Ministry of Transportation and Communications

Taiwan New Car Assessment Program (TNCAP)

3.4 Pole Side Impact Testing Protocol

V2.1
May 2025

TABLE OF CONTENTS

3.4.1 Vehicle Preparation 3

3.4.2 Dummy Preparation and Certification 6

3.4.3 Instrumentation 8

3.4.4 Passenger Compartment Adjustments 10

3.4.5 Dummy Positioning and Measurements 14

3.4.6 Carrier and Pole 21

3.4.7 Test Parameters 22

3.4.1 Vehicle Preparation

3.4.1.1 Unladen Kerb Mass

3.4.1.1.1 The capacity of the fuel tank will be specified in the manufacturer's booklet. This volume will be referred to throughout as the "fuel tank capacity".

3.4.1.1.2 Siphon most of the fuel from the tank and then run the car until it has run out of fuel.

3.4.1.1.3 Refill the tank with fuel, water or other ballast to a mass equivalent to 100% of the tank's capacity of fuel.

3.4.1.1.4 Check the oil level and top up to its maximum level if necessary. Similarly, top up the levels of all other fluids to their maximum levels if necessary.

3.4.1.1.5 Ensure that the vehicle has its spare wheel on board along with any tools supplied with the vehicle. Nothing else shall be in the car.

3.4.1.1.6 Ensure that all tyres are inflated according to the manufacturer's instructions for half load.

3.4.1.1.7 Measure the front and rear axle masses and determine the total mass of the vehicle. The total mass is the 'unladen kerb mass' of the vehicle. Record this mass in the test details.

3.4.1.1.8 Measure and record the ride heights of the vehicle at all four wheels.

3.4.1.2 Rated cargo and luggage mass

3.4.1.2.1 Calculate the rated cargo and luggage mass as follows: Subtract the measured unladen kerb mass and the rated occupants mass from the maximum permitted laden mass. The rated occupant mass is equal to rated number of occupants times 68 kg. The maximum permitted laden mass can be found on the Manufacturer's Plate, usually in the engine compartment.

3.4.1.3 Reference loads

3.4.1.3.1 Place both front seats in their mid-positions, this may not be the same. If there is no notch at this position, set the seat in the nearest notch rearward.

3.4.1.3.2 Place weights equivalent to a WorldSID 50th Percentile Male dummy (75kg) in the front driver's seating position.

3.4.1.3.3 Place weights with a mass of the rated cargo and luggage mass or 136kg whichever is less, in the luggage compartment of the vehicle. The normal luggage compartment shall be used i.e. rear seats shall not be folded to increase the luggage capacity. Spread the weights as evenly as possible over the base of the luggage compartment. If the weights cannot be evenly distributed, concentrate weights towards the centre of the compartment.

3.4.1.3.4 Roll the vehicle back and forth to 'settle' the tyres and suspension with the extra weights on board. Determine the front and rear axle loads of the vehicle. These loads are the "axle reference loads" and the total mass is the "reference mass" of the vehicle.

3.4.1.3.5 Record the axle reference loads and reference mass in the test details.

3.4.1.3.6 Measure and record the ride-heights of the vehicle at a point on the wheel arch in the same transverse plane as the wheel centres. Do this for all four wheels.

3.4.1.3.7 Remove the weights from the luggage compartment and the dummy weights from the front seat.

3.4.1.4 Impact Location

3.4.1.4.1 To measure vehicle dimensions and to apply markers, a pointer used to measure coordinates in three dimensions will be used.

3.4.1.4.2 The 'Impact Reference Line' is the line formed on the driver side of the test vehicle by the intersection of the exterior surface of the vehicle and a vertical plane passing through the centre of gravity of the head of the dummy positioned in accordance with section 3.4.5, in the driver seating position. The vertical plane forms an angle of 75° with the vehicle longitudinal centreline, see Figure 1.

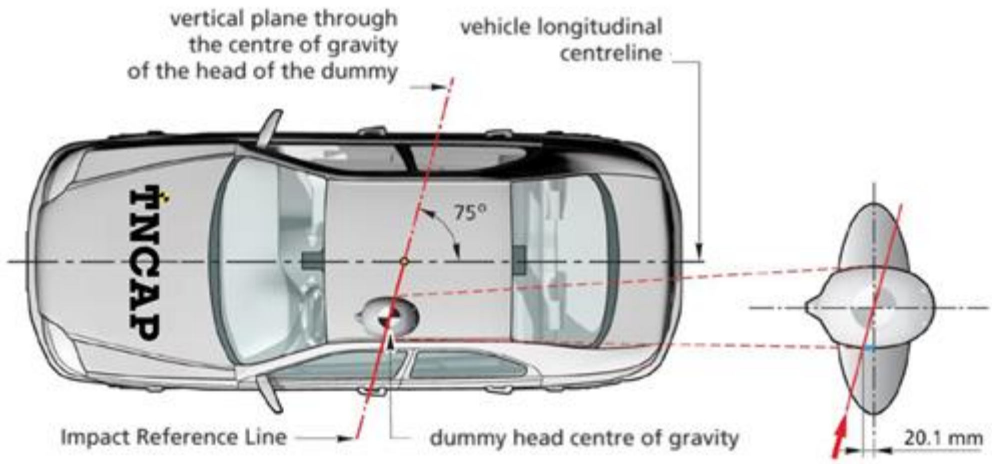


Figure 1 Impact reference line

3.4.1.4.3 Mark the impact reference line on the side of the vehicle on the exterior, from roof to sill.

3.4.1.4.4 Using a piece of sticky tape in a colour to contrast with the body-colour, join the points with one edge of the tape. Mark clearly on the tape, which of its edges aligns with the impact reference line. This edge may be used to assess the alignment of the vehicle with the pole.

3.4.1.5 Vehicle Preparation

Care shall be taken during vehicle preparation that the ignition is not switched on with the battery or any airbag or pretensioner disconnected. This will result in an airbag warning light coming on and the airbag system will need to be reset. Manufacturers will be asked to provide instructions for resetting the airbag so that this may be done 'in-house' in the event that it becomes necessary.

3.4.1.5.1 Remove the carpeting, spare wheel and any tools or jack from the luggage area. The spare wheel shall only be removed if it will not affect the crash performance of the vehicle.

3.4.1.5.2 Ensure that the vehicle's battery is connected, if possible in its standard position. Check that the dashboard light for the airbag circuit functions as normal.

3.4.1.5.3 Fit the on-board data acquisition equipment in the boot of the car. Also fit any associated cables, cabling boxes and power sources.

3.4.1.5.4 Place weights with a mass of approximately the rated cargo and luggage mass in the luggage area.

3.4.1.5.5 Place weights equivalent to a WorldSID 50th Percentile Male dummy (75kg) in the front driver's seat of the car (with the front seats in their mid-positions).

3.4.1.5.6 Weigh the front and rear axle loads of the vehicle. Compare these loads with those determined in section 3.4.1.3.4.

3.4.1.5.7 The total vehicle mass shall be within 1% of the reference mass (section 3.4.1.3). Each axle load shall be within the smaller of 5% or 20 kg of its respective axle reference load. If the vehicle differs from the requirements given in this paragraph, items may be removed or added to the vehicle which has no influence on its structural crash performance. The levels of ballast in the fuel tank (equivalent in mass to 100% (shall be 100%) capacity of fuel) may also be adjusted to help achieve the desired axle loads. Any items added to increase the vehicle mass shall be securely attached to the car.

3.4.1.5.8 Repeat Sections 3.4.1.5.6 and 3.4.1.5.7 until the front and rear axle loads and the total vehicle mass are within the limits set in 3.4.1.5.7.

3.4.1.5.9 For fully electric vehicles, if a total vehicle mass within 25kg of the reference mass cannot be achieved, it is acceptable for the total mass to be within 2% of the reference mass. A heavier test mass may be used with the agreement of the OEM, the test mass must not be below the minimum value of the specified tolerances.

3.4.1.5.10 Record the final axle loads in the test details.

3.4.2 Dummy Preparation and Certification

3.4.2.1 General

3.4.2.1.1 A WorldSID 50th Percentile Male test dummy shall be used in the front driver's position. It shall conform to the specification detailed in ISO 15830, parts 1-5.

3.4.2.2 Certification

Full details of the WorldSID 50th Percentile Male dummy certification requirements are available in the documents mentioned in section 3.4.2.1.1 above. No manufacturer shall have access to any pre-test information regarding any of the test equipment to be used by TNCAP, or be permitted to influence its selection in any way.

3.4.2.2.1 The WorldSID 50th Percentile Male dummy shall be re-certified after every FOUR impact tests.

3.4.2.2.2 Deatils of the IR Tracc length calculation procedure are described in Euro NCAP Technical Bulletin TB017.

3.4.2.2.3 If an injury criterion reaches or exceeds its normally accepted limit (e.g. HIC of 700) then that part shall be re-certified.

3.4.2.2.4 If any part of the dummy is broken in a test then the part shall be replaced with a fully certified component.

3.4.2.2.5 A copy of the dummy certification certificate will be provided as part of the full report for a test.

3.4.2.3 Additions and Modifications to the Dummies

3.4.2.3.1 The WorldSID 50th Percentile Male dummy shall be fitted with half arm assemblies on both sides.

3.4.2.3.2 The dummy can be outfitted with Build Level E ankle joints.

3.4.2.4 Dummy Clothing and Footwear

3.4.2.4.1 The dummy shall be clothed in a sleeveless suit or a modified version of the sleeved suit with sleeves removed.

3.4.2.5 Dummy Test Condition

3.4.2.5.1 Dummy Temperature

3.4.2.5.1.1 The dummy shall have a stabilised temperature in the range of 20.6^{o}C to 22.2^{o}C.

3.4.2.5.1.2 A stabilised temperature shall be obtained by soaking the dummy in temperatures that are within the range specified above for at least 1 hour prior to the test.

3.4.2.5.1.3 Measure the temperature of the driver dummy for at least 5 hours before test at intervals not exceeding 10 minutes and not exceeding

5 minutes before test.

3.4.2.5.1.4 A copy of the temperature readings is to be supplied as part of the standard output of the test.

3.4.2.5.1.5 The temperature shall be measured using an onboard sensor located on the blue band of first thoracic non struck side rib as far from the spine box as possible.

3.4.2.5.2 Dummy Joints

3.4.2.5.2.1 Stabilise the dummy temperature by soaking in the required temperature range for at least 5 hours.

3.4.2.5.2.2 Set the torque on the shoulder screws to obtain a 1-2g holding force of the arm on its pivot.

3.4.2.5.2.3 For adjustable joints in the legs, the tensioning screw or bolt which acts on the constant friction surfaces shall be adjusted to obtain a 1-2g holding force.

3.4.2.5.2.4 The dummy joint stiffnesses shall be set as close as possible to the time of the test and, in any case, not more than 24 hours before the test.

3.4.2.5.2.5 Maintain the dummy temperature within the permissible temperature range between the time of setting the limbs and up to a maximum of 10 minutes before the time of the test.

3.4.2.6 Dummy Painting

3.4.2.6.1 The dummy shall have masking tape placed on the areas to be painted using the sizes detailed below. The tape shall be completely covered with the following coloured paints. The paint shall be applied close to the time of the test to ensure that the paint will still be wet on impact.

Driver

Head (Tape outline painted only)	Red
Head center of gravity (circle diameter 40mm)	Yellow
Along mid-sagittal plane on head top	Green
Shoulder/Arm	Blue
2nd Thorax Rib	Green
3rd Thorax Rib	Red
1st Abdomen Rib	Blue
2nd Abdomen Rib	Green
Pelvis	Orange

Tape Sizes:

Driver

Head = 100mm square, centreline of head with lower edge at C of G.

Arm = 25mm x 150mm, starting at bottom edge of shoulder fixing hole.

Ribs = 25mm x 150mm strip, starting at the rearmost accessible point at seat back.

Pelvis = 50mm x 100mm, centred on hip joint point.

3.4.2.7 Post Test Dummy Inspection

3.4.2.7.1 The dummy shall be visually inspected immediately after the test. Any lacerations of the skin or breakages of the dummy shall be noted in the test details. The dummy may have to be re-certified in this case. Refer to section 3.4.2.2.

3.4.2.7.2 Any screws that have become loose or detached shall be re-tightened to the required torque or replaced as necessary.

3.4.3 Instrumentation

All instrumentation shall be calibrated before the test programme. The Channel Amplitude Class (CAC) for each transducer shall be chosen to cover the Minimum Amplitude listed in the table. In order to retain sensitivity, CACs which are orders of magnitude greater than the Minimum Amplitude shall not be used. A transducer shall be re-calibrated if it reaches its CAC during any test. All instrumentation shall be re-calibrated after one year, regardless of the number of tests for which it has been used. A list of instrumentation along with calibration dates shall be supplied as part of the standard results of the test. The transducers are mounted according to procedures laid out in SAE J211. The sign convention used for configuring the transducers is stated in SAE J211 (2007).

3.4.3.1 Dummy Instrumentation

3.4.3.1.1 The WorldSID 50th Percentile Male dummy shall be instrumented to record the channels listed below. Additional channels may be recorded.

3.4.3.1.2 Where the number of channels in the WorldSID 50th Percentile Male dummy is 45 or more, only in dummy data acquisition systems may be used. Where there are less than 45 channels, the use of umbilical cables is at the technical service discretion.

Location	Parameter	Minimum Amplitude	No. of Channels
Head	Linear Accelerations, Ax, Ay, Az	250g	3
Upper Neck	Forces & Moments Fx, Fy, Fz, Mx, My, Mz	5kN, 300Nm	6
Shoulder-Joints	Forces, Fx, Fy, Fz	8kN	3

Location	Parameter	Minimum Amplitude	No. of Channels
Shoulder-Ribs	Displacement & Rotation	100mm	2
Chest - Upper Ribs	Displacement & Rotation	100mm	2
Chest-Middle Ribs	Displacement & Rotation	100mm	2
Chest - Lower Ribs	Displacement & Rotation	100mm	2
Chest Temperature*	Temperature, e.g. 3.4.2.5.1.3	30°C	1
Abdomen-Upper Ribs	Displacement & Rotation	100mm	2
Abdomen - Lower Ribs	Displacement & Rotation	100mm	2
Spine - T12	Accelerations, Ax, Ay, Az	200g	3
Pelvis	Accelerations, Ax, Ay, Az	200g	3
Pelvis - Pubis	Force	5kN	1
Femoral Neck - Impact Side Only	Forces, Fx, Fy, Fz	5kN	3
	Total Channels		35

Note: * It is not necessary for this channel to be recorded through the dummy onboard Data Acquisition Unit (DAU).

3.4.3.2 Vehicle Instrumentation

3.4.3.2.1 The vehicle is to be fitted with an accelerometer on the unstruck B-pillar. The accelerometer is to be fitted in the lateral direction (Ay).

3.4.3.2.2 Remove carpet and the necessary interior trim to gain access to the sill directly below the B-pillar.

3.4.3.2.3 Securely attach a mounting plate for the accelerometer horizontally on to the sill.

3.4.3.2.4 Fix the accelerometer to the mounting plate. Ensure the accelerometer is horizontal to a tolerance of ±5 degrees.

Vehicle

Location	Parameter	Minimum Amplitude	No. of Channels
B-Post (unstruck)	Acceleration, Ay	350g	1

Battery (including any secondary batteries)	Supply Voltage, V	15V	1
	Total Channels per Vehicle		2

3.4.3.3 Carrier Instrumentation

3.4.3.3.1 The carrier is to be fitted with an accelerometer at its structure at the centre line, near the centre of gravity. The accelerometer is to be fitted in the direction of movement (Ax).

Location	Parameter	Minimum Amplitude	No. of Channels
Carrier C of G	Acceleration, Ax	350g	1
	Total Channels per Carrier		1

1 x WorldSID	35
1 x Vehicle	2
1 x Carrier	1
Total	38

3.4.4 Passenger Compartment Adjustments

3.4.4.1 Overview of Settings

Adjustment	Required Setting	Notes	Methods
Seat fore/aft	As defined in 3.4.4.4		
Seat base tilt	As defined in 3.4.4.4		
Seat height	As defined in 3.4.4.4		
Torso angle	Manufacturer's design position	Otherwise 23° to Vertical	See section 3.4.5.1
Seat lumbar support	Fully retracted		See section 3.4.4.2
Front head restraint height & tilt	Mid locking position	As whiplash test position. If there is any interference with the rear of the dummy head, move the HR to the most rearward position.	See section 3.5.5.2 Front Seat Whiplash Testing Protocol

Adjustment	Required Setting	Notes	Methods
Steering wheel	The highest and furthest rearward position (closest to the dummy)		See section 3.4.4.5
Rear seat fore/aft	Fully rearward		See section 3.4.4.6
Rear seat back angle	Manufacturer's design position	Otherwise, 25° to vertical	See section 3.4.4.6
Rear seat facing	Forwards		
Rear head restraint height & tilt	As recommended in vehicle handbook	Where no details are provided in the handbook, set to mid or middle-low position for height and mid locking position for tilt.	See section 3.5.5.2 Front Seat Whiplash Testing Protocol
Arm-rests (front seats)	Lowered position	May be stowed if dummy positioning does not allow in-use position. Adjustable in horizontal position.	
Arm-rests (rear seats)	Stowed position		
Side Window Glazing	Fully raised		
Gear change lever	In the neutral position		
Parking brake	Engaged		
Pedals	Normal position of rest	Adjustable pedals fully forward	See section 3.4.4.2
Doors	Closed, not locked (except for automatic door locks)	For automatic door locks, refer to Section 3.4.4.7.	
Roof/sunroof	Raised/fully closed	Where applicable	
Sun visors	Stowed position		
Rear view mirror	Normal position of use		

Adjustment	Required Setting	Notes	Methods
Seat belt anchorage (where adjustable)	Initially, manufacturer's 50th percentile design position	If no design position then set to mid position, or nearest notch upwards	See section 3.4.5.3.6

Note: Adjustments not listed will be set to mid-positions or nearest positions rearward, lower or outboard.

3.4.4.2 Seat Adjustments

3.4.4.2.1 Position the seat's adjustable lumbar supports so that the lumbar supports are in the lowest, retracted or deflated adjustment positions.

3.4.4.2.2 Position any adjustable parts of the seat that provide additional support so that they are in the lowest or most open adjustment position.

3.4.4.2.3 Position an adjustable seat cushion length to the retracted position.

3.4.4.2.4 Position an adjustable leg support system in its rearmost position.

3.4.4.2.5 Place adjustable pedals in the full forward position (towards the front of the vehicle.)

3.4.4.3 Seat Markings

3.4.4.3.1 Identify and mark one seat reference point (SRP_1) at the rear side of the seat cushion.

3.4.4.3.2 Where the seat cushion pitch is adjustable, identify and mark a second reference point, SRP_2, that is at least 300mm forward of the rear reference point (SRP_1) and draw a line through the two reference points.

3.4.4.3.3 Locate and mark the longitudinal centreline of the seat cushion. The intersection of the vertical longitudinal plane that passes through the SRP_1 and the seat cushion upper surface determines the longitudinal centreline of a bucket seat cushion.

3.4.4.3.4 Where the front seats are bench seats, locate and mark the longitudinal line on the seat cushion that marks the intersection of the vertical longitudinal plane through the centreline of the steering wheel and the seat cushion upper surface.

3.4.4.4 Positioning the Seat

3.4.4.4.1 Use the seat control that primarily moves the seat vertically to adjust the rearmost seat reference point, SRP_1, defined in 3.4.4.3.1 to the upper most vertical location.

3.4.4.4.2 Use the seat control that primarily moves the seat fore-aft to adjust the rearmost seat reference point, SRP_1, defined in 3.4.4.3.1 to the rearmost location.

3.4.4.4.3 Determine and record the range of angles of the seat cushion pitch and using only the control(s) that primarily adjust(s) the cushion pitch, set cushion pitch to the mid-angle.

3.4.4.4.4 Use the seat control that primarily moves the seat vertically to adjust the rearmost seat reference point, SRP_1, defined in 3.4.4.3.1 to the lowest vertical location. Verify that you are still at the rearmost seat track location. Record the X position of SRP_1.

3.4.4.4.5 Use the seat control that primarily moves the seat fore-aft to adjust the rearmost seat reference point, SRP_1, to the rearmost location. Record the X position of SRP_1.

3.4.4.4.6 Use the seat control that primarily moves the seat fore-aft to adjust the rearmost seat reference point, SRP_1, to the forward most location; Record the X position of SRP_1.

3.4.4.4.7 Measure and mark an X position 20mm rearward of the midpoint (MP +20mm).

3.4.4.4.8 Use the seat control that primarily moves the seat fore-aft to adjust the rearmost seat reference point, SRP_1, to the X position marked in 3.4.4.4.7 or, if this is not possible, to the first X possible position rearward the marked position in 3.4.4.4.7. If the seat cannot be placed at exactly 20mm rearward of the midpoint select the next closest available rearward setting.

3.4.4.4.9 For some vehicles this final step may change the cushion pitch as established in 3.4.4.4.8, this is acceptable.

3.4.4.4.10 Record test seat position using the seat reference point, SRP_1.

3.4.4.4.11 The settings for the passenger seat shall be as near as possible to being the same as that of the driver's seat.

3.4.4.5 Setting the Steering Wheel

3.4.4.5.1 Set the steering wheel at the geometric highest driving position considering the full range of telescopic and tilt adjustment possibilities, in order to provide clearance for the legs and thorax.

3.4.4.6 Setting the Rear Seat (if adjustable)

3.4.4.6.1 If the vehicle rear seat position is adjustable put it in the most rearward fore/aft position and the same seat back angle (where adjustable) as that used in the frontal ODB impact.

3.4.4.7 Automatic Door Locking

3.4.4.7.1 Automatic Door Locking (ADL): System in the vehicle whereby the door latches automatically lock once the vehicle has reached a certain speed. They shall also automatically unlock in the event of an accident, post impact. Short term deactivation for one single journey is permitted.

3.4.4.7.1.1 The TNCAP executive agency will check with the OEM if their vehicle is fitted with automatic locking door latches as standard and inform the test service accordingly.

3.4.4.7.1.2 If ADL is fitted as standard and by default always ON then the doors will be locked by the test service prior to the test. The test service will be informed by the OEM of the procedure to ensure the doors are manually locked for the test.

3.4.4.7.1.3 If ADL is not fitted as standard, or not by default always ON, but fitted to the test variant then doors will be locked in the test.

3.4.5 Dummy Positioning and Measurements

3.4.5.1 Determine the H-Point of the Driver's Seat

The device to be used is the H-point machine as described in SAE J826. If the seat is new and has never been sat upon, a person of mass 75 ± 10kg shall sit on the seat for 1 minute twice to flex the cushions. The seat shall have been at room temperature and not been loaded for at least 1 hour previous to any installation of the machine.

3.4.5.1.1 Set the seat back so that the torso of the H-point manikin is as close as possible to the manufacturer's recommendations for normal use. In absence of such recommendations, an angle of 23 degrees ±1 towards the rear from vertical will be used.

3.4.5.1.2 The driver and passenger seatback angle and seat base shall be set to the same position.

3.4.5.1.3 Place a piece of muslin cloth on the seat. Tuck the edge of the cloth into the seat pan/back join, but allow plenty of slack.

3.4.5.1.4 Place the seat and back assembly of the H-point machine on the seat at the centre line of the seat.

3.4.5.1.5 The length of the lower leg and thigh segments of the H-point manikin shall be adjusted to the 50th percentile (418mm) and 10th percentile (408mm) positions respectively.

3.4.5.1.6 Attach lower legs to machine, ensuring that the transverse member of the T-bar is parallel to the ground.

3.4.5.1.7 Place the right foot on the undepressed accelerator pedal, with the heel as far forwards as allowable. The distance from the centre line of the machine shall be noted.

