. If the seat belt has a CRS locking device, the sensor arranged on the shoulder strap may not be installed to avoid interference.

Table C.6 Sensors Configured on Vehicle

Measuring Parts	Measurement Parameters	Measuring Channel
The left side of the B-pillar	Acceleration A_x	1
The right side of the B-pillar	Acceleration A_x	1
Shoulder strap of ATD at driver side	Shoulder strap force F	1
Shoulder strap of ATD at the front passenger side	Shoulder strap force F	1
Shoulder strap of Q6 child ATD	Shoulder strap force F	1
Shoulder strap of Q10 child ATD	Shoulder strap force F	1
Battery (including spare battery)	Supply voltage V	1
Total number of channels		7

C.7.1.2 ATD test instruments

The THOR 50th ATD shall be equipped with the sensors at various parts shown below:

Table C.7 Measurement Parameters and Test Requirements for ATD (THOR 50th)

Measuring Parts	Measurement Parameters	Measuring Channel
Head	Acceleration A_x, A_y, A_z	3
	Angular rate ω_x, ω_y, ω_z	3
	Inclination X and Y	2
Neck cable	Force	2
Upper neck	Force F_x, F_y, F_z	3
	Moment M_x, M_y, M_z	3
Neck	Inclination X and Y	2
T1	Acceleration A_x, A_y, A_z	3
T4	Acceleration A_x, A_y, A_z	3
Clavicle (L&R)	Force	8
Chest	Compression DC0	4
	Angle Y and Z	8
	Inclination X and Y	2
Middle thoracic bone	Acceleration Ax	1
Abdomen	Compression DC0	2
	Angle Y and Z	4
	Acceleration Ax	1
T12	Acceleration A_x, A_y, A_z	3
	Force F_x, F_y, F_z	3
	Moment M_x and M_y	2
	Inclination X and Y	2
Pelvis	Acceleration A_x, A_y, A_z	3
	Inclination X and Y	2
Ilium (L&R)	Force F_x	2
	Bending moment M_y	2
Acetabular bone (L&R)	Force F_x, F_y, F_z	6
Thigh (L&R)	Force F_x, F_y, F_z	6
	Bending moment M_x, M_y, M_z	6
Knee (L&R)	Displacement D_{knee}	2
Upper tibia (L&R)	Force F_x and F_z	4
	Moment M_x and M_y	4
Lower tibia (L&R)	Force F_x and F_z	4
	Bending moment M_x and M_y	4
Foot (L&R)	Acceleration A_x and A_z	4
Total number of channels of ATD sensor	Total number of channels (including rate sensor)	103
	Inclination sensor (static)	10

The Hybrid III 50th ATD shall be equipped with the sensors at various parts shown below:

Table C.8 ATD Measurement Parameters and Test Requirements (Hybrid III 50th)

Measuring Parts	Measurement Parameters	Measuring Channel
Head	Acceleration A_x, A_y, A_z	3
Measuring Parts	Measurement Parameters	Measuring Channel
	Angular velocity ω_x, ω_y, ω_z	3
Neck	Force F_x, F_y, F_z	4
	Moment M_y	
Chest	Acceleration A_x, A_y, A_z	4
	Compression deformation D	
Thigh and hip (L&R)	Compressive force on thigh F_z	4
	Knee joint sliding displacement D	
Tibia (L&R)	Force on upper tibia F_z	12
	Moment of upper tibia M_x, M_y	
	Force on lower tibia F_z	
	Moment of lower tibia M_x, M_y	
Foot (L&R)	Acceleration A_x and A_z	4
Total number of channels of ATD sensor		34

The Q6 ATD shall be equipped with sensors at various parts shown below:

Table C.9 Measurement Parameters and Test Requirements for ATD (Q6)

Measuring Parts	Measurement Parameters	Measuring Channel
Head	Acceleration A_x, A_y, A_z	3
Neck	Force F_x, F_y, F_z	6
	Moment M_x, M_y, M_z	
Chest	Compression D_{chest}	1
	Acceleration A_x, A_y, A_z	3
Total number of channels of ATD sensor		13

The Q10 ATD shall be equipped with sensors at various parts shown below:

Table C.10 Measurement Parameters and Test Requirements for ATD (Q10)

Measuring Parts	Measurement Parameters	Measuring Channel
Head	Acceleration A_x, A_y, A_z	3
Neck	Force F_x, F_y, F_z	6
	Moment M_x, M_y, M_z	
Chest	Acceleration A_x, A_y, A_z	3
	Compression D_{chest}	4
Abdomen	Pressure P_{aL} and P_{aR}	2
Total number of channels of ATD sensor		18

C.7.1.3 Test instrument for barrier sled

Horizontally install the acceleration sensor at the center of gravity of the sled of MPDB. To ensure that the acceleration waveform of the barrier sled can be accurately obtained, install an additional three-way acceleration sensor at the center of gravity of the sled for backup.

Table C.11 Measurement Parameters and Test Requirements for Barrier Sled

Position	Measurement Parameters	Measuring Channel
Center of gravity of the sled	Acceleration A_x, A_y, A_z	3
Center of gravity of the sled (spare sensor)	Acceleration A_x, A_y, A_z	3
Total number of channels		6

C.7.1.4 Total number of test channels

Table C.12 Number of Test Channels of Test Instruments

Measuring Parts	Number of Measurement Channels
THOR 50th ATD (on the driver seat) channel	103
Hybrid III 50th ATD (on the front passenger seat) channel	34
Q6 ATD (on the rear passenger seat) channel	13
Q10 ATD (on the rear passenger seat) channel	18
Vehicle data channel	7
Data channel for the sled of MPDB	6
Total	181

C.7.2 Measurement of vehicle structural intrusion

Before and after the test, measure at the 12 marking points inside and outside the vehicle at the driver side with a three-coordinate measuring instrument in the same coordinate system.

C.7.2.1 Definition of coordinate system

Define the 3D coordinate system according to the right-hand rule: X direction (positive from front to back), Y direction (positive from left to right) and Z direction (positive from bottom to top).

Before the test, establish a coordinate system using the unloaded vehicle placed on the horizontal ground. The horizontal ground is used for defining the X-Y plane, while the two endpoints of the roof centerline are used for defining the X-axis. The vehicle body coordinate system provided by the enterprise can be used.

Before the crash, measure the coordinates of three reference points marked on the vehicle for restoring the coordinate system of the vehicle after the crash. Generally, the reference points are marked on the vehicle structure of the rear door frame on the non-crash side.

C.7.2.2 Position of measuring points

Vehicle intrusion measuring positions are shown in Fig. C.6:

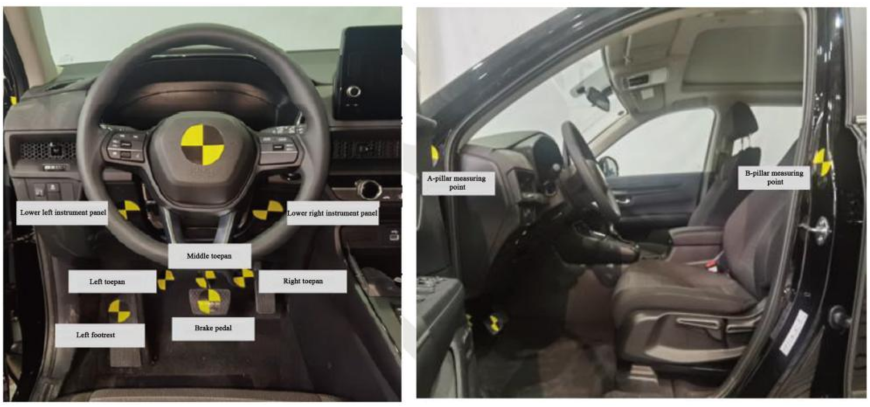


Fig. C.6 Schematic Diagram of Vehicle Intrusion Measuring Positions

C.7.2.2.1 Steering column (one point)

The measuring point is the geometric center of the steering wheel and is usually located on the airbag cover plate. After the crash, it is necessary to restore the airbag cover plate to the non-detonating state. If the steering column is loose or completely separated from the instrument panel during the crash, post and maintain the steering wheel and steering column at their dynamic maximum (upward and forward) positions for measurement, and the steering column position can be determined by high-speed photography.

C.7.2.2.2 Brake pedal (one point)

The measuring point is the geometric center of the brake pedal (upper surface). If the brake pedal is loose and shakes after the crash, push the brake pedal directly forward to the toepan or floor, and keep it in this position for post-crash measurement. If the pedal is completely disengaged, no post-crash measurement will be performed.

C.7.2.2.3 Left footrest (one point)

The vertical coordinate of the measuring point is consistent with that of the brake pedal measuring point, and the lateral coordinate is obtained by subtracting 25 cm from the lateral coordinate of the brake pedal measuring point. The floor structure shall be marked and measured with reference to the Small Overlap Frontal Crash Test Protocol. If there is a special structure at the footrest measuring point, remove the structure, and then mark and measure on the floor. Restore the structure before the crash.

C.7.2.2.4 Toepan (three points)

The vertical coordinate of the toepan measuring point shall be consistent with that of the brake pedal measuring point. The lateral coordinate of the middle toepan measuring point shall be consistent with that of the brake pedal measuring point, the lateral coordinate of the left toepan measuring point shall be obtained by subtracting 15 cm from that of the brake pedal measuring point, and the lateral coordinate of the right toepan measuring point shall be obtained by adding 15 cm to that of the brake pedal measuring point.

Make a temporary mark on the toepan. Draw a small "v" shape on the carpet and the floor mat on the toepan with tools and peel them off, and then mark and measure on the exposed floor. Restore the carpet and the mat before the crash.

C.7.2.2.5 Lower dashboard (two points)

The vertical coordinate of the lower dashboard measuring point shall be obtained by adding 45 cm to the height of the floor at the driver side (excluding the foot pad). The lateral coordinate of the left lower dashboard measuring point shall be obtained by subtracting 15 cm from the lateral coordinate of the center point of the steering column, and the lateral coordinate of the lower right dashboard measuring point shall be obtained by adding 15 cm to the lateral coordinate of the center point of the steering column. If the dashboard is loose or damaged during the crash, the measurement after the crash shall be achieved by pressing and holding the dashboard on the framework structure.

C.7.2.2.6 Intrusion between A and B pillars (two points)

The A-pillar measuring point shall be the corresponding A-pillar outer panel sheet metal at the lower beam of the windshield, and the B-pillar measuring point shall be the center point of the B-pillar outer panel in the horizontal direction. The vertical coordinate of the A-pillar measuring point shall be consistent with that of the B-pillar measuring point.

C.7.2.2.7 Seat bolts (two points)

The measuring points shall be two rear bolts that fix the front right passenger seat on the floor.

C.7.3 Measurement of barrier surface

To measure the deformation of the MPDB surface, honeycomb aluminum in front of the barrier shall be scanned with a three-coordinate measuring instrument. The system must be able to record the 3D coordinates of the single point and the point cloud.

C.7.3.1 Before test

C.7.3.1.1 The coordinates of four corner reference points on the front surface of the undeformed honeycomb aluminum shall be measured.

C.7.3.1.2 With the lower right corner reference point as the origin, the direction from the lower left corner reference point to the lower right corner reference point as the Y axis, and the optimum fitting plane of the four corner reference points as the YZ plane, a measurement coordinate system for honeycomb aluminum unit shall be established, as shown in Fig. C.7.

C.7.3.1.3 At least four reference points shall be marked and measured on the left and right boundaries of the metal back plate, as shown in Fig. C.8. These reference points shall be located at different heights so that the coordinate system can be restored after the crash.

C.7.3.1.4 At least four reference points shall be marked and recorded at the rear of the honeycomb aluminum on the non-crash side of the barrier.

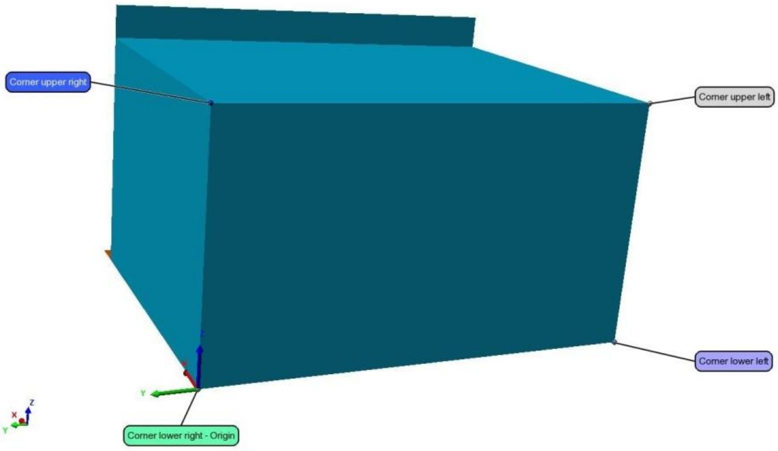


Fig. C.7 Schematic Diagram of Establishment of Barrier Measurement Coordinate System

Fig. C.8 Schematic Diagram of Reference Point for Barrier Deformation Measurement

C.7.3.2 After test

C.7.3.2.1 If the VUT and the barrier surface remain connected, they must be carefully separated.

The separation operation shall not affect the honeycomb aluminum barrier deformation. The barrier can be carefully removed from the barrier vehicle for separation operation, if necessary. If the separation is still unsuccessful, it is allowed to remove front structural components of the vehicle (such as the bumper beam and the longitudinal rail).

C.7.3.2.2 The liquid, dirt, glass, plastic particles and loose adhesive tape shall be removed from the barrier surface.

C.7.3.2.3 Before the scanning of the barrier, it is necessary to treat the deformation of the barrier surface that is not caused by the crash.

C.7.3.2.3.1 If separation occurs at the honeycomb aluminum bond, it is necessary to try to re-contact it, without further deforming the honeycomb aluminum. The metal cover plates wrapped at the top and bottom of the honeycomb aluminum can be removed, if necessary.

C.7.3.2.3.2 If the honeycomb aluminum cover plate bends outward due to the "hooking" of front-end components during the crash and rebound, the metal cover plate needs to be repaired to match the honeycomb outline.

C.7.3.2.3.3 If part of the longitudinal beam is stuck in the barrier, the scanning of the barrier can be performed in two or more areas. First, scan the obstacle surface as much as possible before disassembling the vehicle components; then carefully remove the components without affecting the original barrier surface as much as possible; finally, scan the part where the components are removed, and process the data of this part together with the data of other obstacle surfaces.

C.7.3.2.3.4 Cracks that are obviously not caused by vehicle intrusion shall be filled with clay (or plasticine) before the scanning of the barrier.

C.7.3.2.4 The bare metal areas can be coated with bright primers to improve the quality of barrier scanning.

C.7.3.2.5 Use the measurement reference points (eight on the left and right sides) in C.7.3.1.3 herein to restore the coordinate system. If the honeycomb aluminum is separated from the back plate, use the reference points on the non-crash side of the rear of the honeycomb aluminum described in C.7.3.1.4 herein to restore the coordinate system.

C.7.3.2.6 Scan the honeycomb aluminum surface to obtain a point cloud of the deformed surface, which shall cover the honeycomb aluminum surface before the test (projection in X-direction).

C.7.3.2.7 Create a grid based on the point cloud. The maximum side length of 10 mm shall be used, and moderate smoothing and point cloud reduction can also be applied.

C.7.3.2.8 Create an equidistant grid, with 1400 points in total and a 20 mm long side on the barrier surface before the test.

C.7.3.2.9 Project the grid points onto the scanned surface of the barrier along the X-axis, and export the corresponding coordinate values to the assessment file.

C.7.4 Measurement of ATD space position

The measurement of ATD space position is performed after the ATD is installed and positioned, and the measurement contents are shown in Fig. C.9 and Table C.13 ~ Table C.15.

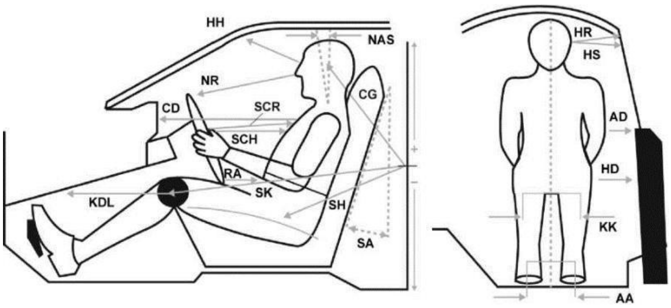


Fig. C.9 Schematic Diagram of Measuring Position

Table C.13 Description of ATD Space Position Measurement (Driver)

Position	Code	Measurement Description
Ankle - ankle	AA	Distance between the centers of both ankles
Arm - door	AD	Horizontal distance between the elbow center and the initial contact point of the door panel
Chest - dashboard	CD	Horizontal distance between the marking point of the clavicle adjusting hole in the chest and the dashboard
Head - A-pillar	HA	Horizontal distance between the left marking point of the center of gravity of the head and the A-pillar (unmarked in the figure)
Steering wheel - chest (minimum distance)	HCM	Minimum horizontal distance between the central point of the steering wheel and the ATD's chest (not marked in the figure)
H-point - door	HD	Horizontal distance between the H-point and the initial contact point of door panel
Head - headliner	HH	Distance between the middle of eyes and the upper edge of the front windshield of vehicle
Head - roof	HR	Distance between the marking point of the gravity center of head and the roof (other than the top edge of the door), perpendicular to the longitudinal axis of the vehicle
Head - side window	HS	Distance between the marking point of the gravity center of head and the side window, measured horizontally and perpendicular to the longitudinal axis of the vehicle
Knee - dashboard (left)	KDL	Horizontal distance between the center point of the left knee joint and the dashboard
Knee - dashboard (right)	KDR	Horizontal distance between the center point of the right knee joint and the dashboard
Knee - knee	KK	Distance between outer sides of flanges of knees
Neck angle (sitting/standing position)	NAS	Angle between the neck centerline and the vertical line
Nose - steering wheel rim	NR	Distance from the top of the nose to the upper rim of the steering wheel
Pelvic angle	PA	Angle measured by placing a T-bar on the H-point of ATD
Steering wheel lower rim - abdomen	RA	Distance from the joint between the bottom of the ATD's chest jacket and the ATD's abdomen filler to the lower rim of the steering wheel
Seat backrest angle	SA	Head restraint rod angle
Steering wheel - chest (horizontal)	SCH	Horizontal distance between the steering wheel center and the ATD's chest
Steering wheel - chest (reference)	SCR	Distance between the steering wheel center and the marking point of the clavicle adjusting hole in the chest
Lock catch - center of gravity of head (horizontal)	CGH	Horizontal distance between the marking point of the center of gravity of head and the driver's door lock catch
Lock catch - center of	CGL	Lateral offset between the marking point of the center of gravity of head and

Position	Code	Measurement Description
gravity of head (lateral)		the driver's door lock catch
Lock catch - center of gravity of head (vertical)	CGV	Vertical distance between the marking point of the center of gravity of head and the driver's door lock catch
Lock catch - H-point (horizontal)	SHH	Horizontal distance between the H-point and the driver's door lock catch
Lock catch - H-point (vertical)	SHV	Vertical distance between the H-point and the driver's door lock catch
Lock catch - knee	SK	Distance between the knee center and the driver's door lock catch
Lock catch - knee angle	SKA	Angle between the knee center and the driver's door lock catch
Torso recline angle	TRA	Angle between the H-point and the center of gravity of head

Table C.14 Description of ATD Space Position Measurement (Front Passenger)