3.4.5.1.8 Place left foot at equal distance from centre line of machine as the right leg is from centre line. Place the foot flat on the footwell.

3.4.5.1.9 Apply lower leg and thigh weights.

3.4.5.1.10 Tilt the back pan forwards to the end stop and draw the machine away from the seatback.

3.4.5.1.11 Allow the machine to slide back until it is stopped by contacting the seat back.

3.4.5.1.12 Apply a 10kg load twice to the back and pan assembly positioned at the intersection of the hip angle intersection to a point just above the thigh bar housing.

3.4.5.1.13 Return the machine back to the seat back.

3.4.5.1.14 Install the right and left buttock weights.

3.4.5.1.15 Apply the torso weights alternately left and right.

3.4.5.1.16 Tilt the machine back forwards to a vertical position and, while holding the T-bar, rock the pan by 5 degrees either side of the vertical. The feet are NOT to be restrained during the rocking. Holding the T-bar to prevent the H-Point machine from sliding forward on the seat cushion, return the machine back to the seat back.

3.4.5.1.17 Reposition the feet by lifting the leg and then lowering the leg so that the heel contacts the floor and the sole lies on the undepressed accelerator.

3.4.5.1.18 Check the lateral spirit level and if necessary apply a lateral force to the top of the machine back, sufficient to level the seat pan of the machine.

3.4.5.1.19 Adjust the seat back angle to the angle determined in 3.4.5.1.1, measured using the spirit level and torso angle gauge of the H-point machine. Ensure that the torso remains in contact with the seat back at all times. Ensure that the machine pan remains level at all times.

3.4.5.1.20 If the measured angle is not within ±1° of the target, the chest and buttocks weights shall be removed, the seat back readjusted, and the steps to position the H-point manikin shall be repeated, beginning with tilting the back pan forward as in 3.4.5.1.10.

3.4.5.1.21 Measure and record in the test details the position of the H-point relative to some easily identifiable part of the vehicle structure.

3.4.5.2 Head Protection Device marking

3.4.5.2.1 Using the location of the H-point as measured in section 3.4.5.1.21 for the front seating position, calculate and record the corresponding 5th female and 95th male head centre of gravity positions for the front seat to determine the corners of the head CoG-box:

5th female Head CoG:

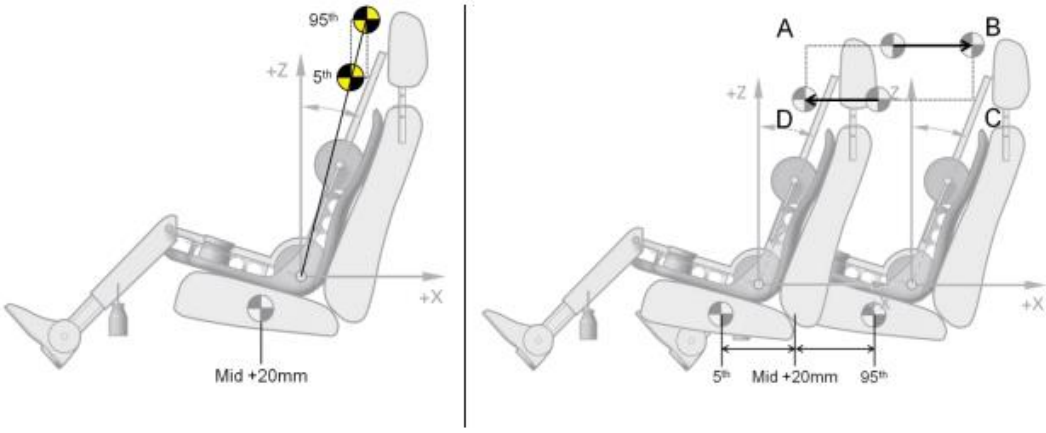
$X_{CoG,5th}$ = H point (X)+ 126 - seat travel (5th-50th)

$Z_{CoG,5th}$ = H point (Z)+ 594

95^{th} male Head CoG:

$X_{CoG,95th}$ = H point(X)+ 147 + seat travel (50^{th}-95^{th})

$Z_{CoG,95th}$ = H point(X)+ 693



The four corners of the head CoG-box are:

	X-position	Z-position
A	$X_{CoG,5th}$	$Z_{CoG,95th}$
B	$X_{CoG,95th}$	$Z_{CoG,95th}$
C	$X_{CoG,95th}$	$Z_{CoG,5th}$
D	$X_{CoG,5th}$	$Z_{CoG,5th}$

3.4.5.2.2 The seat travel for the 5^{th} and 95^{th} positions will be required from the vehicle manufacturer.

3.4.5.2.3 Using the location of the H-point for the rear seating position as measured for the Rear Whiplash protocol, calculate and record the corresponding head centre of gravity positions in the most forward and rearward seating positions:

5^{th} female Head CoG in most forward seating position:

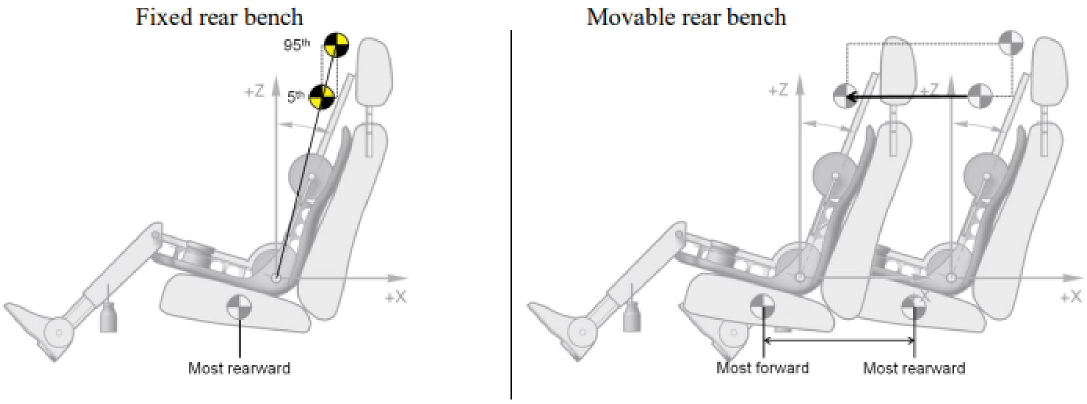
$X_{CoG,5th}$ = H-point(X) + 126 – remaining seat travel (if applicable)

$Z_{CoG,5th}$ = H-point(Z) + 594

95^{th} male Head CoG in most rearward seating position:

$X_{CoG,95th}$ = H-point(X) + 147 + remaining seat travel (if applicable)

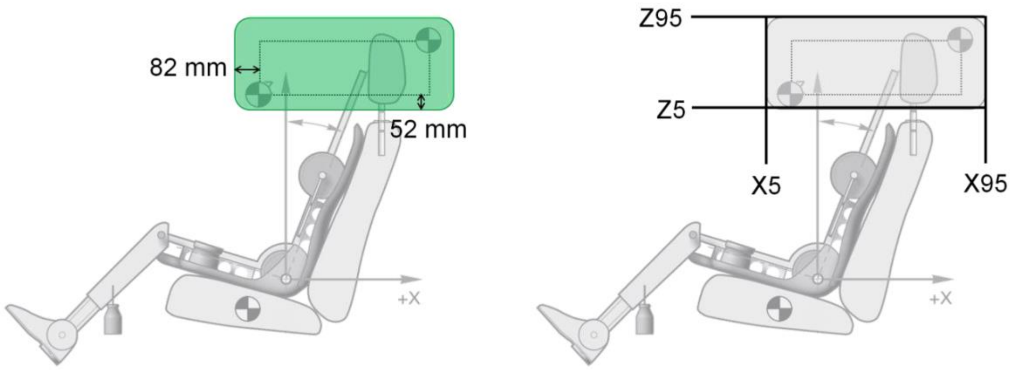
$Z_{CoG,95th}$ = H-point(Z) + 693



3.4.5.2.4 The evaluation zone for the head protection device (HPD) is defined as a rounded rectangle surrounding the head CoG box, situated at a distance of 82mm from the upper and fore/aft edges and 52mm below the bottom edge. It is permissible for the 82mm radius in the lower corners of the airbag to be truncated at 52mm below the CoG box.

3.4.5.2.5 The horizontal edges of the area shall be parallel to the ground reference level, and the vertical edges shall be perpendicular to the ground reference level.

3.4.5.2.6 Mark vertical lines X5 and X95, as well as horizontal lines Z95 and Z5, on both the interior of the vehicle on the impact side and the exterior of the vehicle on the non-impact side.



3.4.5.3 Dummy Placement

3.4.5.3.1 It is the intention that the dummy shall not be left to sit directly on the seat for more than 2 hours prior to the test. It is acceptable for the dummy to be left in the vehicle for a longer period, provided that the dummy position is checked no more then one hour prior to test. It is not acceptable for the dummy to be left in the vehicle overnight or for a similarly lengthy period.

3.4.5.3.2 H-point

The H-point of the WorldSID dummy is situated 20mm forward of that of the

H- point determined by the H-point manikin.

3.4.5.3.2.1 Using only the controls that move the seat fore-aft, move the test seat to the rearmost position to facilitate placement of the dummy.

3.4.5.3.2.2 Position the dummy in the seat such that the mid-sagittal plane is coincident with the centreline markings and the upper torso resting against the seat back.

3.4.5.3.2.3 Apply a fore-aft and lateral rocking motion to settle the pelvis rearward in the seat.

3.4.5.3.2.4 To ensure a repeatable and stable pelvis position, ensure that the pelvis is in contact with the seat cushion over the whole length.

3.4.5.3.2.5 To ensure a repeatable placement of the lower abdominal rib, make sure it is inside the pelvis flesh and not on top of it.

3.4.5.3.2.6 Move the seat together with the dummy to the test seat position defined in3.4.4.4.10. If it is not possible to reach the seat test position due to knee contact, shift the targeted test seat position rearwards in the stepwise increments to the closest position where the knee clearance is at least 5mm. Modify the target H-point accordingly.

3.4.5.3.2.7 Verify that the H-point is reasonably close (±10mm) to the target H-point 3.4.5.1.21 or as defined in 3.4.5.3.2.6 if the target H-point has been modified. If not, repeat step 3.4.5.3.2.3. If it is still not possible, record the rearmost seat cushion reference point and the dummy H-point and proceed to the next step.

3.4.5.3.2.8 Extend the right leg without displacing the thigh from the seat cushion. Allow the sole of the foot to settle on the accelerator pedal; the heel of the shoe shall be in contact with the floor pan. Where a lack of ankle articulation prevents the foot from sitting flat on the accelerator pedal, keep the foot at a 90 degree angle to the tibia and ensure that the heel is in contact with the floor.

3.4.5.3.2.9 Extend the left leg without lifting the thigh from the seat cushion and allow the sole of the foot to settle on the footrest or floor if no footrest is present. The heel of the shoe shall be in contact with the floor. In case of tibia contact, slide the foot rearward toward the seat until a 5mm clearance is obtained. Where a lack of ankle articulation prevents the foot from sitting flat on the floor, keep the foot at a 90 degree angle to the tibia and ensure that the heel is in contact with the floor.

3.4.5.3.2.10 Position the H-point of the dummy to match the WorldSID H-point coordinates recorded following section 3.4.5.1 to within ±10mm. Prioritise the X coordinate.

3.4.5.3.3 Head and Torso

3.4.5.3.3.1 Adjust the dummy until the thorax tilt sensor coincides with the angle specified by the manufacturer.

3.4.5.3.3.2 If the rib angle is not specified by the manufacturer and the torso angle is 23° ± 1°, adjust the dummy until the thorax tilt sensor reads −2° (2° downwards) ± 1°.

3.4.5.3.3.3 If no rib angle is specified and the seat back angle is not 23° ± 1°, no further adjustment of rib angle is required.

3.4.5.3.3.4 Adjust the dummy neck bracket to level the head at the closest position to 0° ± 1°.

3.4.5.3.4 Legs and Feet

3.4.5.3.4.1 Proceed to the final foot and leg positioning by repeating section 3.4.5.1.7 and 3.4.5.1.8. Where a lack of ankle articulation prevents the foot from sitting flat on the accelerator pedal/floor, keep the foot at a 90 degree angle to the tibia and ensure that the heel is as far forward as possible and in contact with the floor.

3.4.5.3.4.2 No distance is specified for the knee spacing. However, priority shall be given to ensure the following:

3.4.5.3.4.3 There is 5 mm clearance between the knees/legs and the steering shroud and centre console.

3.4.5.3.4.4 There is a stable foot and ankle position.

3.4.5.3.4.5 The legs are as parallel as possible to the sagittal plane.

3.4.5.3.5 Arms

3.4.5.3.5.1 Place both arms at the first detent downward of the most upward detent that corresponds to a differential angle of 32° between rib angle sensor and the arm angle.

3.4.5.3.6 Seat Belt

3.4.5.3.6.1 Where possible, initially position the upper seat belt anchorage in the manufacturers 50th percentile design position. If no design position is provided, set the adjustable upper seat belt anchorage to the mid-position or nearest notch upward.

3.4.5.3.6.2 Carefully place the seat belt across the dummy and lock as normal.

3.4.5.3.6.3 Remove the slack from the lap section of the webbing until it is resting gently around the pelvis of the dummy. Only minimal force shall be applied to the webbing when removing the slack. The route of the lap belt shall be as natural as possible.

3.4.5.3.6.4 Place one finger behind the diagonal section of the webbing at the height of the dummy sternum. Pull the webbing away from the chest horizontally forward and allow it to retract in the direction of the D-loop using only the force provided by the retractor mechanism. Repeat this step three times, only.

3.4.5.3.6.5 After following the above steps, the seatbelt shall lie in a natural position across the dummy sternum and shoulder clavicle. Where this is not the case, for example the belt is close to or in contact with the neck or the belt is above the shoulder rotation adjustment screw, and the upper belt anchorage is adjustable the anchorage shall be lowered and steps 3.4.5.3.7.3 and 3.4.5.3.7.4 repeated.

3.4.5.3.6.6 The upper anchorage shall be lowered by a sufficient amount to ensure a natural belt position following the repetition of steps 3.4.5.3.7.3 and 3.4.5.3.7.4. This may require multiple attempts.

3.4.5.3.6.7 Once the belt is positioned the location of the belt shall be marked across the dummy chest to ensure that no further adjustments are made. Mark also the belt at the level of the D-loop to be sure that the initial tension is maintained during test preparation.

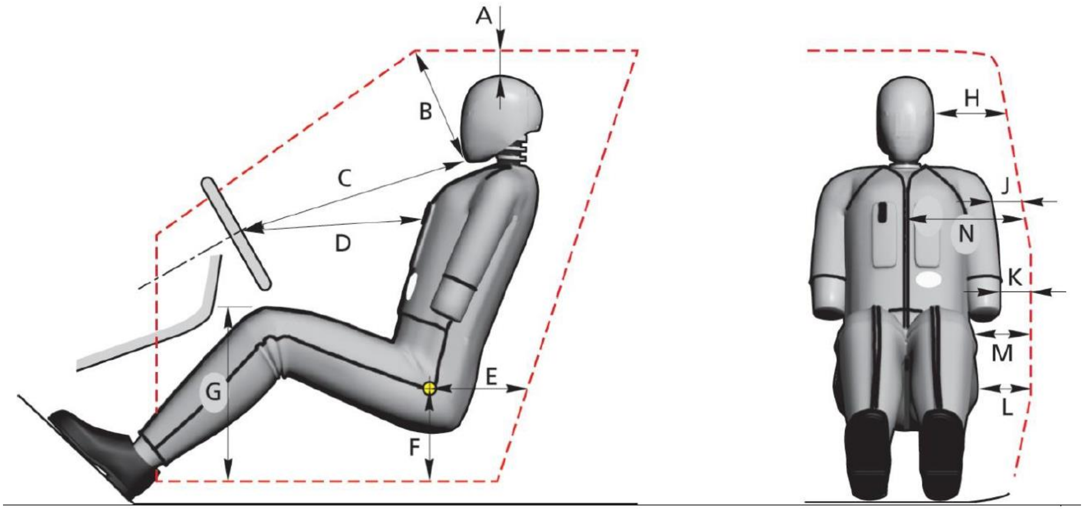
3.4.5.3.6.8 Measure the vertical distance between the dummy nose and the diagonal webbing.

3.4.5.3.6.9 Measure the horizontal distance between the diagonal webbing and the door/window.

3.4.5.3.7 After positioning the dummy measure and record the dummy position according to section 3.4.5.4 and determine the impact location as described in section 3.4.1.4.

3.4.5.4 Dummy Positioning Measurements

The following measurements are to be recorded prior to the test after the dummy settling and positioning procedures have been carried out.



Driver Measurements	
A	Head/roof panel
B	Chin/windscreen joint
C	Chin/centre of the steering
D*	Thorax strap/centre of the steering wheel
E	Hip-joint point/inside opening of the door (horizontal)
F	Hip-joint point/inside opening of the door (vertical)
G	Knee/floor covering (vertical)
H	Head/side window pane (or padding)
J	Shoulder/window pane (or padding)
K	Elbow/door (or padding)
L	Pelvis/door (or padding)
M	Knee/door (or padding)
N	Belt webbing to door (horizontally)

Note: *Horizontal distance from steering wheel centre.

3.4.6 Carrier and Pole

3.4.6.1 Carrier

3.4.6.1.1 A carrier shall be used which has a horizontal flat surface with a sufficiently large area to allow unobstructed longitudinal displacement of the vehicle of about 1000mm and rotation of the vehicle during the deformation phase of the impact.

3.4.6.1.2 To minimise effects of friction between the tires of the test vehicle and the surface of the carrier this friction is reduced to a minimum by placing the vehicle with each tyre on two sheets of PTFE.

3.4.6.1.3 To avoid vehicle movement prior to the impact, the vehicle may be fixed to the carrier until 5m before the point of impact. The impact speed shall be reached 10m before the point of impact.

3.4.6.1.4 Crumple tubes or a comparable device will decelerate the carrier not earlier than 80ms after the moment / point of impact.

3.4.6.1.5 The carrier may be fitted with an emergency abort system. This is optional; the test facility may elect to test without an abort system.

3.4.6.2 Pole

3.4.6.2.1 The rigid pole is a vertical metal structure beginning no more than 102mm above the lowest point of the tires on the striking side of the test vehicle when the vehicle is loaded as specified in section 3.4.1 and extending at least 100mm above the highest point of the roof of the test vehicle.

3.4.6.2.2 The pole is 254 ±3mm in diameter and set off from any mounting surface, such as a barrier or other structure, so that the vehicle will not contact such a mount or support at any time within 100ms of the initiation of the vehicle to pole contact.

3.4.6.2.3 Mark a line along the vertical centreline of the pole which may be used to check the alignment of the test vehicle on the carrier.

3.4.7 Test Parameters

An on-board data acquisition unit will be used. This equipment will be triggered by a contact plate at the point of first contact (t=0) and will record digital information at a sample rate of 20 kHz (alternatively a sample rate of 10 kHz may be used). The equipment conforms to SAE J211 (2007).

Before the test, ensure that the live battery is connected, a single key is in the ignition, the ignition is on and that the airbag light on the dashboard illuminates as normal (where fitted).

If the vehicle is fitted with a suspension system, pedal retraction system or any other system which requires running of the engine just before test execution, the engine shall be run for a predetermined time, specified by the manufacturer.

3.4.7.1 Impact Speed

3.4.7.1.1 During the acceleration phase of the test, the acceleration of the carrier shall not exceed $1.5m/s^2$.

3.4.7.1.2 Measure the speed of the vehicle as near as possible to the point of impact using an infra-red beam intercepting two markers at a measured distance apart.

3.4.7.1.3 Record the actual test speed in the test details. The target speed shall be 32±0.5km/h.

3.4.7.2 Alignment

3.4.7.2.1 The test vehicle shall be propelled so that, when the vehicle-to-pole contact occurs, the direction of vehicle motion forms an angle of 75° ±

3° with the vehicle longitudinal centreline.

3.4.7.2.2 The impact angle shall be measured between the vehicle longitudinal centreline and a vertical plane parallel to the vehicle impact velocity vector.

3.4.7.2.3 The impact reference line shall be aligned with the centreline of the rigid pole surface, as viewed in the direction of vehicle motion, so that, when the vehicle-to-pole contact occurs, the centreline of the pole surface contacts the vehicle area bounded by two vertical planes parallel to and 25 mm forward and aft of the impact reference line.

3.4.7.2.4 With the vehicle offered up against the pole, tape a small rivet on the centreline of the pole such that it is aligned with the vertical impact reference line marked in 3.4.7.2.3.

3.4.7.2.5 It shall be noted that the point of first contact between the pole and vehicle does not align with the impact reference line marked on the vehicle, see Figure 2.

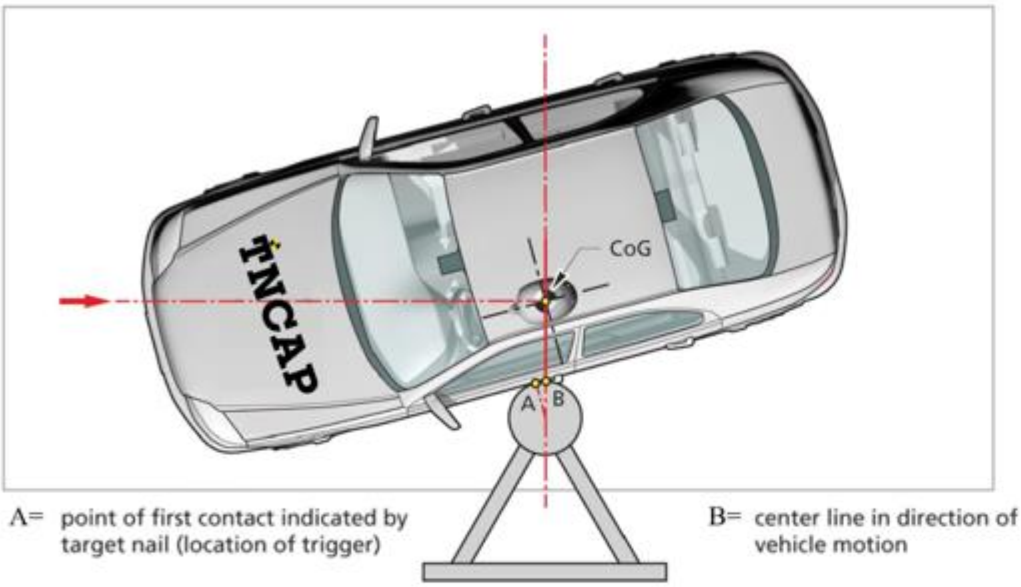


Figure 2 Point of initial contact

3.4.7.3 After Test

3.4.7.3.1 Door Opening

3.4.7.3.1.1 Check that none of the doors, including boot lids and any movable roofs, have opened or partially opened during the test. Where this is the case photographic evidence shall be obtained and provided in the test report.

3.4.7.3.1.2 Struck side doors handles shall be immediately covered with tape to prevent inadvertent opening. Reference measurements shall be taken between the door skin and aperture to ensure that the door has not move or been disturbed between the test and inspection.

3.4.7.3.1.3 Check that the unstruck side doors are not locked and open the doors by hand (front door followed by rear door). For vehicles fitted with ADL, the technical service will immediately check if any of the non-struck side doors in the test has remained locked/has not automatically unlocked.

3.4.7.3.1.4 If the doors do not open, record this in the test details.

3.4.7.4 Dummy Removal

3.4.7.4.1 Do not move the driver seat. Try to remove the dummy.

3.4.7.4.2 If the dummy still cannot be removed, try to slide the seat back on its runners or remove the steering wheel.

3.4.7.4.3 If the dummy cannot be removed with the seats in its original position, recline the seat back and try again.

3.4.7.4.4 If the dummy still cannot be removed, the seat can be cut out of the car.

3.4.7.5 Side Airbag Head Protection Evaluation

3.4.7.5.1 Curtain airbags

3.4.7.5.1.1 After the pole test, deploy the head protection device on the non struck side of the vehicle. Make sure that the airbags are identical on both sides of the vehicle. Where this is not the case, the assessment must be performed on both sides.