Position	Code	Measurement Description
Ankle - ankle	AA	Distance between the centers of both ankles
Arm - door	AD	Horizontal distance between the elbow center and the initial contact point of the door panel
Chest - the center of the dashboard	CD	Horizontal distance between the marking point of the clavicle adjusting hole in the chest and the dashboard
Chest - dashboard (minimum)	CDM	Minimum horizontal distance between the chest and the dashboard (unmarked in the figure)
Head - A-pillar	HA	Horizontal distance between the marking point of the gravity center of head and the A-pillar (not marked in the figure)
H-point - door	HD	Horizontal distance between the H-point and the initial contact point of door panel
Head - headliner	HH	Distance between the middle of eyes and the upper edge of the front windshield of vehicle
Head - roof	HR	Distance between the marking point of the gravity center of head and the roof (other than the top edge of the door), perpendicular to the longitudinal axis of the vehicle
Head - side window	HS	Distance between the marking point of the gravity center of head and the side window, measured horizontally and perpendicular to the longitudinal axis of the vehicle
Knee - dashboard (left)	KDL	Horizontal distance between the center point of the left knee joint and the dashboard (unmarked in the figure)
Knee - dashboard (right)	KDR	Horizontal distance between the center point of the right knee joint and the dashboard (unmarked in the figure)
Knee - knee	KK	Distance between outer sides of flanges of knees
Neck angle (sitting/standing position)	NAS	Angle between the neck centerline and the vertical line
Nose - the center of the dashboard	ND	Distance from the top of the nose to the center of the dashboard
Pelvic angle	PA	Angle measured by placing a T-bar on the H-point of ATD
Seat backrest angle	SA	Head restraint rod angle
Lock catch - center of gravity of head (horizontal)	CGH	Horizontal distance between the marking point of the center of gravity of the head and the front passenger door lock catch
Lock catch - center of gravity of head (lateral)	CGL	Lateral offset between the marking point of the center of gravity of the head and the front passenger door lock catch
Lock catch - center of gravity of head (vertical)	CGV	Vertical distance between the marking point of the center of gravity of the head and the front passenger door lock catch

Position	Code	Measurement Description
Lock catch - H-point (horizontal)	SHH	Horizontal distance between H-point and the front passenger door lock catch
Lock catch - H-point (vertical)	SHV	Vertical distance between H-point and the front passenger door lock catch
Lock catch - knee	SK	Distance from the knee center to the front passenger door lock catch
Lock catch - knee angle	SKA	Angle between the knee center and the front passenger door lock catch
Torso recline angle	TRA	Angle between the H-point and the center of gravity of head

Table C.15 Description of ATD Space Position Measurement (Rear Passenger)

Position	Code	Measurement Description
Hip joint - door	HD	Hip joint (thigh mounting hole) to door
Head - side window	HS	CG to door or window (horizontal)
Hip joint - rocker panel	HS	Hip joint (thigh mounting hole) to floor
Head - roof	HR	Top of head to roof (vertical)
Shoulder - door	NW	Shoulder (axis) to door or window (horizontal)
Lower rib - door	WD	Lower rib to door (horizontal)

C.7.5 ATD motion and contact position

C.7.5.1 The motion of ATD is analyzed by using high-speed photography. Check and record the contact of the ATD's head and knees with the vehicle interior based on the adhesion of paint after the crash.

C.7.5.2 After the crash, check the ATD while keeping it as it is, and record any damage or abnormal posture on the ATD.

C.7.5.3 The time point when a crash starts and the time points of occurrence of various events during the crash are determined according to high-speed photography. The crash starts at the time point when the T0 indicator lights up. The starting time point of each event is determined based on the number of images played since the crash starts and the number of frames taken by cameras. For a camera with a shooting rate of 1000 frames/second, the starting time point of crash may be delayed by 2 ms, and it can be advanced or delayed by 2 ms according to the time point of event occurrence determined based on high-speed photography. Record the time points when the driver's airbag is initially deployed, the airbag is fully deployed, the initial contact with the ATD is made, and other important events happen.

C.7.6 Fuel system integrity

Record the results of fuel system integrity observed after the crash test. Collect all the liquid leaked from the fuel system within 1 min after the crash. The first sample is usually collected by absorbing the leaked liquid with a water absorption pad of known quality. The second sample is collected within 5 min immediately after the first sample is collected, and it is generally the liquid collected in the tray below the identified leakage source. The third sample is collected within 25 min immediately after the second sample is collected. The tray for every sample collection shall be clean and empty. The volume of each sample is obtained by dividing the sample mass by the liquid density. Record the time taken with a stopwatch, and record the whole process with a camera with an internal timer.

C.7.7 High voltage system integrity

After the test, monitor the hybrid or battery electric vehicle to check whether the high voltage system is damaged. According to GB/T 31498-2021 *Post Crash Safety Requirement for Electric Vehicle*, post-test observation items include electrolyte leakage, REESS safety, movement, and electric shock protection.

Immediately after the test, monitor the temperature of REESS to check whether there is a rapid temperature rise, so as to prevent thermal runaway. REESS temperature shall be monitored for at least 4 hours. After the test, the electric energy can be fully released from the high voltage system in the mode specified by the manufacturer.

C.7.8 Inspection of E-call function

In the automatic triggering mode of E-call, check and review the communication function of the VUT.

C.7.9 Inspection of other functions

C.7.9.1 After the test, check whether the door on the crash side is opened from outside the vehicle. The door shall not be opened when it is pulled vertically outward with a tension meter reading not more than 400 N at the position shown in the figure (except for the door handle), as shown in Fig. C.10. After the test, the door on the non-crash side shall be unlocked. Check whether the door can be opened normally from outside the vehicle without using tools.

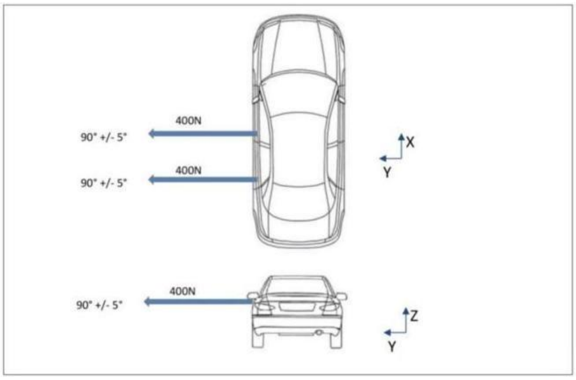


Fig. C.10 Schematic Diagram of Door Opening Measurement

C.7.9.2 After the test, measure the opening force of the seat belt buckle with a seat belt release device.

Annex C
Side Impact Crash Test Method

D.1 Introduction

In the side impact crash test, an Advanced Chinese Mobile Deformable Barrier ("AC-MDB" for short) is installed at the front end to impact the driver side of the vehicle under test (VUT). For the AC-MDB, its moving direction is perpendicular to the longitudinal center plane of the VUT, and its longitudinal centerline is aligned with the impact reference line of the VUT, with a crash speed of 50 km/h±1 km/h. A SID-IIs (Version D) ATD, placed at the driver's position and the second-row left seat of the VUT respectively, and a World SID 50th ATD, placed at the front passenger seat, function to determine the injuries of the driver, the second-row left passenger and the front passenger during the crash and observe the kinematics of the ATDs.

D.2 Vehicle preparation

D.2.1 Vehicle inspection

After the vehicle arrives at the laboratory, first check and confirm whether the vehicle is in good condition (such as whether vehicle parts are complete, whether there is oil leakage, and whether vehicle state indicators are normal). In case of any abnormalities, record the abnormal states and positions in detail. If such abnormalities are directly related to the test, the vehicle shall be repaired or replaced.

D.2.2 Vehicle preparation

D.2.2.1 Adjust the vehicle to normal running state, that is, without driver, passenger and goods. Then drain the fuel tank and fill it to 90% ~ 95% of its total capacity with Stoddard solution or other fuel substitutes of equal weight to ensure the entire fuel system is fully filled. Also, the vehicle is provided with on-board tools and spare tires (if provided as standard equipment by the vehicle manufacturer). If the vehicle suspension is adjustable, adjust it to the position recommended by the manufacturer for urban working conditions or the default position (which shall be specified in the vehicle manual or instruction). Measure and record the vehicle mass and front and rear axle loads in this condition. This is the curb mass.

D.2.2.2 If the VUT is a hybrid electric vehicle or battery electric vehicle, test its high voltage system at the maximum charging state recommended by the manufacturer. If there is no manufacturer's recommendation, the high voltage system shall be tested under the live state of not less than 50% of the maximum capacity. The fuse of the high voltage system shall not be removed, and the precautions before and after the crash specified by the vehicle manufacturer shall be followed. Relevant devices must be prepared and installed according to the technical requirements in the *Post Crash Safety Requirement for Electric Vehicle* (GB/T 31498-2021). The device parameters required in the technical requirements must be tested.

D.2.2.3 Three high-speed cameras are installed on the vehicle.

D.2.2.4 Install brackets for fixing the testing equipment in the trunk area of the vehicle. If necessary, the carpet, spare tire, jack, on-board tools and third-row seats in this area may be removed. The following testing equipment shall be installed on brackets in the trunk area:

- Data acquisition system: The system acquires data from sensors during the test.
- Power supply system for on-board high-speed cameras and on-board fill lamps: This system supplies power for on-board high-speed cameras and on-board fill lights.

D.2.2.5 Remove the foot pad in the vehicle. If it is a standard configuration, keep it there.

D.2.2.6 Lower or remove the right window glass to avoid affecting the visual field of the high-speed cameras on the vehicle during the test.

D.2.2.7 Remove pedals on both sides of the vehicle; if they are configured as standard parts, keep them there.

D.2.2.8 Install T0 time indicators at appropriate positions outside or inside the vehicle, and stick a strip switch at the first contact point with the AC-MDB on the vehicle.

D.2.2.9 Mark the center of gravity of the vehicle, the vehicle centerline, the centerline over the height of the front and rear doors on the crash side, the crash reference line, the crash target marking points, etc. (see Fig. D.1) on the vehicle surface.

D.2.2.10 Shield the front airbag and side airbag on the right front passenger side (by connecting resistors with appropriate resistance and power in the airbag circuit), so as to avoid the impact of airbag deployment on camera shooting.

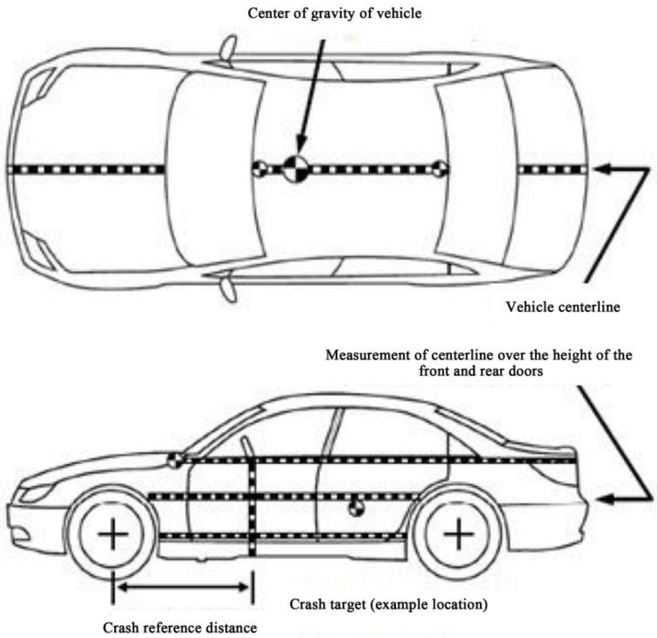


Fig. D.1 Identification of External Surface of Vehicle

D.2.2.11 To prevent a vehicle with a higher center of gravity (like an SUV, a pickup or a minibus) from rollover during a side crash, install an anti-rollover device on its non-crash side.

D.2.3 Adjustment of passenger compartment

D.2.3.1 Adjustment of driver seat and steering column

D.2.3.1.1 For the detailed procedure for adjustment of driver seat and steering column, see the *ATD and Frontal Seat Positioning Protocol*.

D.2.3.1.2 Adjust the upper anchorage of the driver seat belt to the position recommended by the manufacturer or the lowest position.

D.2.3.1.3 After adjustment of the driver seat, check the locking device and record whether all parts are locked. If some parts are locked and calibration fails through normal seat adjustments from the observation, record the situation and conduct a test with calibration not done.

D.2.3.1.4 Adjust the driver seat head restraint to the position recommended by the manufacturer or the lowest position. If the tilt of the head restraint is adjustable, adjust the head restraint to the rearmost tilt position.

D.2.3.1.5 Adjust the manually adjustable driver's inner/outer armrest to the lowest position, or the multi-stage adjustable armrest to the closest horizontal position.

D.2.3.2 Adjustment of front passenger seat

D.2.3.2.1 For the detailed procedure for adjustment of front passenger seat, see the *ATD and Frontal Seat Positioning Protocol*.

D.2.3.2.2 Adjust the upper anchorage of the front passenger seat belt to the position recommended by the manufacturer or the uppermost fixing position.

D.2.3.2.3 After adjustment of the front passenger seat, check the locking device and record whether all parts are locked. If some parts are locked and calibration fails through normal seat adjustments from the observation, record the situation and conduct a test with calibration not done.

D.2.3.2.4 Adjust the top of the front passenger seat head restraint to a locking position flush with the ATD head. If the front passenger seat head restraint cannot be locked in the current position, adjust it upward to the nearest locking position. If the tilt of the head restraint is adjustable, adjust the head restraint to the rearmost tilt position.

D.2.3.2.5 Adjust the manually adjustable front passenger's inner/outer armrest to the lowest position, or the multi-stage adjustable armrest to the closest horizontal position.

D.2.3.3 Adjustment of rear seat

D.2.3.3.1 For the detailed procedure for adjustment of rear seat, see the *ATD and Rear Outboard Seat Positioning Protocol*.

D.2.3.3.2 Adjust the rear seat head restraint to the position recommended by the manufacturer or the lowest position. If the tilt of the head restraint is adjustable, adjust the head restraint to the rearmost tilt position.

D.2.3.3.3 Adjust the manually adjustable rear seat inner/outer armrest to the lowest position, or the multi-stage adjustable armrest to the closest horizontal position.

D.2.3.3.4 Close all doors but do not lock them. If the vehicle has an automatic locking function and this function can be disabled, carry out the test with this function disabled and the doors not locked; if this function cannot be disabled, carry out the test with the doors locked.

D.2.3.3.5 Before the test, the front and rear window glasses on the crash side shall be fully raised. Adjust the ignition switch to the ON position, and shift the transmission to the neutral position. The parking brake shall be in the normal release position. Wedge wheels before the test to prevent the vehicle from moving.

D.3 ATD preparation and setting

D.3.1 Place 1 SID-IIs (Version D) ATD and 1 World SID 50th ATD on the driver seat and the front passenger seat respectively, and position them as per the *ATD and Frontal Seat Positioning Protocol*. Place another SID-IIs (Version D) ATD on the second-row left seat and position it as per the *ATD and Rear Outboard Seat Positioning Protocol*.

D.3.2 Indicate the position of the center of gravity of the head with photographic marks on both sides of the ATD's head.

D.3.3 After 5 tests, the ATD shall be re-calibrated. The SID-IIs (Version D) ATD is calibrated according to 49CFR572(V), and the World SID 50th ATD is calibrated according to ISO 15830 and WG5 N1041. If the measured value of a certain part reaches the "poor" index in the rating protocol, or the compression of the ATD's shoulder, chest and abdomen exceeds 50 mm during the test, this part shall be re-calibrated. If damaged parts are found after crash, repair the parts and re-calibrate.

D.3.4 Before the test, put the ATD in an environment with a temperature of 20.0°C ~ 22.2°C and a relative humidity of 10% ~ 70% for at least 5 hours.

D.3.5 Fasten the ATD's seat belt and strain the lap strap. Pull out the shoulder strap from the retractor and rewind it. Repeat that for 4 cycles. When dealing with seat belts with retractors on both shoulder and waist belts, perform the operation 4 times on each retractor.

D.3.6 Apply the front and rear ATDs' heads with paint in different colors to identify the contact between ATDs and the vehicle interior or AC-MDB during crash.

D.3.7 Requirements for ATD painting are shown in Table 1.

Table D.1 ATD Painting Requirements

SID-IIs ATD Painting Requirements	
Left face (above CG point of head)	Red
Left face (below CG point of head)	Yellow
Back of head	Green
Shoulder	Blue
	
World SID 50th ATD Painting Requirements	
Left face (above CG point of head)	Red
Left face (below CG point of head)	Yellow
Back of head	Green
Shoulder	Blue
	

D.4 Test photos

Record states of the VUT before and after crash and positions of the ATDs before and after crash.

Record the position of the vehicle relative to AC-MDB as well as conditions at the crash side of the vehicle and on the AC-MDB surface after the test. Record the positions of the driver ATD, the front passenger ATD and the rear ATD, as well as the contact between these ATDs and the vehicle or AC-MDB after crash. With ATDs removed from the vehicle, photograph the corresponding passenger compartment area to explain the deformation of the vehicle. Photograph the vehicle after its door on the crash side is removed.

Table D.2 Test photos

S/N	Shooting Angle	Before Test	After Test
1	Front view photo of the vehicle	√	√
2	Front view photo of the left side of the vehicle	√	√
3	Photo taken at 45° in the left front of the vehicle	√	√
4	Photo taken at 45° in the left rear of the vehicle	√	√
5	Photo of the front left quarter of the vehicle	√	√
6	Front view photo of the right side of the vehicle	√	√
7	Photo taken at 45° in the right front of the vehicle	√	√
8	Photo taken at 45° in the right rear of the vehicle	√	√
9	Photo of contact between vehicle and barrier (partial)	√	——
10	Photo of contact between vehicle and barrier (overall)	√	——
11	Photo of the relative position between the vehicle and the barrier	√	√
12	Photo of front view at the left side of driver	√	——
13	Photo of front view in front of driver	√	√
14	Photo of front view at the right side of front passenger		
15	Photo of front view in front of front passenger		
16	Photo of front view at the left side of rear passenger	√	——
17	Photo of front view at the right side of rear passenger	√	√
18	Photo of driver contact	——	√
19	Photo of front passenger contact	——	√
20	Photo of rear passenger contact	——	√
21	Driver area in passenger compartment (with ATD removed)	——	√
22	Front passenger area in passenger compartment (with ATD removed)	——	√
23	Second-row left passenger area in passenger compartment (with ATD removed)	——	√
24	Photo of each airbag deployed	——	√
25	Photo of front view at left side of vehicle (with doors removed)	——	√
26	Photo of front view in front of barrier	√	√

D.5 High-speed photography

Ten high-speed cameras are used in the test, 7 on the ground and 3 on the vehicle. The high-speed cameras record at a speed of not less than 1000 frames per second. Table D.3 lists the shooting angles of the high-speed cameras on the vehicle. Fig. D.2 and Fig. D.3 illustrate the positions of the high-speed cameras on the ground and those on the vehicle respectively.