3.4.7.5.1.2 Inflate the airbag to the pressure recommended by the OEM.

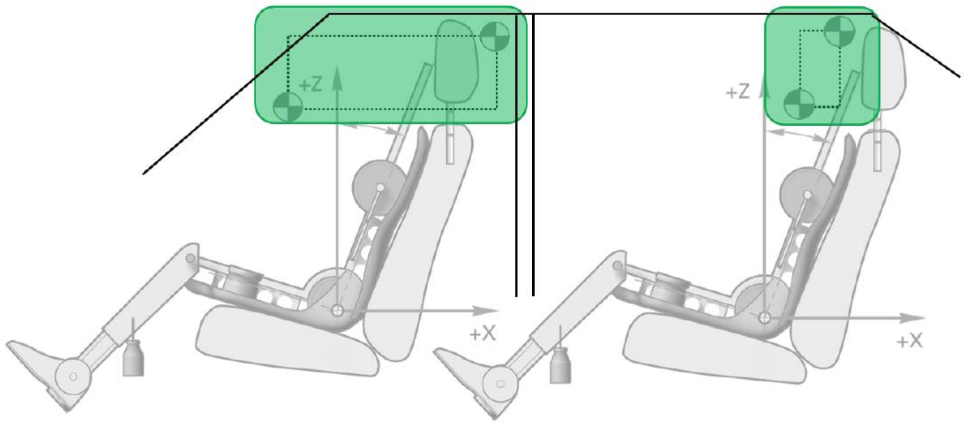
3.4.7.5.1.3 Project the HPD assessment zone onto the inflated airbag, using a laser, for front and rear seating positions using the measurements marked/recorded in section 3.4.5.2.

3.4.7.5.2 Seat mounted head protection devices

3.4.7.5.2.1 Based on the head CoG paint mark on the airbag, mark the HPD assessment zone defined as a rounded rectangle extending 95mm forward, 90mm rearward, 120mm upward and 115mm downward on the flattened airbag.

3.4.7.5.2.2 When the paint mark cannot be used, the OEM needs to supply TNCAP in-house data for the Side Airbag Head Protection Evaluation.

3.4.7.5.3 Evaluate coverage area of the airbag(s), record and check the dimensions of any joined, stitched or seamed areas.


+Z
+X
+Z
+X

Ministry of Transportation and Communications

Taiwan New Car Assessment Program (TNCAP)

3.5 Front Whiplash Testing Protocol

V2.1

Apr 2025

TABLE OF CONTENTS

3.5.1 Definitions..3

3.5.2 Coordinate System 4

3.5.3 Sled Seat Mounting and Positioning..5

3.5.4 H-Point Machine (HPM) & Dummy Positioning H 14

3.5.5 Head Restraint Positions 18

3.5.6 Biorid ATD Requirements..28

3.5.7 Test Sled Requirements..32

3.5.8 Test Sled Instrumentation...32

3.5.9 Whiplash Assessment Criteria 33

3.5.10 Manufacturer's Specified Settings 39

3.5.11 RCAR GLORIA Jig & Calibration Procedure (HPM/HRMD Calibration) 40

3.5.12 Preliminary Adjustments to the HRMD and H-Point Machine 50

3.5.13 Sled pulse specification...51

3.5.14 Seat Movement Definitions 56

3.5.1 Definitions

3.5.1.1 Head Restraint: A device designed to limit the rearward displacement of an adult occupant's head in relation to the torso in order to reduce the risk of injury to the neck in the event of a rear impact.

3.5.1.1.1 Integrated Head Restraint or Fixed Head Restraint: A head restraint formed by the upper part of the seat back, or a head restraint that is not height adjustable and/or cannot be detached from the seat or the vehicle structure except by the use of tools or following the partial or total removal of the seat furnishings.

3.5.1.1.2 Adjustable Head Restraint: A head restraint that is capable of being positioned to fit the anthropometry of the seated occupant. The device may permit horizontal displacement, referred to as "tilt" adjustment and/or vertical displacement, known as "height" adjustment.

3.5.1.1.3 Re-active Head Restraint: A device designed to improve head restraint geometry during an impact. It will usually be deployed by the occupant's mass within the seat operating a mechanism during the crash. They also usually re-set after loading to a pre-accident condition.

3.5.1.1.4 Pro-active Head Restraint: A device designed to automatically improve head restraint geometry prior to an impact, which utilises sensors to trigger pyrotechnics, magnetic or other device to release stored energy in order to deploy head restraint or seatback elements. Such systems require no input from the occupant to operate. They are usually not re-settable following a deployment and remain in their deployed state.

3.5.1.1.5 Automatically Adjusting Head Restraint: A head restraint that automatically adjusts its position depending on the stature of the seated occupant.

3.5.1.1.6 Locking: An adjustable head restraint fitted with a device to prevent inadvertent downward or rearward movement from its adjusted position, i.e. when a rear seat occupant uses a front seat head restraint as a hand hold to facilitate easy entry or exit from the vehicle. A locking device may be fitted to both the horizontal and vertical adjustments of the head restraint. A locking device shall incorporate a mechanism that requires intervention to allow downward/rearward head restraint adjustment after which the mechanism shall re-engage automatically.

3.5.1.2 H-Point Manikin (HPM): The device used for the determination of "H" points and actual torso angles. (SAE Standard J826, SAE Handbook, Vol 3, 1999) modified according to the Insurance Corporation of British Columbia (ICBC) Instruction Manual for the HRMD, see section 3.5.12.

3.5.1.3 Head Restraint Measuring Device (HRMD): A separate head-shaped device used with the H-point machine to measure the static geometry of a vehicle head restraint. It was developed under the sponsorship of the Insurance Corporation of British Columbia (ICBC)-(SAE paper 1999-01-0639). The HRMD is equipped with two probes to measure head restraint height and backset. The height probe projects horizontally, level with the top of the head, to provide a reference line for the vertical measurement to the top of the restraint. The backset probe simulates the rear profile of the head and neck and projects horizontally, to provide the horizontal measurement to the restraint.

3.5.1.3.1 HRMD Height: This is defined as the vertical measurement between the height probe of the HRMD and the top of the head restraint.

3.5.1.3.2 HRMD Backset: This is defined as the horizontal measurement between the back surface of the HRMD head and the front surface of the head restraint as measured by the backset probe of the HRMD.

3.5.1.3.3 BioRID Reference Backset: This is derived from the horizontal measurement between the back surface of the HRMD and the selected reference point on the front surface of the head restraint. The BioRID Reference Backset is 15 mm greater than the HRMD backset and will be used to position the dummy prior to test.

3.5.1.3.4 BioRID Backset is defined as the horizontal measurement between the back surface of the BioRID head and the selected reference point on the front surface of the head restraint.

3.5.1.4 Seat Movement Definitions: For an illustration of seat movement definitions, see section 3.5.14.

3.5.2 Coordinate System

3.5.2.1 Sled Coordinates

3.5.2.1.1 The coordinate system used must be an ordinary Cartesian co-ordinate system with 90˚ between the axes.

3.5.2.1.2 The origin for all measurements made using CMM is to be located on the upper surface of a seat mounting bolt hole, in the stationary part of the seat runner. This common origin will provide a means of comparing seat positions across technical service, where required. In the first instance, the right hand rear mounting hole shall be used. If this is not present, the next available fixation point shall be chosen, considering available options in the following order: left hand rear, left hand front, right hand front.

3.5.2.2 Dummy Coordinates

3.5.2.2.1 The coordinate system for the BioRID instrumentation used must be in accordance with SAE J211.

3.5.3 Sled Seat Mounting and Positioning

For the base seat setup specifications used in section 3.5.3.2 to 3.5.3.5, manufacturers will be requested to provide data listed in 3.5.10 prior to test preparation. Alternatively, physical vehicle measurements may be used. In all cases the vehicle shall be placed on level ground with no occupant load and a full tank of fuel. Ensure that the vehicle has its spare wheel and all tools supplied on board and all tyre pressures set to manufacturer's recommendations. For vehicles with active suspension and/or automatic levelling the suspension shall be set to a driving speed of 40km/h in normal running conditions as specified by the manufacturer.

All base seat setup specifications must be achieved within 0.2° and 5mm of linear tolerance, with the exception of seat belt attachments. Please refer to section 3.5.5.2 for details on the correct location.

Due to the BioRID dummy's unsuitability for more upright seating positions, heavy vehicles (as defined in section 1.4) are exempt from dynamic testing and are not subject to this protocol.

3.5.3.1 Packaging Issues

3.5.3.1.1 TNCAP executive agency reserves the right to refuse the sled testing of a seat where the performance of the seat or head restraint could be influenced by the vehicle environment or packaging. There shall be no stiff structure in the vicinity of the head restraint that could be contacted by the head in a rear impact or that could influence the dynamic deflection of the seat back. There shall be no additional support for the seat back that is not present in the sled test set-up.

3.5.3.1.2 Where such circumstances exist, for example with 2 seater sports cars, the vehicle manufacturer may be offered the opportunity to test with a body-in-white or to simulate all relevant structures on the sled set-up. The additional test costs and provision of a body-in-white shall be paid for by the manufacturer in these circumstances.

3.5.3.1.3 The mid track seat position shall allow a seat back angle of 25 degrees adjustment in all cases. Where a bulkhead or similar structure prevents this, the seat track shall be adjusted forward until 25 degrees is achieved.

3.5.3.2 Seat Structure Reference Point

In addition to the coordinate system origin determined in 3.5.2.1.2, a further seat structure reference point shall also be chosen. This is defined as a fixed point on the seat structure which stays in the same position relative to the vehicle, independent of any seat adjustment. Record (with a photograph) the location used and ensure that this is consistent between vehicle and sled measurements for a particular seat.

For vehicle manufacturers sourced seat setups, this reference point must also be specified. Figure 1

Figure 1 shows an example seat reference point being the front left bolt hole, but other non-moving parts of the seat mounting structure are acceptable. The seat structure reference point shall be chosen such that the relationship of the seat to the vehicle floor can be accurately reproduced on the sled.

Figure 1: Definition of the Seat reference point

3.5.3.3 Toe Board

The toe board is defined as a simulated floor and toe pan, consisting of a horizontal section sufficiently large to rest the dummy’s feet and connected to a section oriented 45° from the horizontal. When positioned for test, the gap between the front of the seat and rear of the toe board shall be no more than 100mm. Both surfaces shall be covered with short-piled carpet. A suitable arrangement is illustrated in Figure 2.

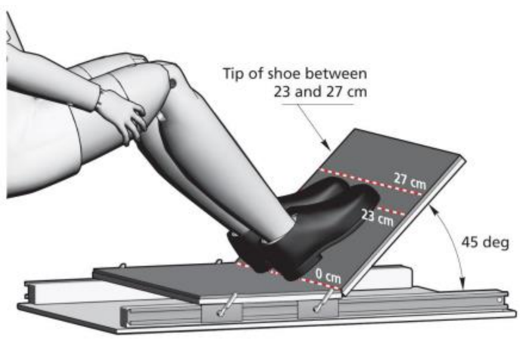


Figure 2 Toe board arrangement showing correct positioning of BioRID feet

3.5.3.4 Heel surface

The heel surface is defined as the horizontal plane of the toe board (i.e. sled floor or movable footrest) on which the dummy's heel rests. Its target position is determined using the heel rest point location defined from the vehicle measurements, or from information provided by the vehicle manufacturer. An accurate height setting shall be obtained at this stage; however an initial approximated horizontal position may be set. The final horizontal position will be obtained in section 3.5.5.6.8.

3.5.3.4.1 Heel Rest Point Location

3.5.3.4.1.1 Determine heel rest point location

Determine the heel rest point location. The heel rest point location is defined in the vehicle (with removable floor mats not fitted) by using the accelerator pedal as the steps outlined in 3.5.3.4.1.2.

3.5.3.4.1.2 Find the geometric centre point of the accelerator pedal contact surface (both laterally and vertically). Place a straight edge between the accelerator pedal centre point and the fixed carpeting on the vehicle floor such that the straight edge is tangential to the accelerator pedal surface at the centre point. The heel rest point location is then the contact point of the straight edge on the vehicle floor, see Figure 3.

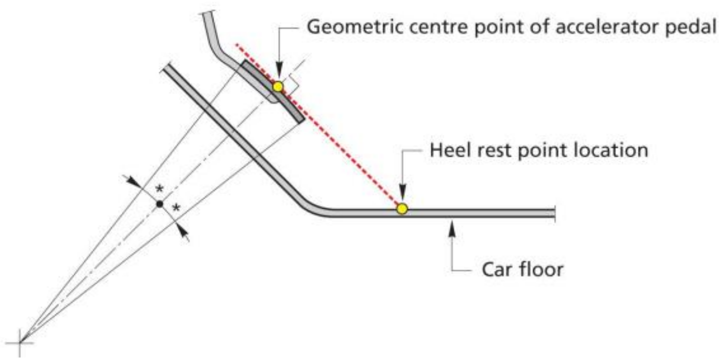


Figure 3 Heel rest point

3.5.3.5 Seat Mounting to Sled

3.5.3.5.1 The seat, including all of its adjustment mechanisms and hardware that normally connects it to the vehicle floor (e.g. longitudinal adjustment rails), shall be securely fastened to the test sled platform.

3.5.3.5.2 The attachment shall be made so that the seat's orientation relative to the horizontal is the same as it would be in its vehicle as defined by physical vehicle measurements or vehicle manufacturer data. The actual height of the seat from the sled platform may be different from its height above the vehicle floor.

3.5.3.5.3 The toe board is also attached to the sled platform. The horizontal floor portion shall be mounted at the same height relative to the seat bolts/rails as the heel rest point. The fore/aft position of the toe board shall be adjustable. Figure 4 shows an example seat both in-vehicle and mounted on the sled platform.

3.5.3.5.4 The seat structure reference, seat rail angle and heel rest point shall be recorded in the test report. Seat mounts shall be rigid and non-deformable, and the seat mount interface to the seat shall approximate that of the interface to the vehicle floor. The vehicle manufacturer will be asked to provide details of the relevant seat mounting measurements/tolerances and will be invited to examine the fixture prior to test. Alternatively, the car manufacturer may provide the technical service with a suitable seat attachment frame or fixture.

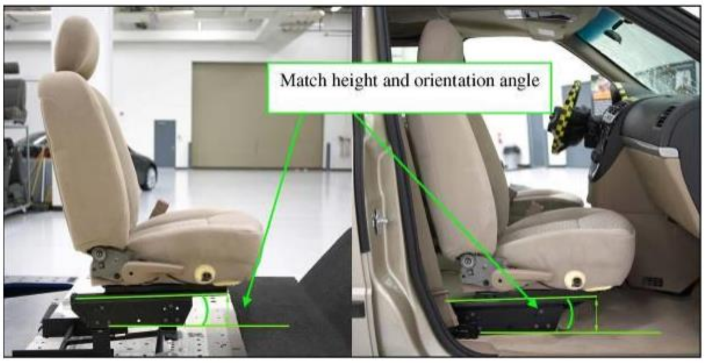


Figure 4 Attachment of seat to test sled

3.5.3.6 Seat Position

3.5.3.6.1 Seats with Automatically Adjusting Head Restraints

The BioRID dummy used for these dynamic tests represents a midsize adult male driver or vehicle occupant. Consequently, seats equipped with head restraints that automatically adjust depending on other seat adjustments (e.g. seat track or height) shall be set to a position most likely to be used by a seat occupant of the same size as the dummy. Therefore, the seat shall be adjusted to its mid track and mid height position.

Since the seat's starting position can affect the final position of the head restraint, a consistent setup sequence shall be followed. During setting of the mid/mid position, the seat shall always be moved rearward from the forward most position, and downward from the fully up position. The seatback shall then be positioned following the procedure in section 3.5.4.3. All other seat settings that have not already been adjusted shall be set according 3.5.3.6.2.

3.5.3.6.2 Setting manual seat adjustments

The various seat adjustments possible on many modern vehicle seats shall be set according to the following instructions. Because the setting of some adjustments may affect the adjustment range of other adjustments, the seat shall be set by following the order of the procedure outlined here. If the seat is new and has never been sat on, a person of mass 75kg ± 10kg shall sit on the seat for 1 minute, twice, to flex the cushions. The seat shall have been at room temperature for at least six hours and not loaded for at least one hour previous to the initial installation of the H-point manikin. Following this pre-conditioning, the seat set up may be undertaken. The seatback angle will be set in section 3.5.4.3, the initial setting is not important so long as it doesn't interfere with other adjustments.

Seat adjustments shall now be set using the sequence described in section 3.5.3.6.2.1 to 3.5.3.6.2.7. Subsequent seat adjustments may affect the original position of a previous setting. If this is the case there shall be no re-adjustment of the previous settings.

3.5.3.6.2.1 Initial Adjustment of Seat Adjustment Controls

All seat controls shall be set in sequence as follows. Section 3.5.14 provides more detailed descriptions with illustration of each of these seat adjustments.

(1) Seat track shall be in its most rearward locking position.

(2) Seat height shall be set to its lowest position.

(3) Seat tilt shall be set to the extreme of its range that puts the cushion angle closest to zero (horizontal). Section3.5.3.6.2.2 describes the method for measuring the cushion angle.

(4) Cushion height shall be set to its lowest position.

(5) Cushion tilt shall be set to the extreme of its range that puts the cushion angle closest to zero (horizontal). Section 3.5.3.6.2.2 describes the method for measuring the cushion angle.

(6) Lumbar support shall be set to its most rearward or least prominent position.

(7) Upper seat back, if separately adjustable from the lower portion shall be rotated fully rearward.

(8) Cushion extension shall be set to its most rearward or least extended position.

(9) Side bolsters shall be set to the widest position.

(10) Arm Rests shall be set in the stowed position.

3.5.3.6.2.2 Measurement of Cushion Angle

Locate and mark a point on the forward edge of the top surface of the seat cushion and midway between the right and left edges of the cushion. Locate, mark, and record a second point that is 400mm rearward along a line parallel to the direction of the sled movement. The cushion angle is the reading from a digital protractor sitting on the surface of the seat with the rearmost end on the rear seat mark. A suitable length protractor shall be chosen such as the entire length of its underside (measurement surface) is in contact with the central panel of the seat cushion. The angle measurement shall not be influenced by padding or bolstering on the front of the seat base.

Alternatively, if a coordinate measurement machine (CMM) is used to record the locations of the seat marks, then the Sine of the cushion angle is the difference in the Z-coordinates (in mm) of these 2 points (first minus second) divided by 400mm. See Figure 5.

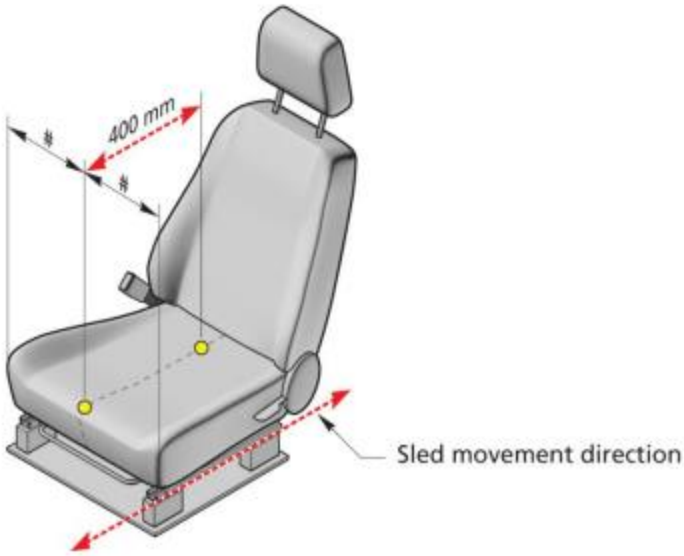


Figure 5 Measurement of cushion angle

3.5.3.6.2.3 Setting Seat Track Adjustment to Midrange

Mark both sides of the seat track and adjacent portion of the seat support structure. Move the seat to its most forward most locking adjustment position and mark the seat track adjacent to the repositioned marks on either side of the seat support structure. On both sides of the seat, measure the distance between the two seat track marks and mark the track midway between the first two marks.

Alternatively, a CMM may be used. With the seat in the rearmost position, mark a hard point on the seat and record its location.

Move the seat to its most forward adjustment position and record the position of the seat hard point. Move the seat rearward until the mark on the seat support structure aligns with centre seat track mark, or until the marked hard point is midway between the two previously recorded hard point locations. The final position will depend on whether the seat track adjusts continuously or incrementally.

The seat shall be checked to ensure that both seat runners are set and locked correctly. In some cases there may be different amounts of travel between the two seat runners, care shall be taken to ensure that in such cases both seat runners are locked in the correct positions.

3.5.3.6.2.3.1 Continuously Adjusting Seat Track

The seat mark shall align (±2mm) with the mid-track mark. Alternatively, the hard point shall have an X-coordinate that is midway (±2mm) between the X-coordinates of the forward most and rearward most adjustment positions.

3.5.3.6.2.3.2 Incrementally Adjusting seat Track

If the midrange adjustment does not correspond to an incremental adjustment position (±2mm), then the seat shall be set to the first incremental position rearward of the calculated midrange position.

3.5.3.6.2.4 Setting Seat Height Adjustment to Midrange

Mark two hard points on the side of the seat, which are attached to and move with the cushion frame, one near the front of the cushion and one near the rear. Record the locations of both points with a CMM or measure the vertical heights of the points relative to a fixed reference with a measuring tape. Use the seat height adjuster control(s) to move the seat to its highest position. If the front and rear of the seat adjust separately, then make sure that both the front and rear of the seat are raised to their highest positions.

Record the locations of the two hard points with the CMM or measure the vertical heights of the points relative to a fixed reference with a measuring tape. Then lower the seat until both hard points are midway between their highest and lowest positions. The final position will depend on type of seat height adjuster.

3.5.3.6.2.4.1 Single Control Seat Height

If the height is controlled by a single adjuster, its final position will depend on whether it is continuously or incrementally adjusting.

3.5.3.6.2.4.1.1 Continuously Adjusting seat Height

For single control height adjusters, the rear hard point shall be ± 2mm of the calculated midpoint.

3.5.3.6.2.4.1.2 Incrementally Adjusting Seat Height

If the midrange adjustment does not correspond to an indexed adjustment position (±2mm), then the seat shall be set to the first indexed position below the calculated midrange position.

3.5.3.6.2.4.2 Dual control seat height

If the front and rear of the seat adjust separately, then use the front adjuster to lower the front hard point and the rear adjuster to lower the rear hard point. The final position will depend on whether it is continuously or incrementally adjusting. Note that the adjustment of the front and rear controls may need to be iterated in order to achieve the calculated midpoints.

3.5.3.6.2.4.2.1 Continuously Adjusting Seat Height

Both hard points shall be ±2mm of the calculated midpoints. If this is not possible, then the rear hard point shall be ±2mm of the calculated midpoint and the front hard point as close to the calculated midpoint as possible.

3.5.3.6.2.4.2.2 Indexed Adjusting Seat Height

If either midrange adjustment does not correspond to an indexed adjustment position (±2mm), then it shall be set to the first indexed position below the calculated midrange position for the corresponding seat hard point.

3.5.3.6.2.5 Setting Cushion Height Adjustment

The cushion height adjustment uses the points marked on the top surface of the cushion in section 3.5.3.6.2.2.

3.5.3.6.2.5.1 Single Control Cushion Height Adjustment

Raise the cushion to its highest adjustment and record the position of the rear cushion point (400mm behind front edge point). Lower the seat cushion to its mid-position. The final position will depend on whether it is continuously or incrementally adjusting.