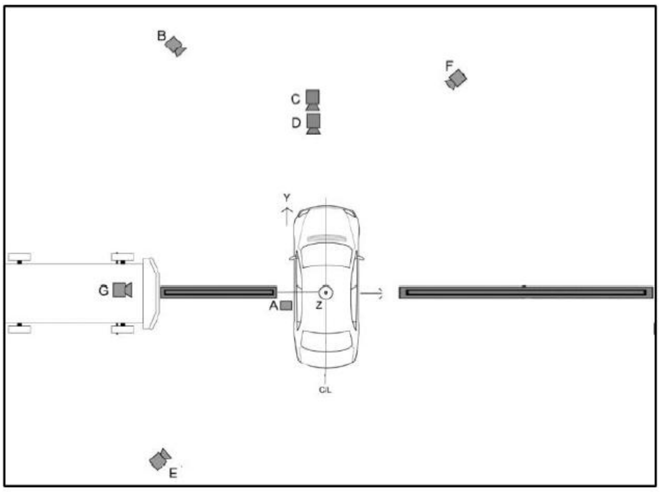


Fig. D.2 Positions of High-speed Cameras on the Ground and Those on Moving Barrier

Table D.3 Setting of High-speed Cameras on the Vehicle

Camera Position	H	I	J
Shooting angle	Driver and rear passenger side	Driver and front passenger	Rear passenger side

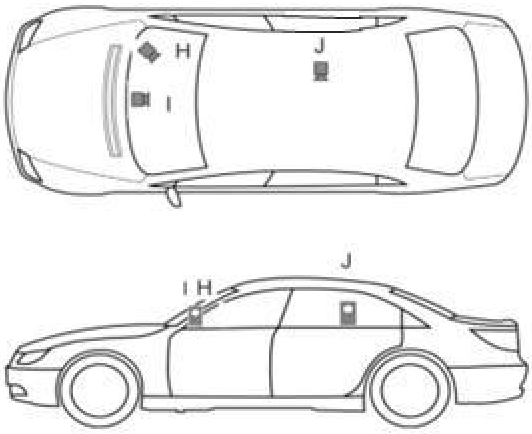


Fig. D.3 Positions of High-speed Cameras on Vehicle

D.6 Test conditions

D.6.1 AC-MDB

The AC-MDB consists of a crash block and a barrier vehicle (see Fig. D.4). The AC-MDB has a test mass of 1650 kg±20 kg (including the mass of the crash block and test instruments). Under test conditions, the center of gravity of the AC-MDB is 1174 mm±25 mm behind the front axle, 0±10 mm along the longitudinal centerline, and 547 mm±25 mm above the ground.

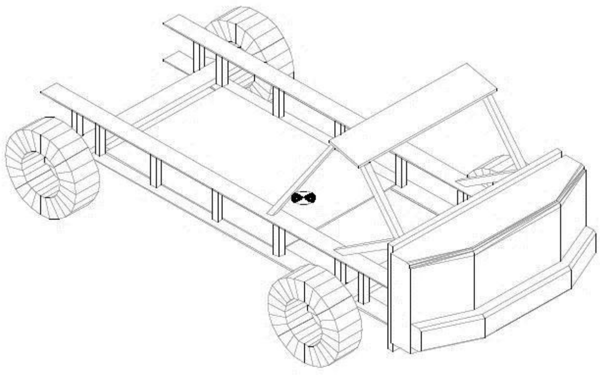


Fig. D.4 Advanced Chinese Mobile Deformable Barrier (AC-MDB)

The crash block is 1800 mm wide and 500 mm high and is 400 mm above the ground after being installed on the barrier vehicle (see Figs. D.5 and D.6). See Fig. D.7 for the stiffness corridor requirements of each block.

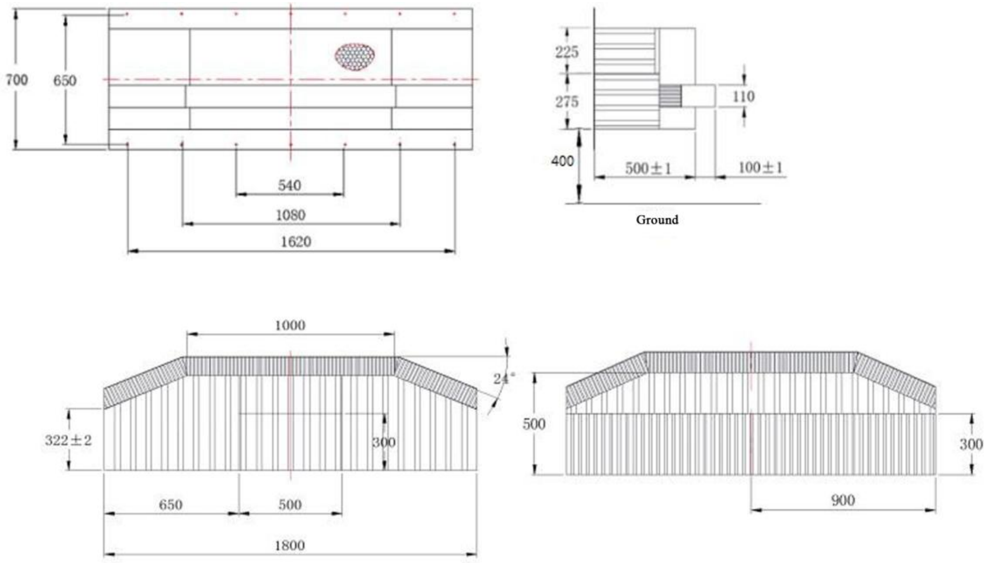


Fig. D.5 Size of Crash Block (mm)

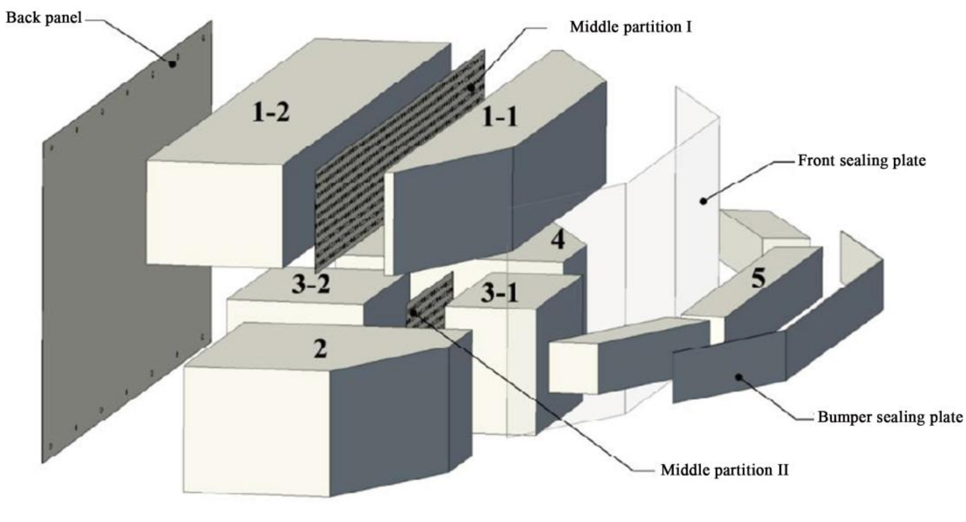
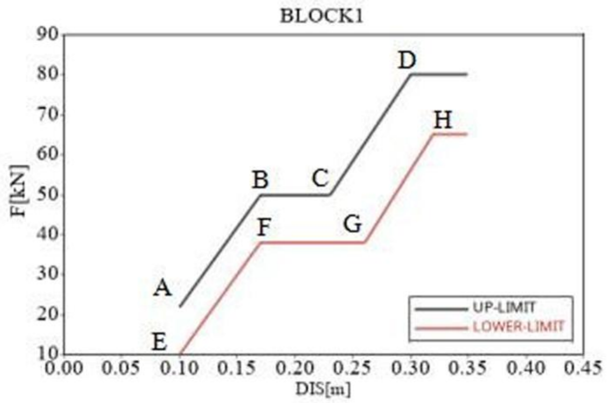
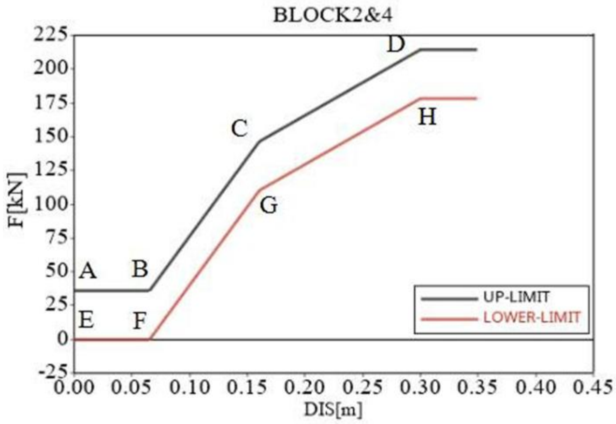


Fig. D.6 Assembly Drawing of Crash Block



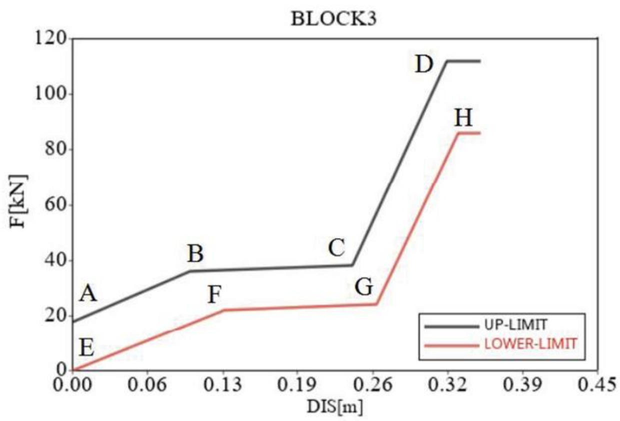
	Deformation [m]	Force [KN]
A	0.1	22
B	0.17	50
C	0.23	50
D	0.3	80
E	0.1	10
F	0.17	38
G	0.26	38
H	0.32	65

(a) Stiffness Characteristic Requirements of Block 1



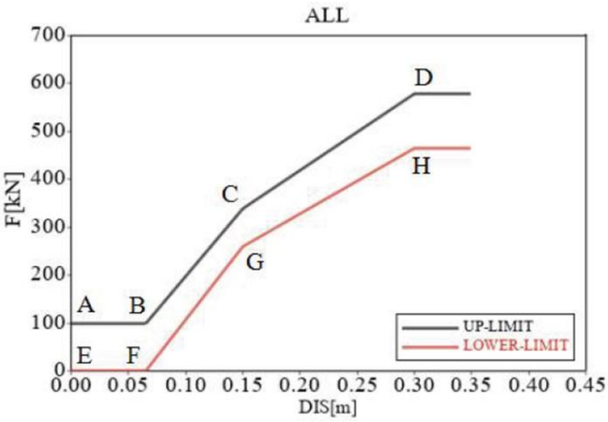
	Deformation [m]	Force [KN]
A	0	36
B	0.065	36
C	0.16	146
D	0.3	214
E	0	0
F	0.065	0
G	0.16	110
H	0.3	178

(b) Stiffness Characteristic Requirements of Blocks 2 and 4



	Deformation [m]	Force [KN]
A	0	18
B	0.1	36
C	0.24	38
D	0.32	112
E	0	0
F	0.13	22
G	0.26	24
H	0.33	86

(c) Stiffness Characteristic Requirements of Block 3



	Deformation [m]	Force [KN]
A	0	100
B	0.065	100
C	0.15	340
D	0.3	580
E	0	0
F	0.065	0
G	0.15	260
H	0.3	465

(d) Stiffness Characteristic Requirements of the Whole Block

Fig. D.7 Stiffness Corridor Requirements of Each Honeycomb Block

D.6.2 Test mass

The vehicle's test mass, including the mass of all testing equipment, 1 World SID 50th ATD and 2 SID-IIs (Version D) ATDs, shall be measured upon completion of the installation of all testing equipment. The vehicle test mass shall be 200 kg ~ 240 kg larger than the measured curb mass. If the vehicle's test mass fails to be within this range, additional weight shall be provided in the trunk, and the increased mass distribution shall be close to the load distribution (front/rear and left/right) under the curb mass. If the vehicle's test mass goes beyond this range, parts in the rear of the vehicle not affecting test results (like the silencer and exhaust pipe) shall be removed.

Determine the longitudinal position of the center of gravity of the VUT by the front and rear axle loads.

For the SUV, pickup or minibus as the VUT, the test mass shall be the mass without anti-rollover device installed.

D.6.3 Crash speed

The speed of the AC-MDB impacting the VUT is 50 km/h±1 km/h. The crash speed is measured with a velocimeter, and the measured speed of the traction system itself is used as a backup of the crash speed.

D.6.4 Crash position

The longitudinal crash point of the AC-MDB on the driver side of the VUT depends on the wheelbase of the VUT. The impact reference distance (IRD) refers to the distance between the front axle of the VUT and the longitudinal centerline of the AC-MDB when the VUT contacts the AC-MDB for the first time (see Fig. D.8). The crash position shall be so determined that the load borne by the passenger compartment is maximized and that the flat part of the barrier surface is aligned with the driver ATD's head. For most vehicles, the rear ATD's head is also within the crash range of the barrier. If the calculated crash position allows for overlap between the flat part of the barrier surface and the front/rear wheel, the IRD shall be revised to prevent the barrier from directly contacting the front/rear wheel in the initial crash phase. For this category of vehicles, the test room may either negotiate with the vehicle manufacturer to determine the crash position or determine it based on the crash position during vehicle development.

Determination of IRD:

- In case of wheelbase < 250 cm, IRD = 144.8 cm;
- In case of 250 cm ≤ wheelbase ≤ 290 cm, IRD = (wheelbase/2) + 19.8 cm;

- In case of wheelbase > 290 cm, IRD = 164.8 cm.

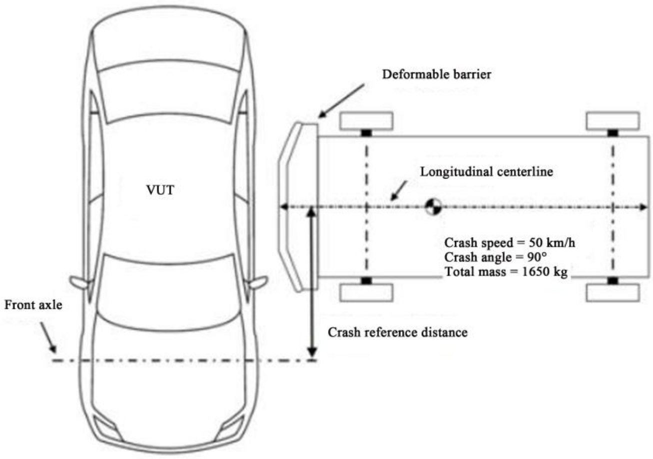


Fig. D.8 AC-MDB and VUT

D.6.5 Crash offset

The crash position offset is ±25 mm in the horizontal direction and vertical direction.

D.6.6 AC-MDB brake

The AC-MDB brake system acts on four wheels and starts braking 0.5 s after T0 of crash.

D.7 Test measurement

Test instruments shall be inspected or calibrated regularly, generally, every 12 months. The measured values recorded by all instruments shall conform to SAE J1733 *Sign Convention for Vehicle Crash Testing*.

D.7.1 Test instrument

D.7.1.1 VUT and AC-MDB test instruments

Table D.4 shows VUT and AC-MDB acceleration sensor channels.

Table D.4 VUT and AC-MDB Acceleration Sensor Channels

Test Part	Measurement Parameters	Measuring Channel
B-pillar on the non-crash side of the vehicle body	A_x, A_y and A_z	3
Position of center of gravity of AC-MDB	A_x, A_y and A_z	3

D.7.1.2 ATD test instruments

See Tables D.5 and D.6 for sensor channels installed on the SID-IIs (Version D) ATD at the driver's position/the second-row left seat and the World SID 50th ATD at the front passenger seat.

Table D.5 SID-IIs ATD Sensor Channels

Measuring Parts	Measurement Parameters	Measuring Channel
Head	Acceleration A_x, A_y, A_z	3
Neck	Force F_x, F_y, F_z	3
	Moment M_x, M_y, M_z	3
Shoulder	Force F_x, F_y, F_z	3
	Displacement D_y	1
Vertebra	T1 acceleration A_y	1
	T4 acceleration A_y	1
	T12 acceleration A_y	1

Measuring Parts	Measurement Parameters	Measuring Channel
Chest	Compression deformation D_y of (upper, middle and lower) ribs	3
	Acceleration A_y of (upper, middle and lower) ribs	3
Abdomen	Compression deformation D_y of (upper and lower) ribs	2
	Acceleration A_y of (upper and lower) ribs	2
Pelvis	Force on hip bone F_y	1
	Force on iliac bone F_y	1
	Pelvis acceleration A_y	1

Table D.6 World SID 50th ATD Sensor Channels

Measuring Parts	Measurement Parameters	Measuring Channel
Head	Acceleration A_x, A_y, A_z	3
	Angular velocity ω_x, ω_y, ω_z	3
Upper neck	Force F_x, F_y, F_z	3
	Moment M_x, M_y, M_z	3
Lower neck	Force F_x, F_y, F_z	3
	Moment M_x, M_y, M_z	3
Shoulder	Force F_x, F_y, F_z	3
	Compression deformation D_y	1
Chest	Compression deformation D_y of (upper, middle and lower) ribs	3
Abdomen	Compression deformation D_y of (upper and lower) ribs	2
T12	Acceleration A_x, A_y, A_z	3
Lumbar spine	Force F_x, F_y, F_z	3
	Moment M_x, M_y, M_z	3
Pelvis	Force on pubis F_y	1
	Force on iliac bone F_y	1
	Pelvis acceleration A_x, A_y, A_z	3

D.7.1.3 Total number of test channels

Table D.7 Number of Test Channels of Test Instruments

Test instrument	Number of Test Channels
Channel of SID-IIs (Version D) ATD in the driver's position	29
Channel of SID-IIs (Version D) ATD in the second-row seat position	29
Channel of World SID 50th ATD in the front passenger seat	41
Vehicle data channel	6
Total	105

D.7.2 Intrusion measurement

D.7.2.1 Definition of coordinate system

Define the 3D coordinate system according to the right-hand rule: X direction (positive from front to back), Y direction (positive from left to right) and Z direction (positive from bottom to top).

Before the test, establish a coordinate system using the unloaded vehicle placed on the horizontal ground. The horizontal ground is used for defining the X-Y plane, while the two endpoints of the roof centerline are used for defining the X-axis. The vehicle body coordinate system provided by the enterprise can be used.

Before the crash, measure the coordinates of three reference points marked on the vehicle for restoring the coordinate system of the vehicle after the crash. Generally, the reference points are all marked on the vehicle structure of the rear door frame on the non-crash side.

D.7.2.2 Measurement of vehicle structure

Before and after the test, measure the side contour structures at the left and right B-pillars and at the driver side of the VUT. Before the test, measure and record the centerline over the height of the front and rear doors on the crash side (see Fig. D.1). After the test, use the identical coordinate system to measure the centerline. Before the test, measure the contours (with interiors removed) marked on the outer surface of the B-pillar on the crash side and the outer and inner surfaces of the B-pillar on the non-crash side. After the test, measure the contours (with interiors removed) marked on the outer and inner surfaces of the B-pillar on the crash side.

As removal and reinstallation of interiors may affect the normal deployment of the head protection airbag installed on the side of the roof rail, the inner surface of the B-pillar on the crash side is not measured before the crash but is determined by the mirror image of the vertical section inside the B-pillar on the non-crash side. The relative displacement of the inner surface of the B-pillar on the crash side is determined by the mirror image. Fig. D.9 is an example of the vertical section of the B-pillar before and after crash.

In the vehicle structure measurement, only the structural part of the retractor is measured, and the reel and gas generator are not measured.