3.5.3.6.2.5.1.1 Continuously Adjusting Seats

The rear cushion point shall have a Z-coordinate midway (±2mm) between the lowest (initial) and highest positions.

3.5.3.6.2.5.1.2 Incrementally adjusting seats

If the midrange adjustment does not correspond to an indexed adjustment position (±2mm), then the seat cushion height shall be set to the first indexed position below midrange.

3.5.3.6.2.5.2 Dual control cushion height adjustment

Use the rear cushion height adjuster to raise the rear of the cushion to its highest position and record the location of the rear cushion point (400 mm behind front edge point). Again using the rear cushion height adjuster, lower the rear of the cushion so that the rear cushion point is midway between the lowest (initial) and highest positions. Use the front cushion height adjuster to raise the front of the cushion until the cushion angle matches the angle recorded in step 3.5.3.6.2.2. The final position will depend on whether it is continuously or incrementally adjusting. Note that the adjustment of the front and rear controls may need to be iterated in order to achieve the calculated midpoints.

3.5.3.6.2.5.2.1 Continuously Adjusting Seat Height

The rear seat point Z-coordinate shall be ±2mm of the calculated midpoint and the cushion angle shall match that recorded instep 3.5.3.6.2.2 to within (±0.5°).

3.5.3.6.2.5.2.2 Indexed Adjusting Seat Height

If the midrange adjustment of the rear adjuster does not correspond to an indexed adjustment position, then it shall be set to the first indexed position below the calculated midrange. Likewise, if the cushion angle from 3.5.3.6.2.2 cannot be matched (±0.5°) with the front adjuster adjusted to an indexed position, then set the front adjuster to the next lowest indexed position.

3.5.3.6.2.6 Adjusting Upper Seatback Angle

Measure the angle relative to vertical of the head restraint support post or some flat part of the seatback frame. Without changing the adjustment of the lower seatback, move the upper seatback to its most forward position and measure the angle of the head restraint post or seatback frame. Adjust the upper seatback rearward until the head restraint post or seatback frame angle is midway (±0.5°) between the rearmost and forward most angles.

3.5.3.6.2.7 Other Seat Adjustments

Seat adjustments not set in steps 3.5.3.6.2.2 through 3.5.3.6.2.6 shall remain in the initial adjustment as set in section 3.5.3.6.2.1.

3.5.3.7 Seat Belt

3.5.3.7.1 A generic three point lap-shoulder seat belt equipped with an inertia reel shall be used during the test, placed in such a way that the belt, when worn by the ATD, shall lie across the torso, clavicle and pelvis, and must always be routed above the pelvic angle gauge.

3.5.3.7.2 For generic seat belts, where a seat is equipped with anchorages or buckles, these may be used. Any anchorages not attached to the seat shall be positioned as shown in Figure 6. The marks, which correspond to the arrangement of the anchorages, show where the ends of the belt are to be connected to the sled. The anchorages are the points A, B and K. The tolerance on the position of the anchorage points is such that each anchorage point shall be situated at most at 50mm from corresponding points A, B and K indicated in Figure 6.

3.5.3.7.3 If a fourth anchorage is necessary to attach the retractor, this anchorage:

(1) shall be located in the vertical longitudinal plane passing through K,

(2) shall be located 770mm vertically below K.

In the case of a belt equipped with a belt adjustment device for height, this device shall be secured to a rigid frame.

3.5.3.7.4 The structure carrying the anchorages must be rigid and shall be so constructed that no permanent deformation shall occur in the parts bearing the anchorages during the test.

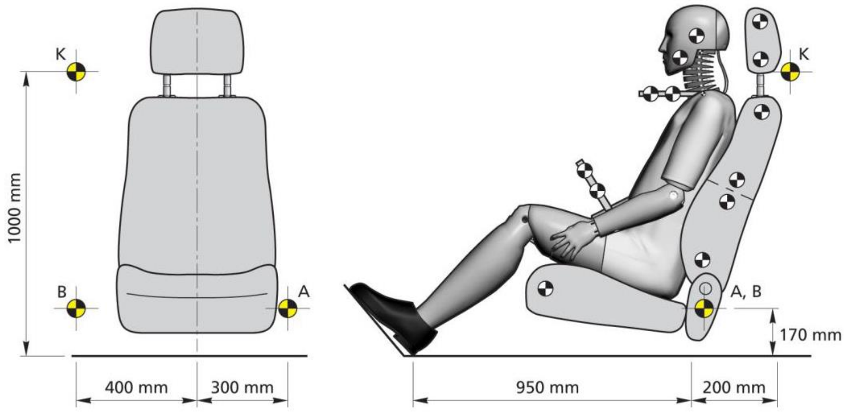


Figure 6 Generic seat belt anchorage mounting

3.5.3.7.5 Where a manufacturer requests and can demonstrate good reason for doing so to the TNCAP executive agency, vehicle specific belts and geometry may be considered. In this case or when testing seats equipped with integrated belts the vehicles own seat belt hard ware (retractor and buckle) shall be used. Seat belt geometry and restraint equipment shall then be used that approximates that of the test vehicle. Where this is agreed, the vehicle manufacturer will be asked to provide details of the relevant mounting measurements/tolerances and will be invited to examine the fixture prior to test. Alternatively, the car manufacturer may provide the technical service with an attachment frame or fixture.

3.5.3.8 Triggering of active elements

For each seat it shall be ascertained from manufacturer data whether active elements (e.g. pro-active head restraint or seat belt pretensioner) are fitted, and whether they would be triggered for each of the test pulses. For each element which requires a trigger, Time to Fire (TTF) shall be specified by the vehicle manufacturer for each pulse if required. Supporting data shall be provided by the manufacturer to show that the system always triggers throughout the entire range of rear impact scenarios considered by TNCAP. For example, the low severity RCAR bumper test would be considered.

3.5.4 H-Point Machine (HPM) & Dummy Positioning H

3.5.4.1 Introduction

The following section contains the current positioning procedure for use with the BioRID dummy. The entire process for a single installation and measurement using the HPM and HRMD shall last approximately 15 minutes maximum per installation.

3.5.4.2 H-point Manikin and HRMD Preparation

The BioRID test position is based on reference measurements made with the H-point manikin (HPM) and HRMD. Parts of the following text contain excerpts from "A Procedure for Evaluating Motor Vehicle Head Restraints" (Issue 2, RCAR, February 2001). A specific pairing of manikin and HRMD must be used which have been certified together. Before using the combination, ensure that the build condition is correct. Remove the head room probe from the H-point machine and install the two washers (supplied with the HRMD) in the spaces remaining on the H-point pivot. The fit of the HRMD on the H-point machine shall be confirmed. Lower the HRMD in position onto the torso weight hangers and onto the top edge of the channel between the torso weight hangers. Ensure that the HRMD fits easily into place without inducing forces which might disturb the manikin position.

3.5.4.3 H-point Manikin Installation

3.5.4.3.1 The seat shall be covered with a cotton cloth large enough to cover both cushions and seatback.

3.5.4.3.2 The cloth shall be tucked into the seat joint by an amount sufficient to prevent hammocking of the material.

3.5.4.3.3 The H-point manikin shall be installed in the seat.

3.5.4.3.4 The lower legs shall be adjusted to the 50th percentile leg length setting, and the upper legs shall be adjusted to the 10th percentile leg length setting; these are the HPM settings closest to the TNCAP front and side impact protocol settings.

3.5.4.3.5 The legs shall be attached to the HPM and set to the 5th position (no.5) on the knee joint T-bar, which places the knees 250mm apart.

3.5.4.3.6 With the legs attached and the back pan tilted forward, the HPM shall be positioned in the seat such that its mid-sagittal plane coincides with the longitudinal centreline of the seat. The centreline of the seat may be defined from features such as the head restraint support tubes or seatback and seat pan side bolsters. Particular attention shall be paid to seats with asymmetric design.

3.5.4.3.7 The back pan shall be straightened to conform to the vehicle seat back.

3.5.4.3.8 The feet shall be placed as far forward as possible, with the heels resting on the heel plane and the feet positioned at 90° to the tibias. The toe pan shall be positioned sufficiently far away so as to avoid any interaction with the feet during the HPM installation process.

3.5.4.3.9 The lower leg and thigh weights shall be attached to the HPM and the assembly shall be levelled.

3.5.4.3.10 The back pan shall be tilted forward to 45° from the seat back and the HPM assembly pushed rearward until the seat pan contacts the vehicle seat back. While maintaining the back pan at 45° to the seat back, a horizontal rearward force of 100N shall be applied using the plunger if present or using a force gauge pressed against the hip angle quadrant structure.

3.5.4.3.11 The load application shall be repeated and, while keeping the 100N applied, the back pan shall be returned to the vehicle seat back and the load then released. As the 100N is released, a small force shall be maintained on the front of the T-bar to prevent any longitudinal movement. This support shall be maintained until the end of section 3.5.4.3.17 is reached.

3.5.4.3.12 A check shall be made to determine that the HPM is level, facing directly forward, and located in the centreline of the seat.

3.5.4.3.13 As an approximation of the vehicle seat back position, it shall be placed such that the torso angle is about 21° before the buttock and chest weights are added. This angle may be varied according to the subjective estimate of the seat cushion stiffness or based on data provided by the manufacturer.

3.5.4.3.14 The HPM torso angle shall be measured by placing an inclinometer on the calibrated block (see 3.5.11) located on the lower brace of the torso weight hanger.

3.5.4.3.15 After estimating the vehicle seat back position, the right and left buttock weights shall be installed. The six chest weights (including the two larger weights) shall be installed by alternating left to right. The two larger HRMD chest weights shall be attached last, flat side down. Throughout the weight installation, maintain a light pressure to the T-bar preventing any longitudinal movement.

3.5.4.3.16 Tilting the back pan forward to a vertical position, the assembly shall be rocked from side to side over a 10° arc, 5° in each direction. Where seat side bolsters prevent movement of up to 5°, the assembly shall be rocked as far as permissible. This rocking shall be repeated twice, making a total of three complete cycles. Care shall be taken to maintain support of the T-bar during the rocking action, and to ensure that no inadvertent exterior loads are applied. Ensure that the movements of the HPM feet not restricted during this step. If the feet change position, they shall be allowed to remain in that attitude for the time being.

3.5.4.3.17 Holding the T-bar to prevent the HPM from sliding forward on the seat cushion, the back pan shall be returned to the vehicle seat back, and the HPM shall be levelled.

3.5.4.3.18 To ensure a stable torso position, apply and release a horizontal rearward load, not to exceed 10N, to the back pan moulding at a height approximately at the centre of the torso weights. Care shall be exercised to ensure that no exterior downward or lateral loads are applied to the HPM.

3.5.4.3.19 Each foot shall be alternately lifted off the floor via the instep until no additional forward foot movement is available.

3.5.4.3.20 The 45 degree plane of the toe board shall be moved toward the feet such that the tip of the toe lies between the 230mm and 270mm lines taking care not to disturb the position of the HPM. To facilitate easier setting of BioRID, the toe board shall be moved such that the toes of the HPM feet are positioned nearer to the 230mm line.

3.5.4.3.21 When each foot is in its final position, the heel shall be in contact with the floor, and the sole of the foot shall be in contact with the 45 degree plane of the toe pan between the 230mm and 270mm lines.

3.5.4.3.22 If the HPM is not level after the feet have been repositioned, a sufficient load shall be applied to the top of the seat pan to level it on the vehicle seat. This may be verified using the bubble gauge fitted to the manikin or alternatively by verifying with CMM that the H-point positions on both sides of the machine are within ±2.5mm of each other.

3.5.4.4 Installation of the HRMD

3.5.4.4.1 The backset and height probes shall be installed and pushed flush against the HRMD.

3.5.4.4.2 The HRMD levelling knob shall be confirmed as finger tight and the plungers which engage at the HPM to HRMD interface shall be fully loosened.

3.5.4.4.3 The HRMD shall then be lowered into position on the HPM torso weight hangers and on the top edge of the channel between the hangers. During the fitment, ensure that the HRMD fits easily into place without inducing forces which might disturb the manikin position. Make note of any longitudinal movement of the manikin, and ensure that this results in consistent H-point position in the subsequent repeat drops conducted in section 3.5.5.5.

3.5.4.4.4 The HRMD shall be levelled by loosening the levelling knob at the rear of the device and repositioning the head using the HRMD bubble level;

the levelling knob shall then be retightened by hand.

3.5.4.4.5 Measure the torso angle on the calibrated block attached to the weight hanger bar.

3.5.4.4.6 If the measured angle is not 25°±1°, the HRMD and chest and buttocks weights shall be removed, the seat back readjusted, and the steps to position the HPM shall be repeated, beginning with tilting the back pan forward and pushing the HPM rearward as in 3.5.4.3.10.

3.5.4.4.7 If more than 3 installations of the HPM and HRMD are required to ascertain a seatback angle that supports a torso angle of 25°±1°, then the seat shall be allowed to recover for 15 minutes with nothing in it between each third and fourth installation. It is recommended to aim to set the SAE manikin as close as possible to the nominal target value for torso angle.

3.5.4.4.8 Some indexed seatback adjustments may have more than 2° between adjustments with none giving a torso angle between 25°±1°. In such cases, adjust the seatback to the most reclined position that supports a torso angle less than 24°.

3.5.4.4.9 The torso angle shall be recorded when it falls within the allowed range.

3.5.4.5 Record the location of the HPM H-point Markers

3.5.4.5.1 Record the H-point positions on both sides of the HPM using a CMM or other means to record the location of both H-points relative to the seat or sled.

3.5.4.5.2 The H-point position on both sides of the machine shall be within ± 2.5mm of each other in X and Z. If this is not the case, the installation procedure from 3.5.4.3.6 shall be repeated.

3.5.5 Head Restraint Positions

3.5.5.1 Head Restraint Measurement Position Definitions

3.5.5.1.1 Down is defined as the lowest achievable position of an adjustable head restraint regardless of other adjustments (e.g. tilt) and without using tools. The lowest position shall be assessed from the point of view of a seated occupant, and without using a third hand.

3.5.5.1.2 Up is defined as the highest adjusted détente position of an adjustable head restraint (taking into account locking détente positions, as defined in section 3.5.1.1.6, only).

3.5.5.1.3 Back is defined as the most rearward adjusted position of an adjustable head restraint, or if this is difficult to ascertain, “back” shall be taken as the position which results in the greatest “HRMD backset” when set at the test height.

3.5.5.1.4 Forward is defined as the most forward locking adjusted position of an adjustable head restraint, or if this is difficult to ascertain, "forward" shall be taken as the position which results in the least "HRMD backset" when set at the test height.

3.5.5.2 Head Restraint Test Positions

The same head restraint position shall be used for all three tests. If any variability exists in the locking mechanism, such as different levels of friction that affect that head restraint position then the TNCAP executive agency shall be informed immediately. The decision of the position to be used in the tests shall be made by the Secretariat. Where there is damage to a seat which affects the test position, details shall be noted by the technical service and provided in the test report, that seat shall not be used for test.

3.5.5.2.1 Head restraint test positions

The test position for the head restraint depends on whether it is fixed or adjustable and, if adjustable, whether the adjustments lock. Automatically adjusting head restraints are tested as if they are fixed restraints and the seat adjustments are set according to section 3.5.3.6.1.

3.5.5.2.2 Non-locking adjustable head restraint

The head restraint is first adjusted to its lowest vertical adjustment position as defined in section 3.5.5.1.1. If a non-locking tilt adjustment is available, this shall then be set to the most rearward horizontal adjustment position possible once the head restraint has been set to its lowest position.

3.5.5.2.3 Locking adjustable head restraints, midrange positions

The head restraint is adjusted to midrange of its vertical and/or horizontal adjustment positions. Only locking adjustments are set to the midrange positions. For example, a restraint with locking height adjustment and non-locking horizontal adjustment would be set to its midrange vertical position and most rearward horizontal position. The head restraint shall first be set for the midrange vertical position. Midrange tilt position shall then be set where this adjustment has locking notches.

3.5.5.2.3.1 Setting of Mid Range Height

3.5.5.2.3.1.1 Lowest Position

Some head restraints can be lowered below the lowest locking position and in these cases the bottom of the restraint may contact the top of the seatback. The lowest vertical adjustment position is defined in section 3.5.5.1.1.

3.5.5.2.3.1.2 Highest Position

The highest position is considered to be the highest locking position. If a restraint has a non-locking position above the highest locking position, then the highest locking position is still considered as the highest position, see Figure 7.

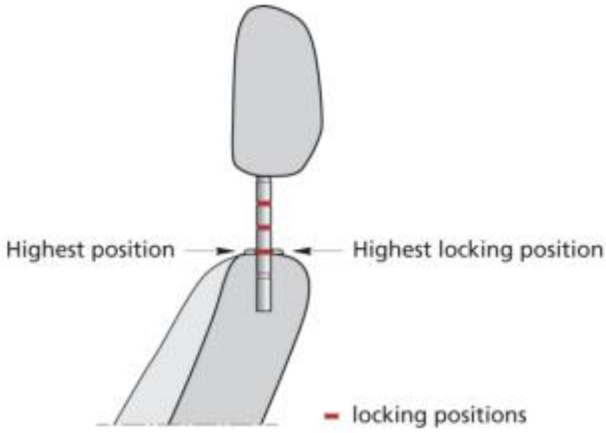


Figure 7 Examples of adjustment positions for head restraints with non-locking positions above/and or below the locking positions

3.5.5.2.3.1.3 When measuring the head restraint travel for the midrange positions, the seat must be adjusted according to section 3.5.3.6, the seatback must be adjusted according to section 3.5.4 and the HPM manikin shall be installed in the seat according to section 3.5.4.

3.5.5.2.3.1.4 Mark a repeatable reference point on the top of the head restraint. This point is typically the highest point on the centreline of the head restraint. Using a coordinate measurement device, this point shall first be measured in the lowest position as defined by in section 3.5.5.1.1, and then in the highest locking position without altering tilt or any other seat settings.

3.5.5.2.3.1.5Midrange height position is determined by calculating the geometric mid point between the lowest position, and highest locking vertical adjustments, considering only the vertical component of measurement, see Figure 8. The test position will then be selected based on the following conditions:

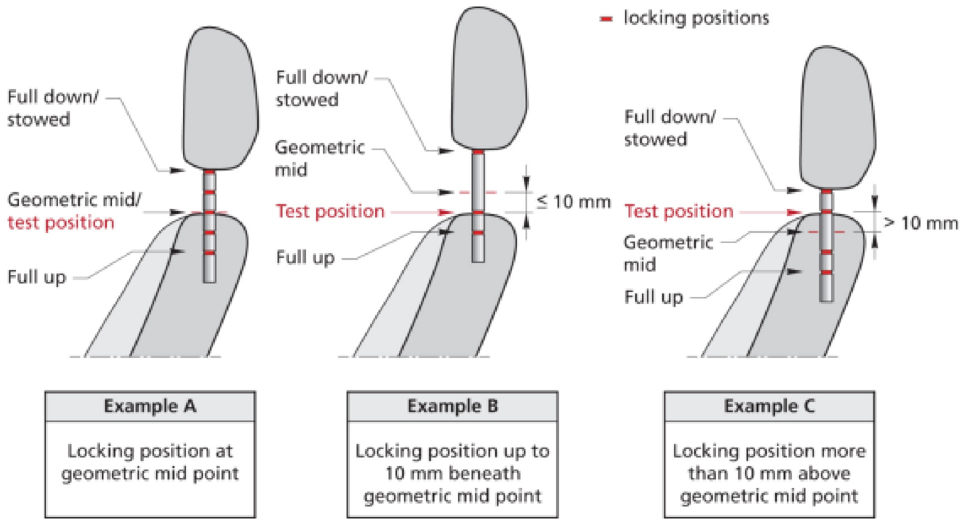


Figure 8 Examples of test position for head restraints with various locking configuration

3.5.5.2.3.1.5.1 Place the head restraint at the geometric mid point if a locking position exists there, see Figure 8, Example A.

3.5.5.2.3.1.5.2 If there is no locking position at the geometric mid point, raise the head restraint by up to 10mm. If a locking position exists within this 10mm of travel, that position will be the test position, see Figure 8, Example B.

3.5.5.2.3.1.5.3 If there is no locking position within 10mm above the geometric mid point, lower the head restraint to the next lowest locking position, see Figure 8, Example C.

3.5.5.2.3.1.5.4 If there is no locking position before the lowest or stowed position is reached, then the head restraint shall be positioned fully down.

3.5.5.2.3.1.5.5 Once the vertical test position has been determined, ensure the head restraint is returned to rearmost tilt position.

3.5.5.2.3.2 Setting of Mid Range Tilt (Locking Tilt Settings Only)

3.5.5.2.3.2.1 Following the setting of midrange height, the procedure shall be repeated for locking horizontal adjustments. For non-locking tilt adjustments, the head restraint shall be tilted fully rearward.

3.5.5.2.3.2.2 Mid tilt position may be influenced by the presence of the HRMD head, consequently the setting of mid range tilt shall be undertaken following successful installation of the H-point machine and HRMD and shall be completed while the equipment is still installed in the seat.

3.5.5.2.3.2.3 For HRMDs equipped with probes having 5mm increments only, a more accurate measurement technique is required to establish the mid position to within 1mm. Using a steel rule, measure the probe extension from the front of the headform at forward and rearward tilt settings. From this data a midpoint target may be derived.

3.5.5.2.3.2.4 Most Rearward Tilt shall be made using HRMD probe backset. The most rearward tilt position shall be that which results in greatest backset measurement. In the situation where the head restraint cannot be placed at most rearward tilt. For example due to a return spring, the most "most rearward tilt" shall be the most rearward position in which the tilt can be locked.

3.5.5.2.3.2.5 Most Forward Tilt shall be determined by finding the most forward locking tilt position. Non-locking positions located further forward than the most forward lock are disregarded. During determination of "most forward tilt" position, the head restraint may come into contact with the HRMD. If contact is achieved, the head restraint shall not be tilted further forward, and shall not be moved such that the HRMD position is affected. If a lock exists at the tilt position where the head restraint contacts the HRMD, this shall be considered the "most forward tilt" position. If no locking position exists in this location, the head restraint shall be tilted rearwards until a locking position is reached. This position shall then be considered "most forward tilt".

3.5.5.2.3.2.6 Midrange Tilt Position is determined by calculating the geometric mid point between the most rearward tilt and most forward locking horizontal adjustments, considering only the HRMD probe backsets measured. Midrange tilt setting shall be undertaken using the same rationale as used in 3.5.5.2.3.1. A locking position shall be sought within a window 10mm forwards from the geometric mid point. If a lock is found within this window, that position shall be considered the test position. In the absence of a lock within this range the head restraint shall be moved rearwards until the next locking position is reached. If no locking positions are reached before the fully rearward tilt position, then fully rearward tilt shall be the test position.

3.5.5.3 Measure and Record the Head Restraint Geometry

3.5.5.3.1 Before measuring the head restraint geometry, ensure that:

(1) The seat is set according to section 3.5.3.6.

(2) The H-point machine and HRMD are correctly installed in the seat according to section 3.5.4.

(3) The head restraint is set in the correct test position according to section 3.5.5.2.

3.5.5.3.2 When measuring backset and height, a light force (e.g. 1N) shall be applied, if needed, to ensure that any trim covering material is in contact with the underlying foams, or that the separation of trim material has not provided artificially favourable measurements.

3.5.5.3.3 Measure the HRMD backset to the nearest millimetre, with the backset probe in first contact with the head restraint. For the geometric assessment, the backset must be measured according to the HRMD backset probe scale, taking note of the method described in section 3.5.5.2.3.2.3 for probes with 5mm increments only. See Figure 9.

3.5.5.3.4 The height from the top of the head restraint to the height probe shall also be measured.

3.5.5.3.5 If the head restraint is too low to be contacted by the backset probe, record as 'no contact'.

3.5.5.3.6 All measurements noted during 3.5.5.3.3 and 3.5.5.3.4 shall be used for the TNCAP geometry points calculation, as defined in the TNCAP assessment protocol.

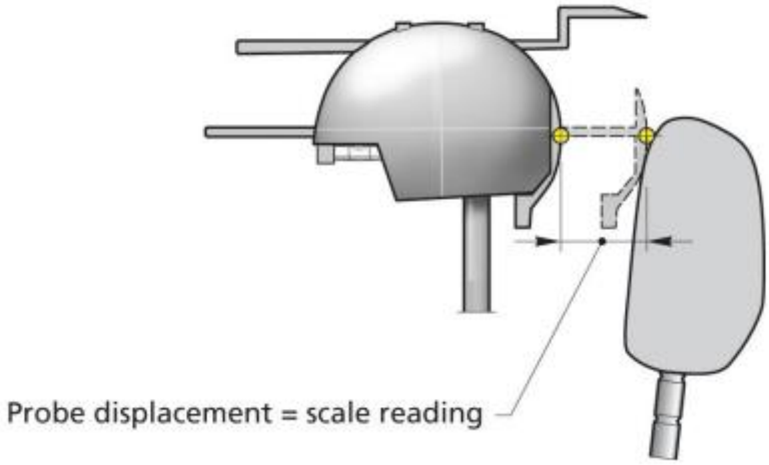


Figure 9 Backset probe for static geometry measurement

3.5.5.4 Measure and Record Reference Geometry for BioRID setup

The HRMD probe measurements used for the geometric assessment will be different than the geometry recorded for use during the BioRID setup. This is due to the curvature of the HRMD probes and is illustrated in Figure 10. Since the

BioRID is set up based on reference geometry recorded using the HRMD, there is a need to measure an equivalent feature on both devices. The rear most point on the HRMD skull (i.e. the screw on the backset probe) is equivalent to the rearmost point on the centreline of the dummy’s skullcap. This point can be found using a measuring tape that contours to the shape of the skullcap: the point is 95mm from the top of the skullcap along the mid sagittal plane of the skull.

3.5.5.4.1 Mark an identifiable point on the head restraint along its vertical centreline. A suggested point is defined by first contact point between backset probe and head restraint.

3.5.5.4.2 Ensure that the backset probe is installed and pushed flush against the HRMD, i.e. stowed/retracted.

3.5.5.4.3 Locate the screw on the centre of the rear surface of the HRMD backset probe.

3.5.5.4.4 Measure and record the BioRID reference backset using CMM (as defined in section 3.5.1.3.3). This is the horizontal distance between the rearmost point on the HRMD skull (i.e. the screw on the retracted backset probe) and the identifiable point on the head restraint +15mm, see Figure 10.

3.5.5.4.5 Ensure that the head restraint has been marked such that it can reliably be returned to the test position. Move the head restraint to the lowest position as defined in section 3.5.5.1.1. Whilst maintaining that lowest position, move the head restraint to the most rearward tilt possible as defined by section 3.5.5.1.3 and 3.5.5.2.3.2.4. Measure the HRMD backset and height to the nearest millimetre using the probes.

3.5.5.4.6 All measurements noted during 3.5.5.4.5 shall be used for the TNCAP ease of adjustment assessment, as defined in the TNCAP assessment protocol.

3.5.5.4.7 Using the marks made in section 3.5.5.4.5, return the head restraint to the test position.

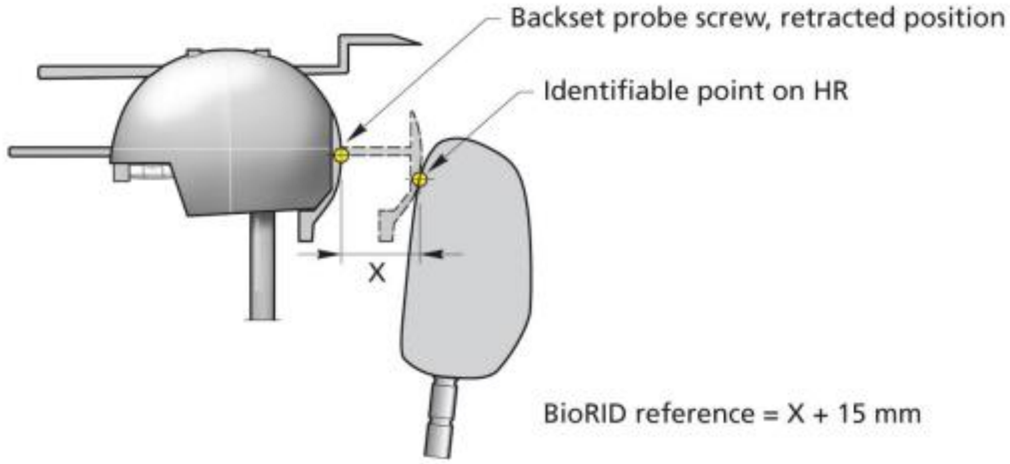


Figure 10 Measuring BioRID reference backset

3.5.5.5 Repeat Measurements

3.5.5.5.1 Remove the manikin and HRMD and repeat sections 3.5.4.3 to 3.5.5.4.6 two further times and record ALL measurements taken for each installation in both the test position (section 3.5.5.3.3) and the down and back position (section 3.5.5.4.5). For the repeat installations, the seat back angle shall not be adjusted. However, where a change in seat back angle is required to obtain a torso angle of 25°±1°, the installation procedure shall be repeated until three consecutive installations have been performed which require no seat back angle adjustment.

3.5.5.5.2 For each individual seat, ensure that the H-point X, H-point Z and reference backset measurements are within ±5mm between the three sets of measurements. Outlying measurements shall be investigated and repeated to achieve consistent static measurement results as necessary.

3.5.5.5.3 Once each individual seat has been measured three times, calculate the average H-point position recorded in section 3.5.4.5 and average reference backset recorded in section 3.5.5.4. These shall be the BioRID setup targets from the three measurements taken on each individual seat.

3.5.5.6 Install BioRID

3.5.5.6.1 The seat shall have already been set to give a torso angle of 25º ±1º measured on the H-point machine fitted with HRMD as described in section 3.5.4. Allow the seat to recover for 15 minutes with nothing in it before installing the BioRID. Note, BioRID handling shall only be undertaken using dedicated lifting tools and associated locations on the dummy following the BioRID manufacturer recommendations. Typically, during the installation of BioRID the H-point will initially be installed further rearward in the seat than is required. Therefore the pelvis shall be moved forward to achieve the target set-up positioning.

3.5.5.6.2 Carefully place the seat belt across the dummy and lock as normal, ensure there is sufficient slack in the belt to allow positioning of BioRID.

3.5.5.6.3 Align BioRID's midsagittal plane with the centreline of the seat.

3.5.5.6.4 Adjust BioRID's midsagittal plane to be vertical; the instrumentation platform in the head shall be laterally level.

3.5.5.6.5 Adjust the pelvis angle to 26.5º from horizontal (±2.5º).

3.5.5.6.6 Position the H-Point 20mm forward (±10mm) and at the same Z-height (± 10mm) as the location recorded in section 3.5.5.5.3, while keeping the pelvis angle at 26.5º (±2.5º). It is recommended to aim to set the ATD as close as possible to the nominal target values, and that the tolerance window shall only be used if there is an issue achieving the required H-Point target or backset value. The BioRID setup tolerances are summarised in Table 1.

3.5.5.6.7 Adjust the spacing of the legs so that the centreline of the knees and ankles is 200mm (±10mm) apart and ensure that the knees are level using an inclinometer or bubble gauge.

3.5.5.6.8 Adjust the dummy's feet so that the heel of BioRID's shoe is resting on the heel surface. The tip of the shoe shall rest on the toe pan between 230mm and 270mm from the intersection of the heel surface and toe board, as measured along the surface of the toe board. Figure 2 shows proper positioning of the feet. Note, the heel point from a vehicle is not replicated, only heel plane height is set according to vehicle geometry.

3.5.5.6.9 Position the BioRID's arms so that the upper arms are as close to the torso sides as possible. The rear of the upper arms shall contact the seatback, and the elbows shall be bent so that the small fingers of both hands are in contact with the top of the vehicle seat cushion with the palms facing the dummy's thighs.

3.5.5.6.10 Level the instrumentation plane of the head (front/rear and left/right directions) to within ±1º. Electronic tilt sensors shall be used to perform this check.

3.5.5.6.11 The BioRID backset (as defined in section 3.5.1.3.4) is the horizontal distance between the rearmost point on the head, and the same identifiable location on the head restraint that was found when measuring the HRMD in section 3.5.5.4.1.

3.5.5.6.11.1 Mark the farthest rearward point on the centreline of the dummy's skullcap. Note, as defined in 3.5.5.4, this point is 95mm from the top of the skullcap along the midsagittal plane of the skull measured using a tape that contours to the shape of the skullcap.

3.5.5.6.11.2 Measure the BioRID backset, using the point identified on the skullcap in 3.5.5.6.11.1 and the same identifiable location on the head restraint that was found when measuring the HRMD in section 3.5.5.4.1. See Figure 11.

3.5.5.6.12 If the BioRID backset is different from the BioRID reference backset obtained in section 3.5.5.4.4 (±5mm), then do the following:

3.5.5.6.12.1 Tip the head for/aft no more than ± 1° from level in order to meet the backset requirement.

3.5.5.6.12.2 If the BioRID backset cannot be brought closer to the BioRID reference backset ± 5mm by step 3.5.5.6.12.1, adjust the pelvis angle and H-point position within their respective tolerance bands. In this case begin at section 3.5.5.6.5 and adjust the BioRID position accordingly.

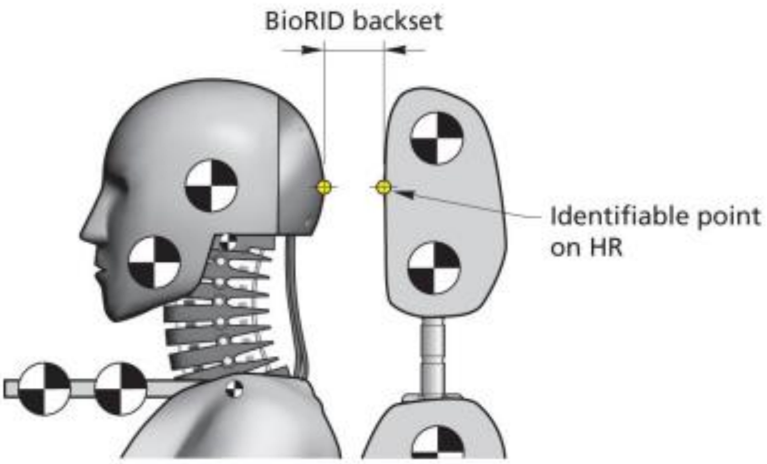


Figure 11 Measuring BioRID backset

3.5.5.6.13 Remove the slack from the lap section of the webbing until it is resting gently around the pelvis of the dummy. Only minimal force shall be applied to the webbing when removing the slack. The route of the lap belt shall be as natural as possible and must be above the pelvic angle gauge.

3.5.5.6.14 Place one finger behind the diagonal section of the webbing at the height of the dummy sternum. Pull the webbing away from the chest horizontally forward and allow it to retract in the direction of the D-loop using only the force provided by the retractor mechanism. Repeat this step three times, only.

3.5.5.6.15 Once the belt is positioned the location of the belt shall be marked across the dummy chest to ensure that no further adjustments are made.

Mark also the belt at the level of the D-loop to be sure that the initial tension is maintained during test preparation.

Table 1 BioRID setup summary

Location	Target Measure	Tolerance
H-point (X-axis)	+ 20mm forward*	±10mm
H-point (Z-axis)	0mm*	±10mm
Pelvis angle	26.5°	±2.5°
Head plane angle	0°(level)	±1°
Backset	15mm forward*	±5mm

Note: *Reference measurements taken using H-Point machine fitted with HRM

3.5.6 Biorid ATD Requirements

The tests shall be conducted with a BioRID IIg dummy built with 'Mould 2' jacket and fitted with electronic tilt sensors capable of measuring X and Y tilt for head and pelvis. The instrumentation umbilical shall exit at the front/side of the pelvis such that it is ensured there will be no seatbelt interaction. The dummy shall comply with both spine stature and dynamic response specifications before the test.

3.5.6.1 Spine Curvature Check

With the pelvis adapter plate placed on a level surface with the Occipital Condyle (OC) angle at 29.5° (±0.5°), the T2 angle at 37° (±0.5°), and the neck plate laterally level (±0.5°), the distance in (X) between the H-Point and the OC pin shall be 156mm (±5mm) and the distance in (Z) between the H-Point and the OC pin shall be 609mm (±5mm). See Figure 12. The curvature check shall be performed after every 15 tests and all measurements shall be recorded and fully documented.

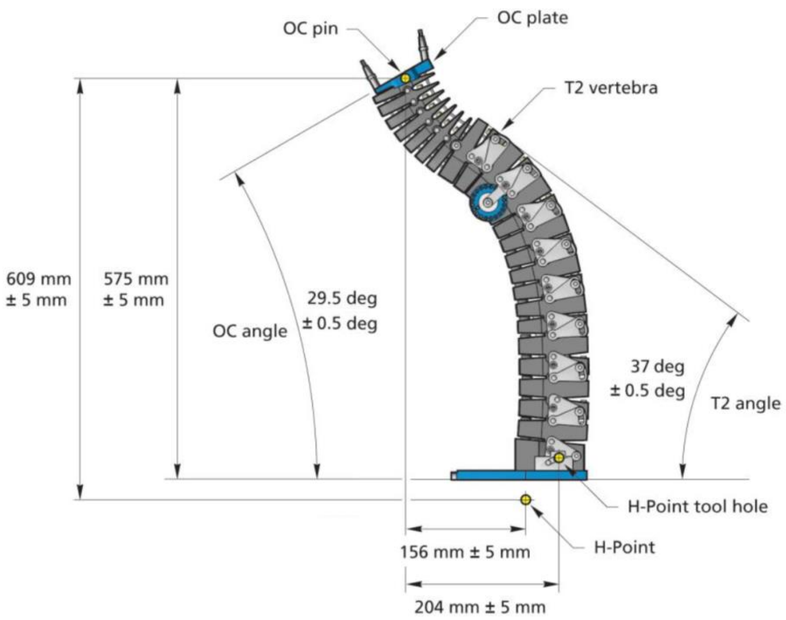


Figure 12 Spine curvature check

3.5.6.2 Certification

The dynamic response of BioRID is checked by attaching the spine, torso and head to a mini-sled that is impacted through foam by a 33.4kg probe and a velocity of 4.76m/s ± 0.1m/s. The specified response of the dummy and detailed test specifications are described in Test Procedure: Calibration of BioRID available from Denton ATD, Inc. Generally, if the dummy's spine curvature changes so that it does not meet the dimensional specifications described in section 3.5.6.1, then likely it will no longer meet the dynamic response specifications. It is recommended that the BioRID be re-certified after every 15 tests and all certification documents provided in the technical service test report.

3.5.6.3 Adjustment of the Dummy Extremities

3.5.6.3.1 The stiffness of both arms and legs shall be checked and adjusted, where necessary, prior to every sled test. The adjustment procedure is as follows:

3.5.6.3.2 Arms

3.5.6.3.2.1 Extend the complete arm laterally outward to a horizontal position. Twist the arm so the elbow cannot rotate downward. Tighten the shoulder yoke clevis bolt so the arm is suspended at 1g, see Figure 13.

3.5.6.3.2.2 Rotate the complete arm assembly so it points forward and is horizontal. Twist the arm so the elbow cannot rotate downward. Adjust the shoulder yoke rotation hexagonal nut so the arm is suspended at 1g.

3.5.6.3.2.3 Bend the elbow by 90° so the hand moves toward the chest. Adjust the elbow rotation bolt through access in the upper arm to hold the lower arm horizontally suspended at 1g.

3.5.6.3.2.4 Reposition the arm so it points forward and is horizontal. Twist the lower arm at the elbow, so the lower arm can pivot downward to vertical. Adjust the elbow pivot bolt through access holes in the lower arm flesh at the elbow to hold the lower arm suspended at 1g, see Figure 13.

3.5.6.3.2.5 Extend the arm and twist the palm so it faces down. Adjust the wrist pivot bolt at the base of the hand so it is suspended at 1g.

3.5.6.3.2.6 Adjust the wrist rotation bolt through access in the wrist flesh to hold it suspended at 1g.

3.5.6.3.2.7 Repeat procedure for other hand and arm.

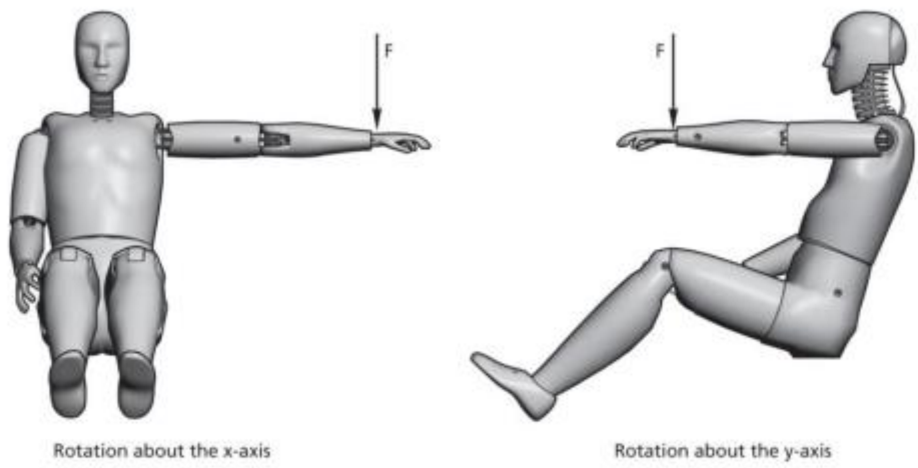


Figure 13 Dummy extremity settings

3.5.6.3.3 Legs

3.5.6.3.3.1 Remove the jacket from the dummy.

3.5.6.3.3.2 With the lower leg at 90° to the upper leg, and the dummy in seated position, lift the upper leg assembly above horizontal. Adjust the femur back set screw so the upper leg is held suspended at 1g.

3.5.6.3.3.3 Rotate the lower leg assembly so it is horizontal. Adjust the knee clevis bolt so the lower leg is held suspended at 1g.

3.5.6.3.3.4 Adjust the ankle ball joint screw so the foot is held suspended at 1g. The ankle adjustment is not critical and is determined by individual feet.

3.5.6.3.3.5 Repeat the procedure on the other leg and foot.

3.5.6.4 Clothing

3.5.6.4.1 The dummy shall be dressed with two pairs of close-fitting, knee-length, spandex/lycra pants and two close-fitting, short-sleeved spandex shirts. The under layer of clothes shall be worn with the shiny/smooth side of the fabric facing out and the over-clothes with the shiny/smooth side against the underclothes (i.e. dull side facing out). The dummies feet shall be shod with size 11 (45 European or 279mm) Oxford-style, hard-soled, work shoes (e.g. MIL-S-13192P).

3.5.6.5 Instrumentation

3.5.6.5.1 The instrumentation required to perform the TNCAP evaluation is listed in Table 2. The T1 acceleration shall be the average of right and left side accelerometer measurements. All instrumentation shall be calibrated before the test programme.

3.5.6.5.2 The channel amplitude class (CAC) for each transducer shall be chosen to according to Table 2. In order to retain sensitivity, CACs which are orders of magnitude greater than the minimum amplitude shall not be used. A transducer shall be re-calibrated if it reaches its CAC during any test. All instrumentation shall be recalibrated after one year regardless of the number of tests for which it has been used. A list of instrumentation along with calibration dates shall be supplied as part of the test report.

Table 2 Required instrumentation

Position	Function	Measurement	CFC	CAC
Sled X	Pulse acceptance	Acceleration (g)	60	100
	Pulse acceptance	Velocity (m/s)	30	NA
	Rebound velocity	Displacement (m)	NA	NA
Head X	NIC	Acceleration (g)	60	100
		Acceleration (g)	1000	100
Head CoG X	Rebound velocity	Velocity (m/s)	30	NA
Neck T1 X (LH and RH)	NIC	Acceleration (g)	60	100
Neck Force X		Force (N)	1000	1400
Neck Force X	My OC and Nkm	Force (N)	600	1400
Neck Force Z		Force (N)	1000	4500
Neck Moment Y	My OC	Moment (Nm)	600	115
Head Restraint Contact Time (T-HRC)	T-HRCstart and T-HRCend	Time (ms)	NA	NA
Neck T1 X		Force (N)	1000	5000
Neck T1Z		Force (N)	1000	5000
Neck T1 Moment Y		Moment (Nm)	600	200
1st Lumbar X		Acceleration (g)	60	200
1st Lumbar Z		Acceleration (g)	60	100
Seat Belt Force (lap section)		Force (kN)	60	16

3.5.6.6 Data Acquisition and Processing

3.5.6.6.1 The measurement data shall be recorded according to ISO 6487 or SAE J211/1 at a minimum sample frequency of 10kHz Table 2 specifies the channel frequency classes for each necessary measurement.

3.5.6.6.2 Measurement data shall be considered for evaluation until the point in time at which the head rebounds from the head restraint or at 300ms after T-zero, whichever occurs first.

3.5.6.6.3 Prior to test all data channels shall be offset to zero, where zero (acceleration/force/moments) is defined by the average quiescent channel value over 100 samples at 10kHz (or equivalent) before time offset. This shall be recorded a significant duration prior to T0 such that the sled acceleration/deceleration phase is avoided.

3.5.7 Test Sled Requirements

3.5.7.1 Acceleration Sled

The dynamic test is intended to simulate a typical rear crash in which the rear-struck vehicle is initially stationary or moving forward very slowly. Consequently, an acceleration sled with the dummy seated facing the direction of motion is required for these tests. Some sled motion is allowed at the initiation of the test (T=0). To accommodate different sled types and different relationships between sled motion and the recording of test data, test time will be indexed as described in section 3.5.13.The sled shall not brake before 300ms from T=0. A deceleration sled is no longer accepted for official TNCAP testing due to its inherently larger variability.

3.5.7.2 Test Time Indexing

To normalise the time index among sled technical service protocols with different T-zero trigger levels, the time indexing procedure described in section 3.5.13 shall be used.

3.5.7.3 Technical service Environment

The temperature in the technical service shall be 22.5º ±3ºC and a relative humidity of between 10% and 70%. The BioRID test dummy and seat being tested shall be soaked at this temperature at least 3 hours prior to the test.

3.5.7.4 Acceleration Pulse

The target sled accelerations and pulse specifications are given in section 3.5.13. Sled accelerations shall be measured by an appropriate accelerometer attached to the sled platform, recorded according to SAE Recommended Practice J211 – Instrumentation for Impact Testing – Part 1 – Electronic Instrumentation. Prior to establishing conformance with the acceleration pulse specification, any quiescent signal bias shall be removed from the acceleration measurement and the data shall be filtered in accordance with Table 2.

3.5.8 Test Sled Instrumentation

3.5.8.1 Record the X-acceleration of the sled in accordance with SAE recommended practice J211. The instrumentation shall be directly attached to the sled platform and not to any other part of the test device.

3.5.8.1.1 If necessary, remove any data channel DC bias. Typically, the value of the average measurement over 100 samples of the quiescent data channel signal is subtracted from every test measurement.

3.5.8.1.2 Filter the sled acceleration to channel frequency class in accordance with Table 2.

3.5.8.2 The time of dummy head to head restraint first contact shall be recorded with a foil contact switch.

3.5.9 Whiplash Assessment Criteria

3.5.9.1 The purpose of the whiplash test is to test the seat and head restraint assembly in order to assess the extent to which they reflect best practice in preventing soft tissue neck injuries. This is based on the following performance criteria:

(1) Head Restraint Contact Time (T-HRC (start), T-HRC (end)).