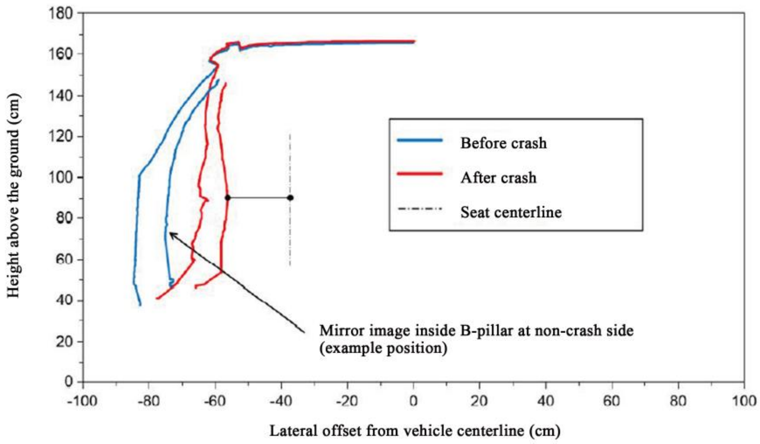


Fig. D.9 Example of Vertical Section of B-pillar

D.7.2.3 Determination of seat centerline position

Before the test, measure the coordinates of two symmetrical reference points (red points ● marked in the figure) on the driver seat cushion (left and right). The decorative ribs of the seat cushion can be used to determine the positions of the left and right reference points. In case of no available decorative rib for the seat cushion, the decorative ribs of the seat backrest can be used. In case of no available decorative rib for the seat cushion or backrest, the center of the head restraint or head restraint rod may be used as a reference line. The seat centerline position is determined by calculating the Y coordinates of two reference points (as shown in Fig. D.10).

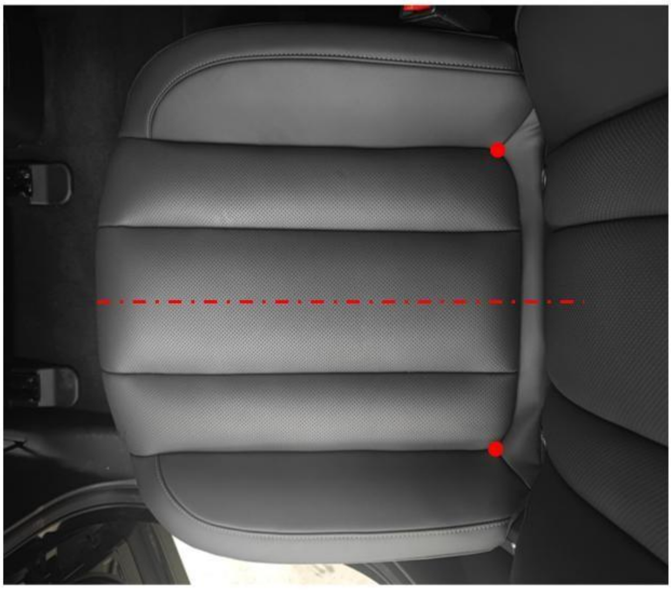


Fig. D.10 Determination of Seat Centerline Position

D.7.3 Measurement of ATD space position

The ATD space position shall be measured after ATD installation and positioning.

D.7.3.1 Measurement of front-row ATD space position

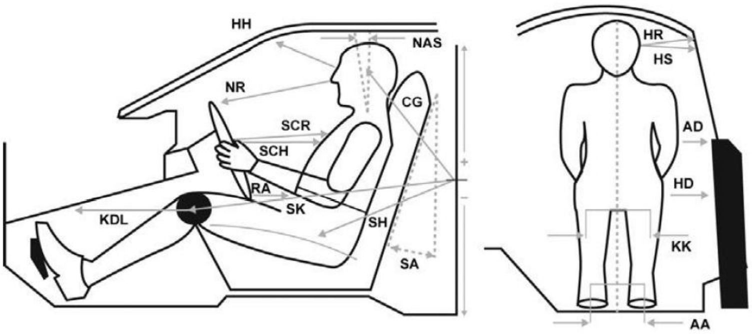


Fig. D.11 Measurement of ATD Space Position

Table D.8 Description of Measurement of Driver ATD Space Position

Position	Code	Measurement Description
Ankle - ankle	AA	Distance between the centers of both ankles
Arm - door	AD	Horizontal distance between the elbow center and the initial contact point of the door panel
Armrest - ATD	ADM	Minimum horizontal distance between the vehicle armrest and the ATD
Head - A-pillar	HA	Horizontal distance between the marking point of the gravity center of head and the A-pillar (not marked in the figure)
Steering wheel - chest (minimum distance)	HCM	Minimum horizontal distance between the central point of the steering wheel and the ATD's chest (not marked in the figure)
H-point - door	HD	Horizontal distance between the H-point and the initial contact point of door panel
Head - headliner	HH	Distance between the middle of eyes and the upper edge of the front windshield of vehicle
Head - roof	HR	Distance between the marking point of the gravity center of head and the roof (other than the top edge of the door), perpendicular to the

Position	Code	Measurement Description
		longitudinal axis of the vehicle
Head - side window	HS	Distance between the marking point of the gravity center of head and the side window, measured horizontally and perpendicular to the longitudinal axis of the vehicle
Knee - dashboard (left)	KDL	Horizontal distance between the center point of the left knee joint and the dashboard
Knee - knee	KK	Distance between outer sides of flanges of knees
Neck angle (sitting/standing position)	NAS	Angle between the neck centerline and the vertical line
Nose - steering wheel rim	NR	Distance from the top of the nose to the upper rim of the steering wheel
Pelvic angle	PA	Angle measured by placing a T-bar on the H-point of ATD
Steering wheel lower rim - abdomen	RA	Distance from the joint between the bottom of the ATD's chest jacket and the ATD's abdomen filler to the lower rim of the steering wheel
Seat backrest angle	SA	Head restraint rod angle
Steering wheel - chest (horizontal)	SCH	Horizontal distance between the steering wheel center and the ATD's chest
Steering wheel - chest (reference)	SCR	Distance between the steering wheel center and the marking point of the clavicle adjusting hole in the chest
Torso recline angle	TRA	Angle between the H-point and the center of gravity of head

Table D.9 Description of Measurement of Front Passenger ATD Space Position

Position	Code	Measurement Description
Ankle - ankle	AA	Distance between the centers of both ankles
Arm - door	AD	Horizontal distance between the elbow center and the initial contact point of the door panel
Chest - the center of the dashboard	CD	Horizontal distance between the marking point of the clavicle adjusting hole in the chest and the dashboard
Chest - dashboard (minimum)	CDM	Minimum horizontal distance between the chest and the dashboard (unmarked in the figure)
Head - A-pillar	HA	Horizontal distance between the marking point of the gravity center of head and the A-pillar (not marked in the figure)
H-point - door	HD	Horizontal distance between the H-point and the initial contact point of door panel
Head - headliner	HH	Distance between the middle of eyes and the upper edge of the front windshield of vehicle
Head - roof	HR	Distance between the marking point of the gravity center of head and the roof (other than the top edge of the door), perpendicular to the longitudinal axis of the vehicle
Head - side window	HS	Distance between the marking point of the gravity center of head and the side window, measured horizontally and perpendicular to the longitudinal axis of the vehicle
Knee - dashboard (left)	KDL	Horizontal distance between the center point of the left knee joint and the dashboard (unmarked in the figure)
Knee - dashboard (right)	KDR	Horizontal distance between the center point of the right knee joint and the dashboard (unmarked in the figure)
Knee - knee	KK	Distance between outer sides of flanges of knees
Neck angle (sitting/standing position)	NAS	Angle between the neck centerline and the vertical line
Nose - the center of the	ND	Distance from the top of the nose to the center of the dashboard

Position	Code	Measurement Description
dashboard		
Pelvic angle	PA	Angle measured by placing a T-bar on the H-point of ATD
Seat backrest angle	SA	Head restraint rod angle
Lock catch - center of gravity of head (horizontal)	CGH	Horizontal distance between the marking point of the center of gravity of the head and the front passenger door lock catch
Lock catch - center of gravity of head (lateral)	CGL	Lateral offset between the marking point of the center of gravity of the head and the front passenger door lock catch
Lock catch - center of gravity of head (vertical)	CGV	Vertical distance between the marking point of the center of gravity of the head and the front passenger door lock catch
Lock catch - H-point (horizontal)	SHH	Horizontal distance between H-point and the front passenger door lock catch
Lock catch - H-point (vertical)	SHV	Vertical distance between H-point and the front passenger door lock catch
Lock catch - knee	SK	Distance from the knee center to the front passenger door lock catch
Lock catch - knee angle	SKA	Angle between the knee center and the front passenger door lock catch
Torso recline angle	TRA	Angle between the H-point and the center of gravity of head

D.7.3.2 Measurement of rear passenger ATD space position

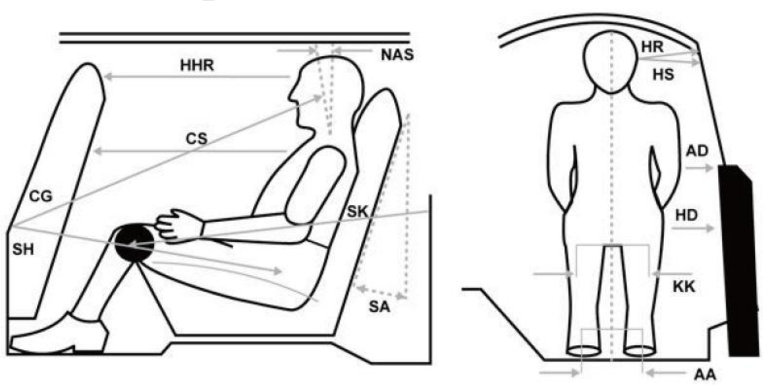


Fig. D.12 Schematic Diagram for Measurement of Rear Passenger ATD Space Position

Table D.10 Description of Measurement of Rear Passenger ATD Space Position

Position	Code	Measurement Description
Ankle - ankle	AA	Distance between the centers of both ankles
Arm - door	AD	Horizontal distance between the elbow center and the initial contact point of the door panel
Ankle - ankle	AA	Distance between the centers of both ankles
Arm - door	AD	Horizontal distance between the elbow center and the initial contact point of the door panel
Armrest - ATD	ADM	Minimum horizontal distance between the vehicle armrest and the ATD
Chest - seat (horizontal)	CS	Horizontal distance between the rib at top of the chest and a point on the driver seat backrest
Head - B-pillar	HB	Horizontal distance between the marking point of the gravity center of the head and the B-pillar (unmarked in the figure)
H-point - door	HD	Horizontal distance between the H-point and the initial contact point of door panel
Head - head restraint system	HHR	Horizontal distance between the middle of both eyes and the rear side of the driver's head restraint system
Head - roof	HR	Distance between the marking point of the gravity center of head and the