(2) T1 X-acceleration (T1).

(3) Upper Neck Shear Force (Fx) and Upper Neck Tension (Fz).

(4) Head Rebound Velocity.

(5) NIC

(6) Nkm

(7) Seatback dynamic opening.

Below a more extensive description is given for the most important assessment criteria.

3.5.9.2 Head Restraint Contact Time T-HRC (start)T-HRC(end)

Head restraint contact time shall be ascertained using a contact switch method, comprised of a proprietary lightweight, self adhesive conductive foil placed over the surface of the head restraint, and the rear of the ATD skull cap.

Head Restraint Contact Time T-HRC(Start) is defined as the time (calculated from T=0) of first contact between the rear of the ATD head and the head restraint, where the subsequent continuous contact duration exceeds 40ms. For the purposes of assessment, T- HRC(Start) shall be rounded to the nearest millisecond.

Minor breaks in the contact time (up to 1ms) are permissible if it can be proven that these are due to poor electrical contacts, however these must be investigated with reference to the film to ascertain whether the breaks in contact are not due to biomechanical phenomena such as ATD ramping, head restraint or seatback collapse, or ‘bounce’ of the head during non-structural contact with the head restraint. For the subsequent criteria, the end of head restraint contact must also be found; T-HRC(end). This is defined as the time at which the head first loses contact with the head restraint, where the subsequent continuous loss of contact duration exceeds 40ms.

3.5.9.3 T1 X-Acceleration

BioRID is fitted with twin accelerometers on the first thoracic vertebra (T1), one on either side of the lower neck loadcell assembly. The data channels acquired from these accelerometers shall both be filtered to channel frequency class (CFC) 60 as defined by SAE J211. An average channel, T1(t), shall then be produced from the two filtered signals, as follows:

$$\mathrm{T1}(t) = \frac{T1_{\mathrm{left}}(t) + T1_{\mathrm{right}}(t)}{2}$$

where：

$T1_{left}(t)$= Acceleration channel measured by the left hand T1 accelerometer.

$T1_{right}(t)$= Acceleration channel measured by the right hand T1 accelerometer.

The maximum , $T1max$ shall be generated from this average T1 channel, considering only the portion of data from T-zero until T-HRC (end) as follows:

$$T1_{max} = \underset{\mathrm{T-HRC(end)}}{\mathrm{Max}}[T1(t)]$$

3.5.9.4 Upper Neck Shear Force (Fx) and Upper Neck Tension (Fz)

The upper neck loadcell of the BioRID records both shear and tensile forces. If the instrumentation is configured in accordance with SAE J211, positive shear shall be indicative of a head-rearwards motion and positive tension shall be associated with pulling the head upwards, generating a tensile force in the neck. Firstly, both the Fx and Fz channels shall be filtered at CFC 1000. Peak values, Fx_{max} and Fz_{max}, shall then be determined for each of the forces, considering only the portion of data from T-zero until $\text{T-HRC}_{(end)}$, as follows:

$$Fx_{max} = \underset{\mathrm{T-HRC(end)}}{\mathrm{Max}}[Fx(t)]$$

$$Fz_{max} = \underset{\mathrm{T-HRC(end)}}{\mathrm{Max}}[Fz(t)]$$

3.5.9.5 Head Rebound Velocity – Acceleration Sled Technique

The head rebound velocity (in the horizontal/X direction) shall be determined using target tracking. Ideally this shall be performed using footage acquired from on-board camera systems, however off-board systems can provide suitable views providing the camera positioning is correct and compensation is made for the movement of the sled. Various proprietary film analysis packages include functions to achieve this analysis consequently this method will not be covered in detail in this document. Refer to the TNCAP Film and Photo protocol for additional considerations regarding the use of high speed cameras.

3.5.9.5.1 Time for occurrence of peak rebound velocity

Theoretically, the peak rebound velocity shall occur due to the elastic energy release from the seat assembly, after the peak sled acceleration has occurred. In the case of an acceleration sled this shall also be prior to the sled braking, which at the earliest shall occur from 300ms. It shall be verified that there is sufficient time before the onset of sled braking for the particular sled being used, and that any peak rebound velocity analysis is not undertaken during the sled braking phase. The rebound velocity of the ATD is usually generated due to the release of stored elastic energy within the seat structure, suspension and foam. The time of occurrence of peak rebound velocity shall be the maximum horizontal component of head rebound velocity calculated between T=0 and 300ms.

3.5.9.5.2 Target Placement

The ATD shall be equipped with a suitable target placed on the side of the head flesh, coincident with the head centre of gravity. Additionally, three sled targets will be required. Two fixed targets of known separation shall be placed on the sled in the same XZ plane, such that a fixed reference can be obtained that will not be obscured during the test (B1 and B2 targets). In the case of an onboard view, a small compensation may be required for camera movement or shake. This can be made using the two fixed targets of known spacing on the sled, and a third target from which a sled coordinate system may be created. All target points used for analysis shall be depth scaled to compensate for any differences in the Y-coordinates.

3.5.9.5.3 Determination of Rebound Velocity

Using a suitable “target tracking” film analysis technique, generate traces as follows:

(1) Had center of Gravity target velocity (absolute technical service reference)

(2) Sled velocity (absolute technical service reference)

Both traces shall be offset adjusted then filtered at CFC30. Head rebound velocity is then defined as the difference between the sled velocity and the head velocity. Rebound velocity can be calculated as:

$$V_{Rebound} = V_{Head\ C-of-G\ (abs)} - V_{Sled\ (abs)}$$

where:

$V_{Rebound}$ ＝C-of-G (abs)= Instantaneous X-velocity of head C-of-G, absolute.

$V_{Sled\ (abs)}$ ＝Instantaneous X-velocity of sled, absolute.

$V_{Sled\ (abs)}$ ＝Instantaneous X-velocity of sled, absolute.

Generate a third trace of head centre of gravity rebound velocity, relative to the sled. The maximum value and the time at which this occurs shall be noted. It shall be verified using the end of head restraint contact time, T-HRC$_{(end)}$, that this maximum is during the rebound from the head restraint and is not generated within the sled braking phase. Shall higher peaks be generated in the sled braking phase, these shall be disregarded and the initial peak of rebound velocity which occurs at or very near to initial rebound from the head restraint shall be taken as the peak value.

3.5.9.6 NIC Calculation

The NIC is based on the relative horizontal acceleration and velocity of the occipital joint relative to T1. To calculate NIC, two data channels are needed, which are the head x-acceleration and average T1 x-acceleration.

Each channel shall first be converted from 'g' to metres per second squared (m/s^2), and the head x-acceleration shall be filtered at CFC 60. The average T1 channel (previously calculated) is the result of combining two channels, both of which were filtered at CFC 60.

Reference shall be made to section 3.5.9.3 for details of how this average channel is produced.

The "relative x-acceleration" (γ_x^{rel})between head and T1 shall be generated by subtracting the head x-acceleration (γ_x^{head})from the T1 x acceleration(γ_x^{T1}). This channel is calculated as follows:

$$\gamma_x{}^{rel} = \gamma_x{}^{T1} - \gamma_x{}^{\mathrm{head}}$$

The relative x-velocity (Vx^{rel}) between head and T1 shall be calculated, by integrating the relative acceleration channel with respect to time, as follows:

$$V_x^{rel}(t) = \int_0^t \gamma_x^{rel}(\tau)d\tau$$

The NIC channel is then calculated as a combination of relative acceleration multiplied by 0.2, and added to the square of the relative velocity. The calculation is according to the following equation:

$$NIC(t) = 0.2 * \gamma_x^{rel}(t) + [V_x^{rel}(t)]^2$$

The maximum overall NIC value (NIC_{max}) shall be determined from the trace, considering only the data portion from T0 until T-HRC (end), as follows:

$$NIC_{max} = \underset{\mathrm{T-HRC(end)}}{\mathrm{Max}} [NIC(t)]$$

This maximum value shall be noted, along with the time at which it occurs.

3.5.9.7 Nkm Calculation

The following definition is provided following the commonly accepted convention that derives the "Anterior/ Posterior" directions from the torso motion relative to the head. Consequently, torso forward motion relative to the head would be referred to as 'anterior', and providing SAE J211 compliant instrumentation is used, would produce an associated positive upper neck shear force, Fx^{upper}. ("Head rearward relative to the torso") Conversely, the movement of the torso rearward relative to the head is referred to as 'posterior' and produces the opposite sign of shear force.

The Nkm criterion is based on a combination of moment and shear forces, using critical intercept values for the load and moment. The shear force intercept value is identical for anterior or posterior values, being 845N in both directions of loading. However, the critical intercept value for the bending moment depends on the direction of loading, having a value of 47.5Nm in extension (head rotation rearwards), but a value of 88.1Nm in flexion (head rotation forwards).

Two channels will be required to perform the Nkm calculation, upper neck shear force Fx^{upper}, in Newtons (N) and moment, My^{upper} in Newton-metres (Nm).Typically the shear force will be acquired in kilo-Newtons (kN), and so in those cases, a conversion from kilo-Newtons (kN) to Newtons (N) will be required. Once it has been confirmed that both shear force and moment are in the correct units, filter

My^{upper} at CFC 600, according to SAE J211. To allow combination of the My^{upper} and Fx^{upper} channels, another Fx^{upper} channel shall be produced, filtered at CFC 600. Due to the construction of the BioRID, a correction must then be made to convert the actual moment measured by the upper neck loadcell into the moment about the Occipital Condyle (OC).

The corrected moment, My^{OC} is equal to the upper neck shear force Fx^{upper} multiplied by a constant, D, then subtracted from the measured moment, My^{upper}.

Calculate the Moment about the OC according to the following equation:

$$M_y{}^{OC}(t) = M_y{}^{upper}(t) - D \times F_x{}^{\mathrm{upper}}(t)$$

where D = 0.01778m

The four components of Nkm are then calculated using the upper neck shear force Fx^{upper} and the corrected moment about the OC, My^{OC}.

Each channel first needs to be separated into it's positive- or negative-going components by generating four new channels as follows:

(1) Generate two new channels, F_{xa} and F_{xp}, based on F^{upper} force channel.

(2) Generate two new channels, M_{yf} and M_{ye} based on the My^{OC} moment channel.

Each of the new channels shall contain only selected positive or negative-going portions of the respective F_x or M_y channels, with all unwanted data points being replaced by null or zero value, as defined by:

(1) F_{xa} channel contains only the positive portion of the $F_x{}^{upper}$ force channel as follows:

If $F_x{}^{upper}(t) > 0$, then $F_{xa}(t) = F_x{}^{upper}(t)$, else $F_{xa}(t) = 0$

(2) F_{xp} ^{channel} contains only the negative portion of the $F_x{}^{upper}$ force channel as follows:

If ^{Fxupper} (t) <0, then $F_{xp}(t) = F_x^{upper}(t)$, else $F_{xp}(t) = 0$

(3) M_{yf} channel contains only the positive portion of the M_y^{OC} moment channel as follows:

If $M_y^{OC}(t) > 0$, then $M_{yf}(t) = M_y^{OC}(t)$, else $M_{yf}(t) = 0$

(4) M_{ye} channel contains only the negative portion of the M_y^{OC} moment channel as follows:

If M_yOC (t)<0, then $M_{ye}(t) = M_y^{OC}(t)$, else $M_{ye}(t) = 0$

The four components of Nkm are then defined as:

(1) "Neck Extension Posterior" (N_{ep}) or the combined negative-going portion of the shear force channel (F_{xp}) and negative-going portions of the moment channel (M_{ye}), as defined by:

$$N_{ep}(t) = \frac{F_{xp}(t)}{F_{x-int}} + \frac{M_{ye}(t)}{M_{ye-int}}$$

where F_{x-int}= -845N, M_{ye-int} = -47.5Nm

(2) "Neck Extension Anterior" (N_{ea}) or the combined positive-going portion of the shear force channel (F_{xa}) and negative-going portions of the moment channel (M_{ye}), as defined by:

$$N_{ea}(t) = \frac{F_{xa}(t)}{F_{x-int}} + \frac{M_{ye}(t)}{M_{ye-int}}$$

Where: F_{x-int} = 845N, M_{ye-int} = -47.5Nm

(3) "Neck Flexion Posterior" (N_{fp}) or the combined negative-going portions of the shear force channel (F_{xp}) and positive-going portions of the moment channel (M_{yf}), as defined by:

$$N_{fp}(t) = \frac{F_{xp}(t)}{F_{x-int}} + \frac{M_{yf}(t)}{M_{yf-int}}$$

Where: F_{x-int} = 845N, M_{yf-int} = 88.1Nm

(4) "Neck Flexion Anterior" (N_{fa}) or the combined positive-going portions of the shear force channel (F_{xa}) and positive-going portions of the moment channel (M_{yf}), as defined by:

$$N_{fa}(t) = \frac{F_{xa}(t)}{F_{x-int}} + \frac{M_{yf}(t)}{M_{yf-int}}$$

Where: F_{x-int} = 845N, M_{ye-int} = 88.1Nm

Each of the four components shall be calculated as a new data channel, using only the positive- or negative-going portions of the F_x and M_y channels as appropriate, and the relevant critical intercept values. Maxima for each of the four components shall be calculated, considering only the portion of data from T-zero until T-HRC$_{(end)}$, as follows:

$$N_{ep_{(max)}} = \underset{\mathrm{T-HRC(end)}}{\mathrm{Max}}\left[N_{ep}(t)\right]$$

$$N_{ea_{(max)}} = \underset{\mathrm{T-HRC(end)}}{\mathrm{Max}}\left[N_{ea}(t)\right]$$

$$N_{fp_{(max)}} = \underset{\mathrm{T-HRC(end)}}{\mathrm{Max}}\left[N_{fp}(t)\right]$$

$$N_{fa_{(max)}} = \underset{\mathrm{T-HRC(end)}}{\mathrm{Max}}\left[N_{fa}(t)\right]$$

The Nkm value is taken as the maximum value reached by any one of the four components ($N_{ea'}$ $N_{ep'}$ $N_{fa'}$ $N_{fp'}$).

It shall be noted which component of the four reached the maximum value and the time at which this occurred.

3.5.9.8 Seatback dynamic deflection

Using a suitable target tracking film analysis technique, measure the seatback dynamic opening from the targets defined in the TNCAP Film and Photo protocol as follows:

(1) Define a line between the upper and lower seatback targets, ST2 and ST3.

(2) Define a second line between the forward and rearward sled base targets, B1 and B2.

(3) Calculate the angle between these two lines at the T-zero position. The instantaneous seatback deflection is defined as the instantaneous difference in angle between the T-zero position and the deflected position. Track the change in instantaneous angle between these two lines, throughout the dynamic test.

The Seatback Dynamic Opening is defined as the maximum change in angle achieved at any time during the test between the T zero position and T-HRC$_{(end)}$. Note this maximum angle, and the time at which it occurred.

For seats with two-point adjusting back, the same seatback deflection criterion will apply using targets ST2 and ST3, however it is recommended to use the two optional targets ST2’ and ST3’ (defined in the TNCAP Film and Photo protocol) such that any contribution from deflection in the two point mechanism can be understood.

3.5.10 Manufacturer’s Specified Settings

Prior to preparation of the sled and seats, the following information shall be provided by the manufacturer to allow for the test preparation.

Adjustment	
Whiplash preparation	
Seat mounting information, drawings etc.	Required information: ● Floor mounting pattern ● Seat rail angles ● Seat rail travel (especially if different on both sides) ● Fixation/support information The manufacturer shall supply suitable seat mountings to the technical service.
Heel plane height	
Seat belt anchorage positions	Where required
Anticipated seat settings Seat back angle (e.g. 3 notches from forward)	● Seat back angle reference point wrt. seat reference point or HR tube angle.
Triggering information for active systems (pre-tensioners, active HR, etc.)	● Triggering system details, all relevant information (magnetic, electronic, required current/voltage, pulse duration etc.)

3.5.11 RCAR GLORIA Jig & Calibration Procedure (HPM/HRMD Calibration)

3.5.11.1 Introduction

For the purposes of standardized seating positions for anthropomorphic test devices the SAE (Society of Automotive Engineers) designed the H-Point Machine (H-PM) that allowed a uniform definition of the human H-Point. Much of this work was completed in the late 1950’s with the machine still in constant use today. The SAE J826 procedure was also defined to allow consistent and authoritative H-points and seating reference points to be defined.

Since the height probe was insufficient to measure both height and backset a head form was designed to fit the H-Point machine, known as the Head Restraint Measuring Device (HRMD). The HRMD probes allow the measurement of both head restraint height and backset and are used to rate whiplash protection in the RCAR (Research Council for Automobile) Head Restraint Measurement procedure.

Research studies from Thatcham and Partnership for Dummy Technology and Biomechanics (PDB) have both shown the location of the H-point on different H-PMs shows little variability. However the location of the weight hangers shows some variability, and this location is not controlled by any calibration procedure. The weight hanger location variability can by transferred to the HRMD, and could affect backset measurements. This could consequently affect head restraint static geometry ratings, so a calibration procedure was developed with the aim of controlling H-PM & HRMD units.

3.5.11.2 Scope

This procedure is designed to allow the calibration of H-PM and HRMD units in isolation or together to restrict build tolerance variations of items currently poorly controlled and allow more repeatable and reproducible results.

3.5.11.3 Definitions

3.5.11.3.1 HPM/OSCAR

Machine defined to locate the H-point. H-PMs can be either the SAE J826 or 3D-H type of manikin, from the US or Europe respectively. It represents a 50th percentile adult male mass and basic morphology. It consists of a module GRP seat/ buttock pan with a metal spine to which are attached weights to represent the average human male. The unit has one central pivot around the pelvis a point which corresponds with that of the H-point. The unit has legs and articulated feet which are all adjustable to represent different percentiles. The unit has attached to the main pivot a height probe and inclinometer not used in the head restraint measurement process. Also known as OSCAR.

3.5.11.3.1.1 SAE J826 Seating Manikin

The US version of the HPM.

3.5.11.3.1.2 3D-H Seating Manikin

The European version of the HPM without the force plunger or the thigh bar and with an additional 1 kg mass.

3.5.11.3.2 HRMD

The Head Restraint Measuring Device consists of a cast magnesium or machined aluminum head representing the basic dimensions of an adult male. The head form is attached to an arm representing the neck with a joint at the T1 area to allow the head to be levelled in the X plane. The HRMD is attached to the H-PM via two machined forks that fit onto the weight hanger of the H-PM. The unit is located via a third tongue that slots into the H-PM spine box.

To facilitate measurement of head restraint geometry two probes are attached to the head form. The first fits into the centre of the head form and is profiled to that of the back of the skull. It is able to slide in and out of the head and has gradations to allow backset measurements to be taken. A similar height probe slides horizontally from the top of the head and allows the height of a head restraint to be measured. When fitting the H-PM to the HRMD it shall be noted that the H-PM must first be modified to accept the unit. The height bar must be removed and its spacing on the spine spindle be replaced by two washers. Four of the original 8 hanger weights are replaced by two larger cylindrical weights. These allow the HRMD forks to locate onto the weight hanger.

3.5.11.4 Equipment Requirements

3.5.11.4.1 HPM/HRMD Calibration Jig

The H-PM/HRMD unit is to be calibrated together as one single unit. The H-PM/HRMD unit is held in a jig, known as GLORIA, which will facilitate calibration. The jig is equipped with feet at each corner to facilitate levelling. The jig holds the seat pan by three horizontal bars of 20mm thickness that support the seat pan allowing the thigh bar to be horizontal. The back pan is supported by 900mm vertical bar with its origin at the base of the seat pan in the area of the buttock. This vertical support has a horizontal bar at the level of the weight hanger bar and is level. A cord is attached to the back pan to prevent the H-PM falling forward. Near the top of the vertical support are scribed markings to indicate the target position of the HRMD height probe. This vertical support allows the calibration of the backset probe when extended.

Figure 14 The HPM/HRMD calibration jig (GLORIA)

3.5.11.5 Setup and Assembly of GLORIA Jig

3.5.11.5.1 The calibration shall be carried out in a room with temperature at 20°(±5°) and the HRMD, H-PM and GLORIA jig shall have been soaked in that same environments for 6 hours prior to commencing with step 3.5.11.3.2.

3.5.11.5.2 The GLORIA jig shall be set on a nominally level surface and levelled by adjustment of the threaded feet. The base plate shall be levelled using an inclinometer. Surfaces to be used as reference are the lower horizontal section of the side rails and the seat pan support rods. Then the front and side surfaces of the vertical support shall be checked to ensure the column is still vertical. All four measurements shall be undertaken to ensure the unit is level. Tolerance for this levelling operation is ±0.1°.

3.5.11.5.3 Remove the H-Point locator rods from the jig left and right.

3.5.11.5.4 Remove the Vertical H-Point to weight hanger bar supports along with the weight hanger guide assembly by extracting the removable rods.

3.5.11.5.5 Loosen the 4 bushes on the seat pan front and rear horizontal support bars and slide them outboard.

3.5.11.6 Preparation of H-PM prior to Calibration

3.5.11.6.1 Ensure that the H-PM Headroom Probe has been removed and replacement spacers installed prior to this calibration in accordance with the HRMD set up procedure (see HRMD User Guide ICBC 1999). Ensure that the H-PM to be calibrated has had the top edge of the weight hanger assembly modified to accept the HRMD unit (Figure 15).

Figure 15 The modified weight hanger assembly

3.5.11.6.2 Remove the H-Point locator plugs from the seat pan left and right.

3.5.11.6.3 When re-assembling the H-PM manikin without the Head Room Probe care shall be taken to ensure that the H-Point pivot nuts are tightened to a torque of X-Y Nm. When set at this torque the manikin back pan can fall forward hence the use of the support strap.

3.5.11.7 Installation and Calibration of H-PM

3.5.11.7.1 Fold the H-PM forward to allow easier installation into the jig.

3.5.11.7.2 Install the H-PM into the jig ensuring that the rear of the seat pan is in contact and square to the rear upper horizontal bar.

3.5.11.7.3 Centre the seat pan on the horizontal support bars and slide the bushes inboard allowing them to contact the seat pan. Tighten the bushes' set screws.

3.5.11.7.4 Adjust the rear Concentric Adjustment Bar from both sides to visually align the H-point holes forward and aft on the H-PM seat pan with the corresponding holes on the side plates of the jig.

3.5.11.7.5 Adjust the lower Concentric Adjustment Bar from both sides to visually align the H-point holes up and down on the H-PM seat pan with the corresponding holes on the side plates of the jig.

3.5.11.7.6 Install the H-Point locator rods through the vertical support guides and then into the H-point guides of the jig base and then through to the H-point holes on the H-PM (Figure 16).

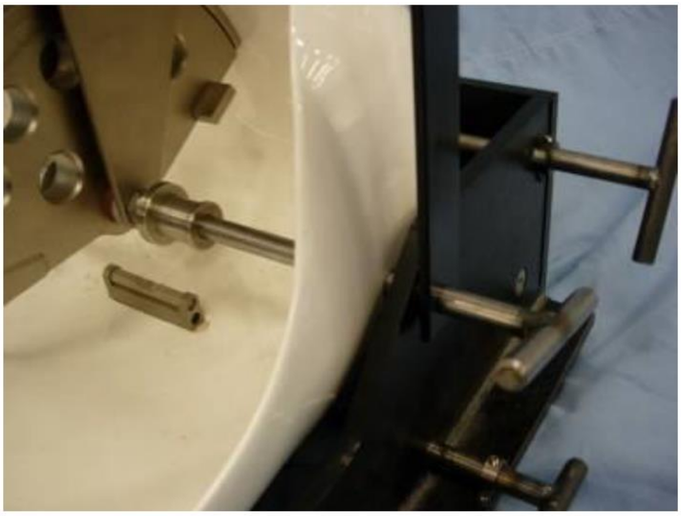


Figure 16 H-point locator bars installed through vertical support rods, jig side and HPM H-point location

3.5.11.7.7 Adjust the front Concentric Adjustment Bar from both sides to level the T-bar (±0.5°).

3.5.11.7.8 Check for horizontal play in the H-PM at the H-Point / torso pivot to check for excessive wear. Tighten or replace as necessary.

3.5.11.7.9 Raise the back pan until it rests upon the jig's vertical support bar and secure with the elastic strap to prevent the back from tipping forward (Figure 17).

Figure 17 HPM back pan held by support strap

3.5.11.7.10 Install the weight hanger alignment fixture over the weight hangers to check for alignment. The fixture shall be allowed to settle under its own weight, no force shall be applied to fit. If this fixture will not locate then it indicates that the weight hanger bars are out of alignment and will require modification and the procedure shall be terminated.

3.5.11.7.11 Remove the weight hanger alignment fixture and support strap. Tip the back pan forward and install the black cylindrical weight hanger bar guides at each out board end of the H-PM weight hanger bars between the bars and the jig arms. Replace the back pan and support strap.

3.5.11.7.12 Visually check alignment of the weight hanger bar guides with the holes in the jig arms.

3.5.11.7.13 If alignment is correct then proceed. If it is not possible due to interference between the H-PM back pan and vertical support then adjustment of the back pan to seat pan offset will be necessary which is outside the scope of this document. This procedure shall therefore be terminated here.

3.5.11.7.14 If the alignment is not possible due to the misalignment of the H-PM's weight hanger support rods then these shall be adjusted to achieve alignment.

3.5.11.7.15 Raise the weight hanger guide bars either side of the jig and insert the weight hanger locator pins through the guide bars, arms and into the black cylindrical weight hanger bar guides (Figure 18).

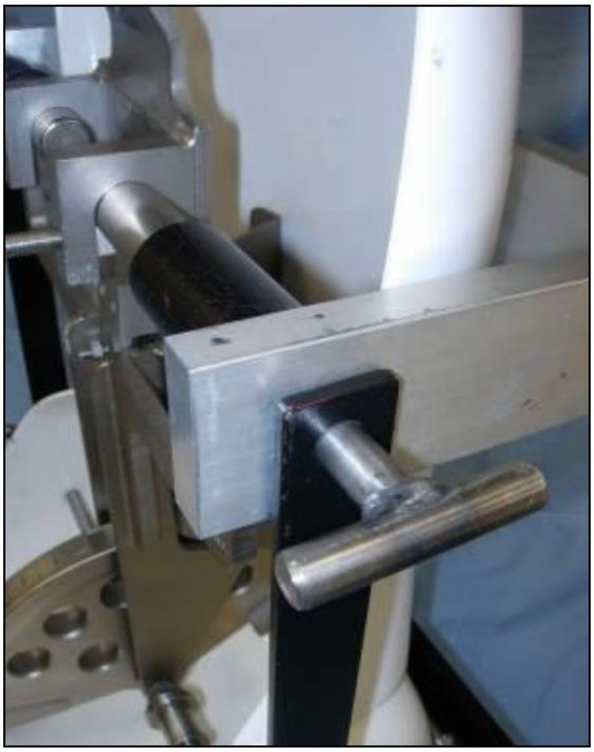


Figure 18 Weight hanger support pins inserted through weight hanger guide bars

3.5.11.8 Calibration of the H-PM Unit

3.5.11.8.1 Once installed in the jig check to ensure that the flat portion of the H-PM back pan is parallel to the vertical jig support and that the gap is no more than 4mm. It is allowed to touch (Figure19).

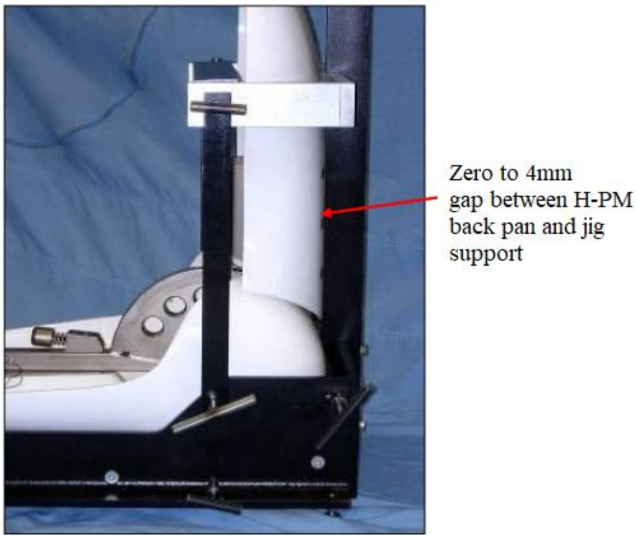


Figure 19 HPM installed into the jig without HRMD assembly. A check shall be made to ensure that the gap between the HPM back pan and jig vertical support is no more than 4mm

3.5.11.9 Installation of HRMD

3.5.11.9.1 Install the HRMD unit with the backset and height probes pre-installed onto the H-PM assembly as per HRMD User Manual ICBC 1999

3.5.11.9.2 Ensure that the plungers fitted to the centre locator fork on the HRMD are in good condition and that they are tight enough to allow the fork to contact the rear surface of the H-PM weight hanger support.

3.5.11.9.3 Level the HRMD head using the adjuster knob and the integral spirit level. Confirm that the spirit level is accurate by checking that the rear surface of the head is vertical (± 0.3°) with a calibrated digital inclinometer. If not than adjust the head using the adjuster knob and digital inclinometer until vertical. The integral spirit level shall then be adjusted or replaced as appropriate.

3.5.11.9.4 Check the trueness of the head bubble level. Place a digital inclinometer on the rear surface of the head and adjust the bubble to level using the screw. The bubble must not then be altered during the remaining calibration procedure or during use.

Figure 20 HPM in calibration jig with H-point to arm supports

3.5.11.10 Calibration of the HPM/HRMD Unit

Once the H-PM/HRMD assembly is installed into the jig the following measures (with tolerances) shall be taken:

3.5.11.10.1 Adjust the HRMD height probe until it is in contact with the forward surface of the jig vertical support. If the lower surface of the height probe contacts the scale at 0mm (±1mm) it is deemed to be within calibration. If this is not possible then the entire HRMD unit shall be checked by the manufacturer (ICBC).

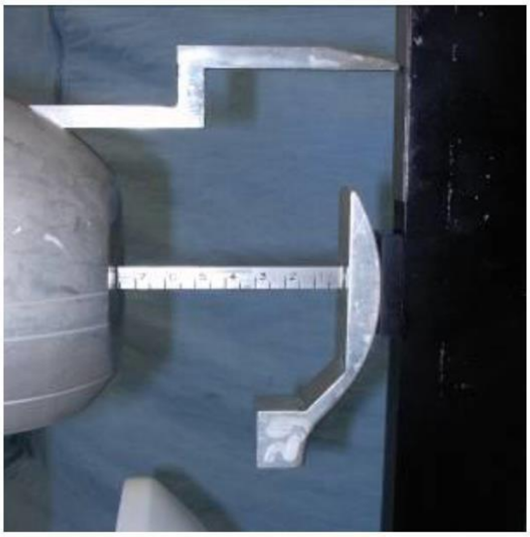


Figure 21 HRMD with backset and height calibration

3.5.11.10.2 Adjust the HRMD backset probe to contact the forward surface of the jig vertical support. The indicated backset shall read 8cm (±1mm). If this is not possible then the entire HRMD unit shall be returned to the manufacturer.

3.5.11.11 Attachment of torso angle measuring surface

3.5.11.11.1 Measure the trunk of the left hand weight hanger with a digital inclinometer (Figure 22).

Figure 22 Measurement being taken of the torso angle at the weight hanger trunk by a digital inclinometer

3.5.11.11.2 A calibrated Angle Measuring surface block shall then be attached to ensure the left hand weight hanger trunk to ensure that an angle of 90° (± 0.3° is indicated), Figure 23.

Figure 23 Calibrated torso angle measurement surface block attached to trunk of weight hanger arm

3.5.11.11.3 If the angle of the left hand weight hanger is not at 90° (±0.3) then a calibrated and adjusted surface block shall be installed in place of the standard item.

3.5.11.11.4 Check the angle of the installed calibrated surface block with a digital inclinometer to ensure that it shows a reading of 90° (±0.3°).

3.5.11.12 Marking of HPM/HRMD Units

3.5.11.12.1 An indelible metallic self adhesive label shall be attached to the H-PM on LH back pan spine to back pan bracket.

3.5.11.12.2 An identical label shall be attached to the HRMD above the build plate.

3.5.11.12.3 These labels shall have the following information:

(1) Calibration Date

(2) Calibration Centre

(3) Serial numbers of the two units

The label shall also contain the following text: “Calibrated to H-PM/HRMD standard”

Figure 24 The label on the HPM

Figure 25 The label on the HRMD

3.5.11.13 Checking the H-Point Torque

3.5.11.13.1 After the two machines are calibrated together, set the torque on the H-point weight hanger pivot to 3.4 Nm (30 in-lbs). This can be done with a torque wrench.

3.5.12 Preliminary Adjustments to the HRMD and H-Point Machine

3.5.12.1 Remove the head room probe from the H-point machine and install the two washers (supplied with the HRMD) in the spaces remaining on the H-point pivot.

3.5.12.2 To accommodate the manufacturing variances in the SAE H-point machines, the fit of the HRMD on the individual H-point machine shall be confirmed as follows.

3.5.12.2.1 Place the H-point machine seat-back and pan in a “sitting position”. Lower the HRMD in position onto the torso weight hangers and onto the top edge of the channel between the torso weight hangers. Before handling the HRMD confirm the knob below the back of the headform is finger tight.

3.5.12.2.2 To ensure the HRMD fits easily over the channel between the torso weight hangers and to prevent damage to the spring plungers, the channel must be chamfered in accordance with RONA Kinetics and Associates Ltd. Drawing No. 10045, see below.

3.5.12.2.3 If there is fore-aft movement of the headform assembly (with the rear knob on the HRMD finger tight), adjust the spring plungers in the HRMD retainer plate until there is no further movement.

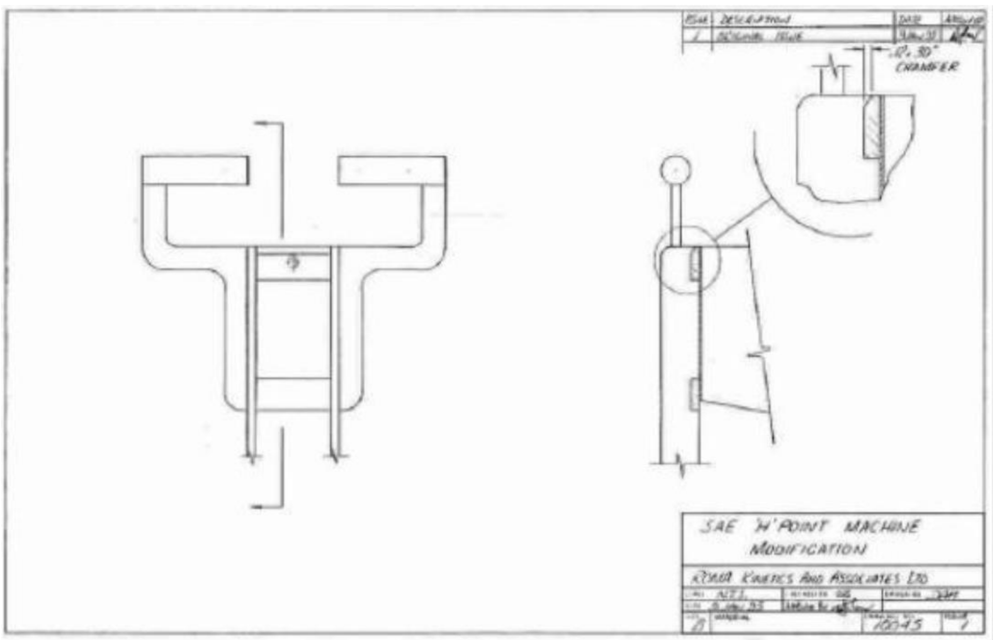


Figure 26 RONA Kinetics and Associates Ltd. Drawing No. 10045 H-point machine modification requirement

3.5.13 Sled pulse specification

3.5.13.1 Definitions

3.5.13.1.1 Offset adjust the accelerometer

In order to make sure that there is no initial acceleration, which result in a non-zero velocity profile, it is required to offset adjust the acceleration signal. It is assumed that this step is a standard procedure for the participating technical service and shall therefore not be discussed into further detail.

3.5.13.1.2 Filter with CFC60

To ensure that low level noise does not influence the results the acceleration signal is filtered with a CFC 60 filter (‘endpoints’-method in Diadem). The CFC 60 filter is used according to SAE J211, for sled acceleration signals.

3.5.13.1.3 Definition of T_0

T_0 is defined as the time before the CFC60 filtered sled acceleration reaches 1.0g. The relevant times for the low, medium and high pulses are 4.6ms, 5.8ms and 3.7ms respectively.

3.5.13.1.4 Definition of T_1

T_1 is defined as the time when the sled acceleration for the first time is > 1g. Both the initial onset of the pulse and specific low acceleration disturbances (< 0.5g) heavily influence the behaviour at the start of the pulse. For that reason, it is in practice not possible to identify the actual start of the pulse. Acceleration levels higher than 1g however are unmistakably a direct result of the pulse on the sled. As such, the moment in time when the sled acceleration crosses 1g can be uniquely and easily be found.

3.5.13.1.5 Definition of TEND

TEND is defined as the time when the sled acceleration for the first time is < 0g

3.5.13.1.6 Definition of dT

dT is defined as the time span between TEND and T_0

$$dT = TEND - T_0$$

3.5.13.1.7 Definition of dV

dV is defined as the difference between the maximum and minimum sled velocity between T_0 and TEND.

3.5.13.2 Low Severity Sled Pulse Requirements

The sled acceleration must be within the corridors for the complete time interval from 0ms to 150ms as illustrated in Figure 27. The corridor data points are detailed in Table 3 along with additional requirements for the low severity sled pulse.

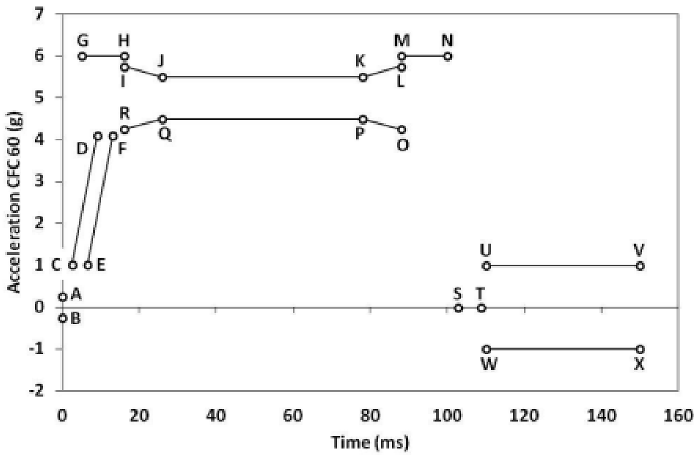


Figure 27 Low severity pulse corridors

Table 3 Low severity pulse requirements

Parameter		Requirement		Limits +/-	Unit
Velocity change dV		16.10		0.80	km/h
Mean acceleration Amean		42.35		4.5	m/s^2
Maximum acceleration Amax		5.00		0.5	g
	Time (ms)	Acceleration (g)		Time (ms)	Acceleration (g)
A	0	0.25	M	88	6.00
B	0	-0.25	N	100	6.00
C	2.6	1.0222	O	88	4.25
D	9.1	4.0982	P	78	4.50
E	6.6	1.0222	Q	26	4.50
F	13.1	4.0982	R	16	4.25
G	5	6.00	S	102.8	0.00
H	16	6.00	T	108.8	0.00
I	16	5.75	U	110	1.00
J	26	5.50	V	150	1.00
K	78	5.50	W	110	-1.00
L	88	5.75	X	150	-1.00

The target rise of the low severity pulse has been calculated using the following formula:

$$\frac{A_{max}}{2}\left\{1-\cos\left(\frac{(t)\pi}{15.4}\right)\right\}$$

To establish the rise corridor C, D E & F, the portion of the target pulse from 4.6ms to 11.1ms is time shifted by -2.0ms for points C & D and +2.0ms for points E & F. This corridor shall be calculated between time (t) = 4.6ms to 11.1ms.

3.5.13.3 Medium Severity Sled Pulse Requirements

The sled acceleration must be within the corridors for the complete time interval from 0ms to 150ms as illustrated in Figure 28. The corridor data points are detailed in Table 4. The data points for the rise corridor, C, D E & F, are described in Table 5.

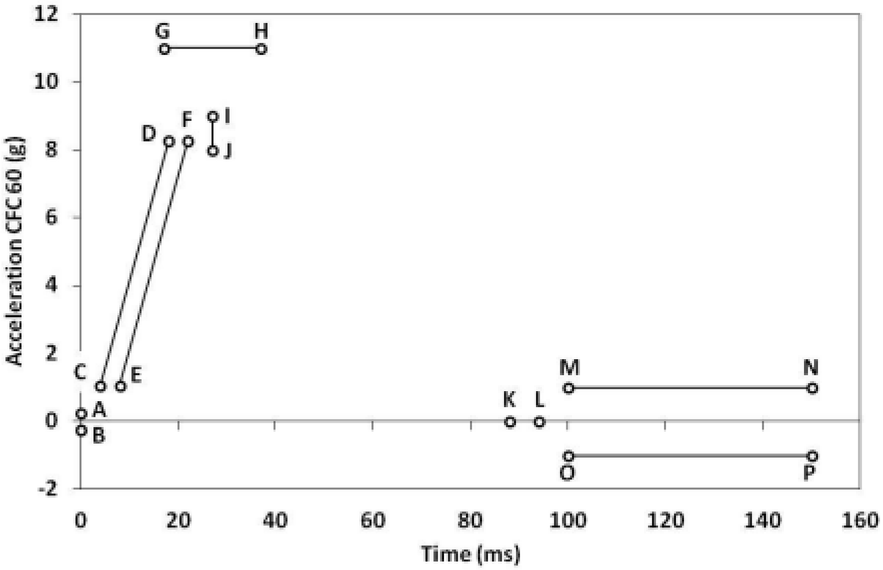


Figure 28 Medium severity pulse corridors

Table 4 Medium pulse requirements

Parameter		Requirement	Limits +/-		Unit
Velocity change dV		15.65	0.80		km/h
Mean acceleration Amean		47.85	4.00		m/s^2
	Time (ms)	Acceleration (g)		Time (ms)	Acceleration (g)
A	0	0.25	I	27	8.00
B	0	-0.25	J	27	9.00
C	4	1.0531	K	88	0.00
D	18	8.2705	L	94	0.00
E	8	1.0531	M	100	1.00
F	22	8.2705	N	150	1.00
G	17	11.00	O	100	-1.00
H	37	11.00	P	150	-1.00

Table 5 Medium pulse rise corridor

Time (ms)	Acceleration (g)	Time (ms)	Acceleration (g)
(C) 4	1.0531	(E) 8	1.0531
5	1.3751	9	1.3751
6	1.7443	10	1.7443
7	2.1608	11	2.1608
8	2.6230	12	2.6230
9	3.1276	13	3.1276
10	3.6691	14	3.6691

11	4.2406	15	4.2406
12	4.8336	16	4.8336
13	5.4384	17	5.4384
14	6.0446	18	6.0446
15	6.6414	19	6.6414
16	7.2181	20	7.2181
17	7.7645	21	7.7645
(D) 18	8.2705	(F) 22	8.2705

3.5.13.4 High Severity Sled Pulse Requirements

The sled acceleration must be within the corridors for the complete time interval from 0ms to 150ms as illustrated in Figure 29. The corridor data points are detailed in Table 6 along with additional requirements for the high severity sled pulse.

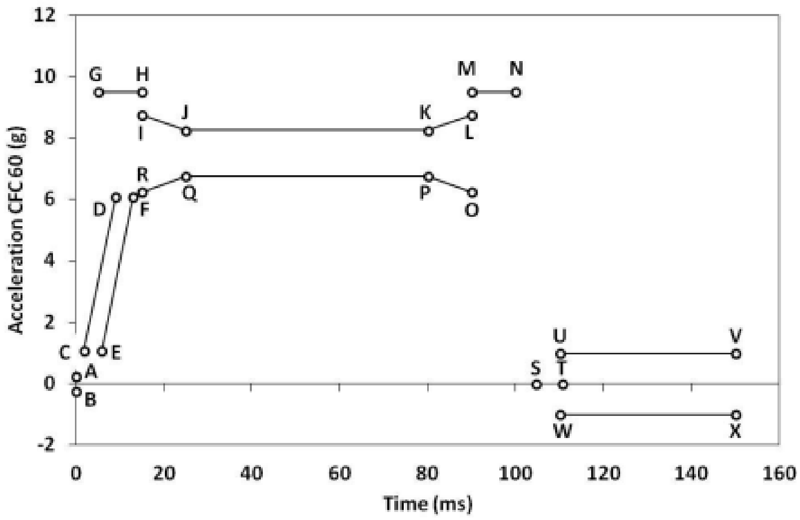


Figure 29 High severity pulse corridors

Table 6 High pulse requirements

Parameter		Requirement		Limits +/-	Unit
Velocity change dV		24.45		1.2	km/h
Mean acceleration Amean		63.15		4.85	m/s^2
Maximum acceleration Amax		7.50		0.75	g
	Time (ms)	Acceleration (g)		Time (ms)	Acceleration (g)
A	0	0.25	M	90	9.50
B	0	-0.25	N	100	9.50
C	1.8	1.0714	O	90	6.25
D	9	6.0880	P	80	6.75

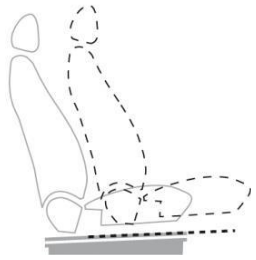
E	5.8	1.0714	Q	25	6.75
F	13	6.0880	R	15	6.25
G	5	9.50	S	104.7	0.00
H	15	9.50	T	110.7	0.00
I	15	8.75	U	110	1.00
J	25	8.25	V	150	1.00
K	80	8.25	W	110	-1.00
L	90	8.75	X	150	-1.00

The target rise of the low severity pulse has been calculated using the following formula:

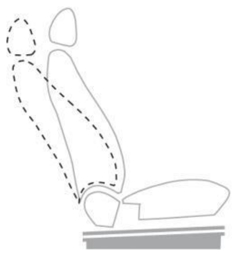
$$\frac{A_{\max}}{2}\left\{1-\cos\left(\frac{(t)\pi}{15.4}\right)\right\}$$

To establish the rise corridor C, D E & F, the portion of the target pulse from 3.8ms to 11.0ms is time shifted by -2.0ms for points C & D and +2.0ms for points E & F. This corridor shall be calculated between time (t) = 3.7ms to 11.0ms.

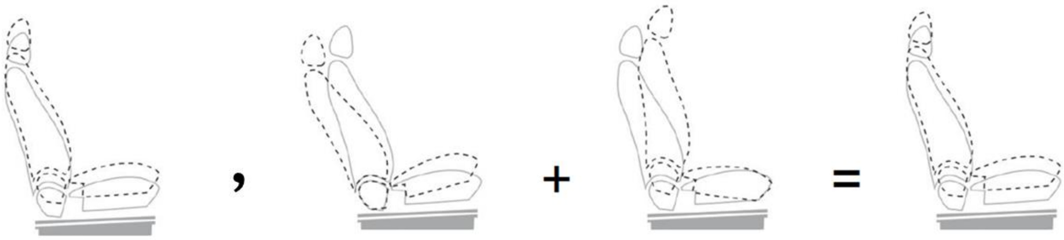
3.5.14 Seat Movement Definitions



Seat Track: An adjustment that moves the entire seat (seat cushion and seat back) in the fore and aft directions.