Position	Code	Measurement Description
		roof (other than the top edge of the door), perpendicular to the longitudinal axis of the vehicle
Head - side window	HS	Distance between the marking point of the gravity center of head and the side window, measured horizontally and perpendicular to the longitudinal axis of the vehicle
Knee - knee	KK	Distance between outer sides of flanges of knees
Neck angle (sitting/standing position)	NAS	Angle between the neck centerline and the vertical line
Pelvic angle	PA	Angle measured by placing a T-bar on the H-point of ATD
Seat backrest angle	SA	Head restraint rod angle
Lock catch - center of gravity of head (horizontal)	CGH	Horizontal distance between the marking point of the center of gravity of head and the driver's door lock catch
Lock catch - center of gravity of head (lateral)	CGL	Lateral offset between the marking point of the center of gravity of head and the driver's door lock catch
Lock catch - center of gravity of head (vertical)	CGV	Vertical distance between the marking point of the center of gravity of head and the driver's door lock catch
Lock catch - H-point (horizontal)	SHH	Horizontal distance between the H-point and the driver's door lock catch
Lock catch - H-point (lateral)	SHL	Lateral offset from H-point to the driver door lock catch
Lock catch - H-point (vertical)	SHV	Vertical distance between the H-point and the driver's door lock catch
Lock catch - knee	SK	Distance between the knee center and the driver's door lock catch
Lock catch - knee angle	SKA	Angle between the knee center and the driver's door lock catch
Torso recline angle	TRA	Angle between the H-point and the center of gravity of head

D.7.4 ATD motion and contact position

D.7.4.1 Before ATDs are moved after the crash, check three ATDs, and record the rest position where any injury or abnormality is observed on the ATDs and the contact condition of lower limbs.

D.7.4.2 Record and photograph the paint inside the vehicle and on the barrier surface.

D.7.4.3 The time point when a crash starts and the time points of occurrence of various events during the crash are determined according to high-speed photography. The moment when T0 indicators installed outside or inside of the vehicle illuminate is considered the time point when a crash starts. The starting time point of each event is determined based on the number of images played since the crash starts and the number of frames taken by cameras. For a camera with a shooting rate of 1000 frames/second, the starting time point of crash may be delayed by 2 ms, and it can be advanced or delayed by 2 ms according to the time point of event occurrence determined based on high-speed photography. Record the time points when the airbag is initially deployed, the airbag is fully deployed, the initial contact with the ATD is made, and other important events happen.

D.7.5 Fuel system integrity

Record the results of fuel system integrity observed after the crash test. Collect all the liquid leaked from the fuel system within 1 min after the crash. The first sample is usually collected by absorbing the leaked liquid with a water absorption pad of known quality. The second sample is collected within 5 min immediately after the first sample is collected, and it is generally the liquid collected in the tray below the identified leakage source. The third sample is collected within 25 min immediately after the second sample is collected. The tray for every sample collection shall be clean and empty. The volume of each sample is obtained by dividing the sample mass by the liquid density. Record the time taken with a stopwatch, and record the whole process with a camera with an internal timer.

D.7.6 High voltage system integrity

After the test, monitor the hybrid or battery electric vehicle to check whether the high voltage system is damaged. According to GB/T 31498-2021 *Post Crash Safety Requirement for Electric Vehicle*, post-test observation items include electrolyte leakage, REESS safety, movement, and electric shock protection.

Immediately after the test, monitor the temperature of REESS to check whether there is a rapid temperature rise, so as to prevent thermal runaway. REESS temperature shall be monitored for at least 4 hours. Subsequently, fully release the electric energy from the high voltage system in the mode specified by the manufacturer.

D.7.7 Inspection of E-call function

In the automatic triggering mode of E-call, check and review the communication function of the VUT.

D.7.8 Inspection of other functions

D.7.8.1 After the test, check whether the door on the crash side is opened from outside the vehicle. The door shall not be opened when it is pulled vertically outward with a tension meter reading not more than 400 N at the position shown in the figure (except for the door handle), as shown in Fig. D.13. After the test, the door on the non-crash side shall be unlocked. Check whether the door can be opened normally from outside the vehicle without using tools.

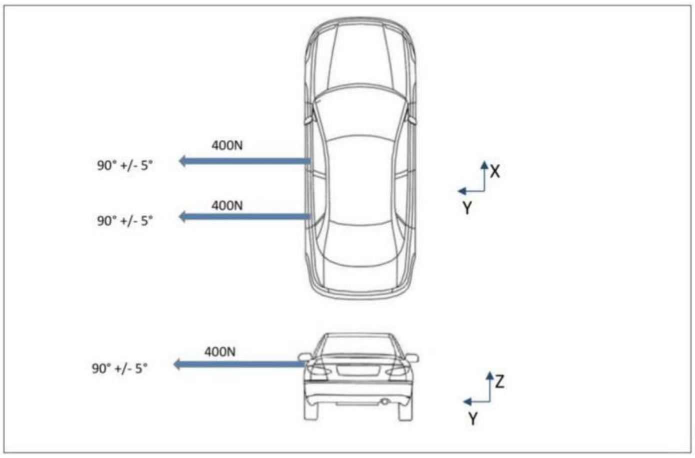


Fig. D.13 Schematic Diagram of Door Opening Measurement

D.7.8.2 After the test, measure the opening force of the seat belt buckle with a seat belt release device.

Annex I (Normative)
Analysis Procedure for Forward Coverage of Side Head Protection Airbag

During the test, the following procedure shall be used to analyze the forward coverage of the side head protection airbag. All high-speed photography screenshots are taken from the same camera (driver or passenger side, wide viewing angle) and have the same size. The measuring positions at the foremost edge of the airbag chamber of the side head protection airbag are as follows:

a) Longitudinal direction: the steering wheel at the foremost position;

b) Vertical direction: 12 cm ~ 22 cm above the center of steering wheel.

1 Select the image of high-speed photography

1.1 When the steering wheel center mark located on the outer surface of the crash side door is closest to the center of the image, save the screenshot of high-speed photography from the crash side view angle.

1.2 Save the screenshot of the fully deployed side head protection airbag, and then save the next 9 screenshots in turn. Measure multiple images to ensure that the measurement results are obtained when the airbag is in the maximum forward coverage.

2 Measure the position of the steering wheel on the door

2.1 Open the first screenshot with image processing software (such as Photoshop), and rotate the image to have the horizontal identification plate on the top of the door parallel to the X-axis. Record the coordinates of the center point mark of the steering wheel on the door with the rear door lock catch mark as the origin (Fig. I.1). At this moment, the steering column is in the foremost position (the foremost compressed position), and the recline angle is in the middle. In the example, X=462 pixels and Z=13 pixels.

2.2 Record the horizontal distance between the door marks in pixels. This measurement will be used for scaling (Fig. I.2). In the example, the distance is 168 pixels. The actual distance between the marks is 61 cm (61 cm=168 pixels).

3 Mark the center of the steering wheel on the door

3.1 Open the second screenshot (the side head protection airbag is fully deployed) and rotate it as described in 2.1. Use the measuring tool in the image processing software to determine the X and Z coordinates of the steering wheel center recorded in 2.1 with the rear door lock catch mark as the origin, and mark the position (Fig. I.3).

3.2 Repeat 3.1 for the remaining 9 screenshots. If the side head protection airbag is not significantly closer to the reference point during the whole crash process (forward or backward), only the first screenshot shall be measured for reference.

4 Determine the front edge of the side head protection airbag

4.1 Under the premise of knowing the number of pixels of 61 cm (the distance between horizontal door marks), determine the number of pixels equivalent to 12 cm and 22 cm (in the example, 33 and 61 pixels respectively).

4.2 Open the second screenshot (the side head protection airbag is fully deployed). Use the measuring tool in the image processing software to measure the number of pixels equal to 12 cm and 22 cm upwards (the Z-axis of the vehicle) from the steering wheel 'point' on the door in 3.2. In this area, move forward or backward (the X-axis of the vehicle) until the arrow comes into contact with the front edge of the deployed side head protection airbag (Fig. I.4). Record the number of pixels in the X-axis direction (negative if behind the steering wheel, positive if in front), and then convert it into centimeters. In the example, the front edge of the side head protection airbag is 2 pixels in front of the center of the steering wheel, and 2 pixels are equal to 0.7 cm.

4.3 Repeat 4.2 for the remaining 9 screenshots.

5 Final measurement

Select the maximum value (the foremost position) from the 10 analyzed screenshots, which is the maximum forward coverage of the side head protection airbag.

Fig. I.1 Measurement of Distance between Lock Catch Mark of Rear Door and Center Mark of Steering Wheel

Fig. I.2 Horizontal Distance between Door Marks (61 cm)

Fig. I.3 Mark Center of Steering Wheel on Door (in Crash)

Fig. I.4 Measurement of Distance between Center of Steering Wheel and Front End of Side Head Protection Airbag