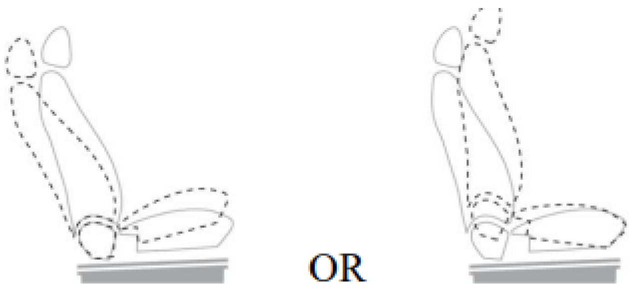
Seatback: An adjustment that rotates the entire seat back, independently of the seat cushion, about a pivot at the seat back/seat cushion joint, therefore, changing the angle of the seat back relative to the seat cushion.



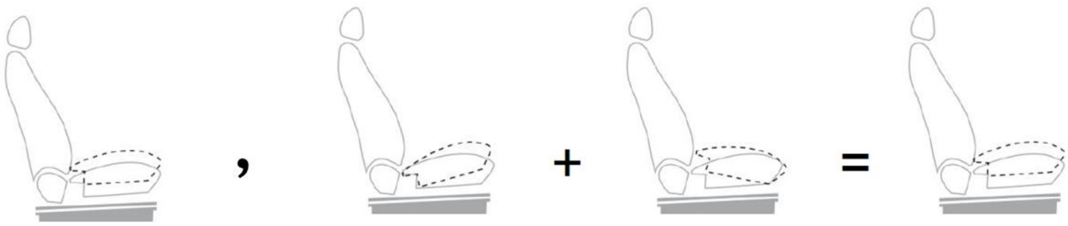
2-way (one control) 4-way (toggle or multiple knobs)

Seat Height: An adjustment that moves the entire seat vertically (seat cushion and seat back in unison). This adjustment must keep the angle of the seat cushion similar relative to the ground. This can be one control (2-way) that moves the whole seat in unison or a combination of controls (4-way – a toggle or multiple knobs) that, when used together, keep the angle of the seat cushion the similar relative to the ground.

NOTE: It is not possible to have 4-way seat height and seat tilt.



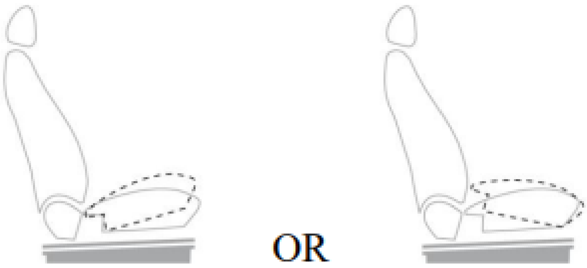
Seat Tilt: An adjustment that rotates the entire seat (seat cushion and seat back in unison). This adjustment rotates a seat in such a way to significantly change the angle of the seat cushion, relative to ground, from its full-down position. This adjustment can move either the front or rear of the seat in order to change the angle.



2-way (one control) 4-way (toggle or multiple knobs)

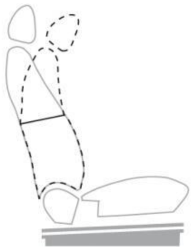
Seat Cushion Height: An adjustment that moves the seat cushion vertically, independent of the seat back, while keeping angle of the seat cushion similar relative to the ground. This can be one control (2-way) that moves the whole seat cushion in unison or a combination of controls (4-way – a toggle or multiple knobs) that, when used together, keep the angle of the seat cushion similar relative to the ground.

NOTE: It is not possible to have 4-way seat cushion height and seat cushion tilt.

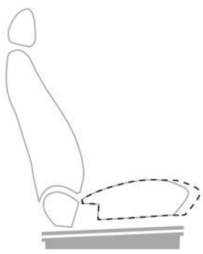


Seat Cushion Tilt: An adjustment that moves the seat cushion, independent of the seat back, in such a way to significantly change the angle of the seat cushion, relative to ground, from its full-down position. This adjustment can move either the front or rear of the seat cushion in order to change the angle.

Lumbar Support: An adjustment that causes the lower centre portion of the seat back to protrude in order to provide support to the lumbar section of an occupant’s spine.

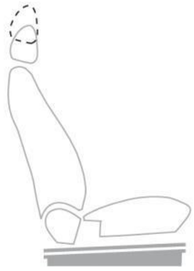


Upper Seat Back: An adjustment that rotates only the upper portion of the seat back about a pivot point in the seat back. This adjustment will change the angle of the upper seat back relative to the lower portion of the seat back.

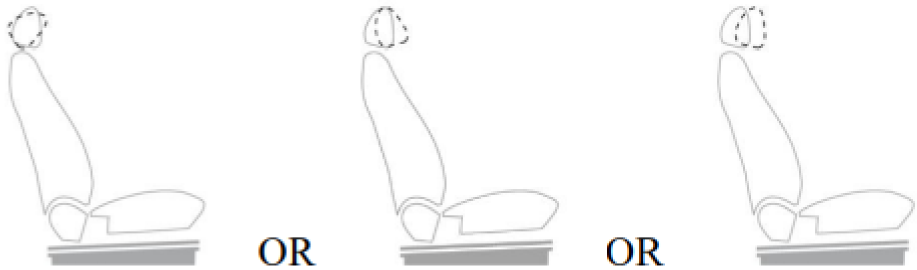


Cushion Extension: An adjustment that moves or extends a portion of the seat cushion forward so that the overall length of the cushion can be increased.

Side Bolsters: An adjustment the moves the sides of the seat back or seat cushion so that the contour of the seat can be changed.



Head Restraint Height: An adjustment that moves the head restraint vertically.



Head Restraint Tilt: An adjustment that moves the head restraint horizontally.

Ministry of Transportation and Communications

Taiwan New Car Assessment Program (TNCAP)

3.6 Rear Whiplash Testing Protocol

V2.0
May 2024

TABLE OF CONTENTS

3.6.1 Definitions..3

3.6.2 Vehicle Setup 3

3.6.3 Test Procedure..5

3.6.4 Head Restraint Position Definitions..13

3.6.5 Discomfort Metric Measuring Device 16

3.6.1 Definitions

3.6.1.1 A-Surface: surface of a head restraint that is nearest to the occupant.

3.6.1.2 Discomfort Metric: A geometrical requirement in terms of size and location for shingled non-use position head restraint designs.

3.6.1.3 Non-use Position: A head restraint position at which the height does not comply with the minimum head restraint height requirements of the Vehicle Safety Testing Directions “50-2, Head Restraint” or UN-ECE Regulation 17-08.

3.6.1.4 Use Position: A head restraint position at which the height complies with the minimum head restraint height requirements of the Vehicle Safety Testing Directions “50-2, Head Restraint” or UN-ECE Regulation 17-08.

3.6.1.5 Highest Use Position: the highest locking use position. If a restraint has non-locking positions above the highest locking position, then the highest locking position is still considered as the highest position.

3.6.1.6 Lowest Use Position: the lowest locking or stowed use position i.e. the lowest locking or stowed position in which the head restraint still meets the minimum height requirements of the Vehicle Safety Testing Directions “50-2, Head Restraint” or UN-ECE Regulation 17-08.

3.6.1.7 Mid Use Position: the locking position at the geometric mid between the highest use position and the lowest use position, or the notch position closest to the geometric mid as determined by the method in 3.6.4.

3.6.1.8 Shingled Head Restraint: a non-use position design where the rear surface of the head restraint overlaps the seatback when the head restraint is adjusted to the non-use position.

3.6.1.9 C/LO: the centreline of a seating position, extending onto the top surface of the head restraint where applicable.

3.6.1.10 HLE: the distance from the R-point to the lower edge of the head restraint measured along the torso line.

3.6.1.11 S: is the maximum thickness of the head restraint (as determined within 25 mm of the head restraint lower edge) measured perpendicular to the torso line between TH and TS from line P.

3.6.1.12 P: is a line parallel to the torso line which intersects the head restraint at TS.

3.6.1.13 TH: is the line perpendicular to the torso line and tangent to the lower edge of the head restraint.

3.6.1.14 TS is the line parallel to and 25 mm from TH.

3.6.2 Vehicle Setup

Before assessment, the manufacturer will be asked to provide ride heights for the vehicle in the unladen kerb state. Ensure that the differences between ride-heights are the same as those provided by the manufacturer. The absolute values of ride-heights do not matter.

Make sure the vehicle is stable by supporting the vehicle on the jacking points as shown in the vehicle hand book.

This protocol also extends to the first-row outboard seats only of heavy vehicles (as defined in section 1.4). In such cases, all intermediate seating positions of M1 category vehicles must be equipped with head restraints in order to earn points.

3.6.2.1 Vehicle Preparation

3.6.2.1.1 If the vehicle is equipped with a foldable roof, sunroof, sunroof blind, position to the closed position. Retract any rear glazing blinds.

3.6.2.1.2 Do not remove floor mats when fitted as standard.

3.6.2.1.3 Set all first row seats fully forward and into the highest position.

3.6.2.2 Second and Third Row Seating Setup

3.6.2.2.1 The manufacturer will be asked to provide seat adjustment information before the assessment is done (this information does not need to be in the vehicle handbook). Set all seat adjustments to the positions specified by the manufacturer.

3.6.2.2.2 Where the manufacturer has not provided seat adjustment specifications, or for particular adjustments where no specifications have been provided, set the seat using all or some of steps 3.6.2.2.2.1 through 3.6.2.2.2.14 (see also section 3.6.4 for details of how to set head restraint positions).

3.6.2.2.2.1 Seat Track – Set to the most rearward position intended for occupant use.

3.6.2.2.2.2 Seat Height – Set to the lowest position.

3.6.2.2.2.3 Seatback – Set to a position to give a nominal HPM torso angle of 25°. 20° in the case of vehicles categorized as 'Heavy Vehicle' (see section 1.4) protocol.

3.6.2.2.2.4 Seat Tilt – Set to a mid position.

3.6.2.2.2.5 Seat Cushion Height – Set to the lowest position.

3.6.2.2.2.6 Seat Cushion Tilt – Set to mid position.

3.6.2.2.2.7 Lumbar Support – Set to the retracted and lowest position.

3.6.2.2.2.8 Upper seat back – Set to the most rearward position.

3.6.2.2.2.9 Cushion Extension – Set to the retracted position.

3.6.2.2.2.10 Side Bolsters – Set to the retracted position on the seat base and seat back.

3.6.2.2.2.11 Head Restraint Vertical Position – Set to the lowest locking use position.

3.6.2.2.2.12 Head Restraint Horizontal Position – Set to mid position.

3.6.2.2.2.13 Head Restraint Tilt Position – Set to the mid position.

3.6.2.2.2.14 For third row assessment, set all second row seats into their fully forward and highest position if possible.

3.6.3 Test Procedure

If the seat to be assessed has never been sat upon, a person of mass 75±10kg shall sit on the seat two times for one minute to flex the seat cushion and seat back.

3.6.3.1 Determination of Seat Centerline C/LO

3.6.3.1.1 Refer to manufacturer specifications for the C/LO.

3.6.3.1.2 If manufacturer specifications are not available, find C/LO as follows:

3.6.3.1.2.1 For seats with defined bolsters, or individual auxiliary seats, C/LO is the centreline of the seat.

3.6.3.1.2.2 For bench seats (or other) seats, C/LO is the middle of the head restraint. If a head restraint is not fitted, find C/LO between the belt anchors.

3.6.3.1.2.3 If the C/LO cannot be found with the procedures 3.6.3.1.2.1 through 3.6.3.1.2.2 the C/LO is located 381mm outboard from the vehicle centreline.

3.6.3.2 H-Point Machine Installation

3.6.3.2.1 Place a piece of muslin cloth on the seat. Tuck the edge of the cloth into the seat pan/back join, but allow plenty of slack.

3.6.3.2.2 Place the seat and back assembly of the H-point machine on the seat at the centre line of the seat.

3.6.3.2.3 Apply thigh weights.

3.6.3.2.4 If it is possible to install the T bar and lower legs assemblies without interference with parts of the vehicle interior, this shall be done as described in the following subsections. However, if installation of the lower leg assemblies and/or the T bar causes interference with parts of the vehicle interior in a way that is likely to influence the position of the H point, do not install the legs and/or T bar. In this situation, every effort shall be made to ensure that the HPM does not slide forward on the seat base.

3.6.3.2.4.1 Attach the shoe and lower leg assemblies to the cushion pan assembly, individually at the knee joint or by using the T-bar lateral segment and lower leg assembly. Use 50th percentile lower leg segments and 50th percentile thigh segments.

3.6.3.2.4.2 The T-bar lateral segment shall be parallel to the Y-axis of the vehicle and perpendicular to the XZ-plane of the vehicle unless specified differently by the manufacturer.

3.6.3.2.4.3 Position both shoes together, or up to 127mm to either side of C/LO to clear obstructions.

3.6.3.2.4.4 With both shoes touching the floor, extend both shoes forward of the HPM while keeping the T-Bar laterally leveled.

3.6.3.2.4.5 Apply lower leg weights.

3.6.3.2.5 Tilt the back pan forwards to the end stop and draw the machine away from the seatback.

3.6.3.2.6 Allow the machine to slide back until it is stopped by contacting the seat back.

3.6.3.2.7 Apply a 100 ± 10N load twice to the back and pan assembly positioned at the intersection of the hip angle intersection to a point just above the thigh bar housing.

3.6.3.2.8 Return the machine back to the seat back.

3.6.3.2.9 Install the right and left buttock weights.

3.6.3.2.10 Apply the torso weights alternately left and right.

3.6.3.2.11 Tilting the back pan forward to a vertical position, the assembly shall be rocked from side to side over a 10° arc, 5° in each direction. Where seat side bolsters prevent movement of up to 5°, the assembly shall be rocked as far as permissible. This rocking shall be repeated twice, making a total of three complete cycles. Care shall be taken to maintain support of the T-bar during the rocking action, and to ensure that no inadvertent exterior loads are applied. Ensure that the movements of the HPM feet not restricted during this step. If the feet change position, they shall be allowed to remain in that attitude for the time being. Return the machine back to the seat back.

3.6.3.2.12 Check the lateral spirit level and if necessary apply a lateral force to the top of the machine back, sufficient to level the seat pan of the machine.

3.6.3.2.13 If applicable, position the shoes as described in 3.6.3.2.4.3 through 3.6.3.2.4.4

3.6.3.2.14 Apply a rearward force not more than 25N at the top of the torso angle bar.

3.6.3.2.15 Release the applied force and apply again until the hip angle readout shows identical values.

3.6.3.2.16 Measure and record in the test details the position of the H-point relative to some easily identifiable part of the vehicle structure.

3.6.3.2.17 Measure and record in the test details the angle of the seat assembly of the H-point machine and the position of the seat cushion front end.

3.6.3.3 HPM Measurement

All CMM measurements are relative to the manufacturer specified car alignment coordinate system or a suitable Cartesian coordinate system if not specified. Record all measurements to 0.1mm precision. For the purposes of this protocol the X-Axis is positive rearward and the Z-Axis is positive upward.

3.6.3.3.1 With a CMM or other means measure and record the X, Y and Z-coordinates for the left and right H-points.

3.6.3.3.2 Compare the left hand and right hand X and Z-coordinates. If the related X and Z coordinates are not within 5.0mm of each other repeat the H-point machine installation.

3.6.3.3.3 Measure and record the torso angle in the vehicle XZ-plane on the calibrated block attached to the weight hanger bar to 0.1 degree precision.

3.6.3.3.4 Repeat the H-point machine installation two more times.

3.6.3.3.5 Calculate the average for the three HPM installations measurements (HPM H-point coordinates and torso angle). Record these values.

3.6.3.3.6 If the average values recorded in 3.6.3.3.5 are within the following tolerances of the manufacturer specified values:

Torso angle:±3°

HPM X and Z:±25mm

then the manufacturer-defined values shall be used in all subsequent calculations. Otherwise, the recorded average values shall be used.

3.6.3.4 Head Restraint Measurement

3.6.3.4.1 Contact point and backset

The distance between the head restraint and the back of the 50thpercentile male head (backset) is determined at two head restraint positions: mid position and worst case (lowest and most rearward). The backset in the mid position is subsequently used in 3.6.3.4.2.1 as part of the determination of the intersection point (IP).

3.6.3.4.1.1 Mark a line showing the C/LO ±5mm along the A-Surface of the head restraint.

3.6.3.4.1.2 Using the values of torso angle and H point determined in section 3.6.3.3, calculate the Contact Point Z-coordinate, CP Z, which represents the height of the rearmost point of the head of a 50th percentile male.

$$CP\ Z = 504.5\cos(\text{Torso angle} - 2.6) + 203 + HPM\ Z$$

3.6.3.4.1.3 Set the head restraint to the mid position (see definitions and 3.6.4). For head restraints with locking tilt positions, it will be necessary to mark and measure CP with the restraint in the most forward and most rearward positions in order to find its location and coordinates with the head restraint in the mid-tilt position (see also 3.6.4)

3.6.3.4.1.4 Use a CMM or other means to mark the CP Z-coordinate (±2.5mm) on the C/LO line. This point is known as the Contact Point, CP.

3.6.3.4.1.4.1 If the CP Z-coordinate cannot be marked on the A-Surface of the head restraint (because the head restraint is below the CP Z-coordinate), record the CP Z-coordinate as the highest point on the C/LO line. If more than one point is at the highest point record the most forward point.

3.6.3.4.1.4.2 If the CP Z-coordinate cannot be marked on the A-Surface of the head restraint as the CP Z-coordinate relates to a gap in the head restraint, CP will be determined using a 165mm diameter sphere with its centre at the same height as the CP Z-coordinate. When the sphere is making first contact with the head restraint, CP is designated as the rearmost point of the sphere in the gap area (see Figure 1).

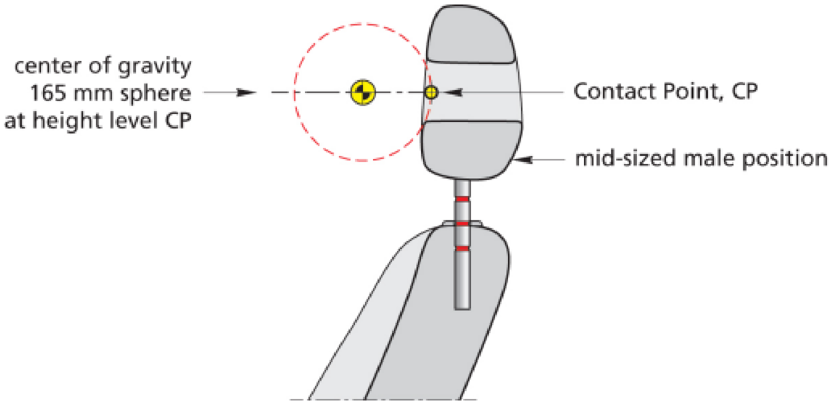


Figure 1 Definition of CP in the presence of a gap in the head restraint

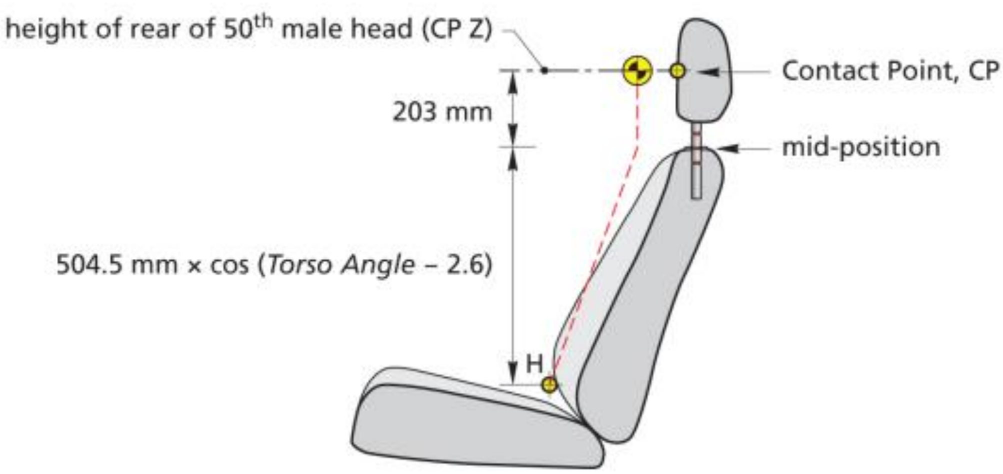


Figure 2 Contact point

3.6.3.4.1.5 Record the X-coordinate of the contact point. Record this as (CP X).

3.6.3.4.1.6 Calculate the CP X-coordinate relative to the HPM X-coordinate, $(\Delta \mathrm{CP\ X})_{mid}$.

$$(\Delta \mathrm{CP\ X})_{mid} = CPX_{mid} - HPM\ X$$

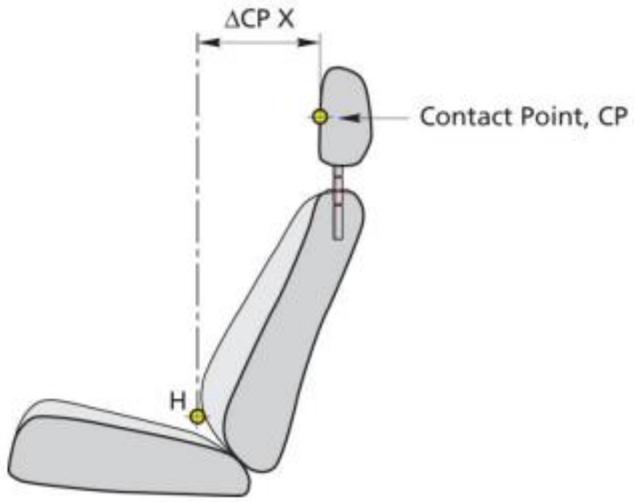


Figure 3 Calculation of backset

3.6.3.4.1.7 Set the head restraint to the lowest Use and most rearward position (see definitions and 3.6.4).

3.6.3.4.1.8 Repeat steps from sections 3.6.3.4.1.4 to 3.6.3.4.1.6 to calculate $(\Delta \mathrm{CP\ X})_{wc}$

$$(\Delta \mathrm{CP\ X})_{wc} = CPX_{wc} - HPM\ X$$

3.6.3.4.2 Intersection Point (IP)

In this step, the 'Intersection Point' is established. To do this, the position of the contact point CP is extended rearward by a distance corresponding to the difference between the rearmost point of a 50th percentile male and a 95th percentile male. The point on the restraint corresponding to this X coordinate is marked as IP on the head restraint, when the restraint is in its highest position.

3.6.3.4.2.1 Calculate the Intersection Point X-coordinate, IP X, which represents the additional distance in X between the back of the head of a 50th percentile male and a 95th percentile male.

$\mathrm{IP\ X} = 88.5 \cdot \sin(\textit{Torso angle}_{(3.6.3.3.5)} - 2.6) + 5 + \mathrm{CPX}_{(3.6.3.4.1.5)}$

This formula derives from the subtraction of two goniometric formulae which, respectively, give the X position of the back of the head of a large male and that of a mid-sized male:

$(593 \cdot \sin(\textit{Torso angle} - 2.6) + 76) - (504.5 \cdot \sin(\textit{Torso angle} - 2.6) + 71)$

$= 88.5 \cdot \sin(\textit{Torso angle} - 2.6) + 5$

3.6.3.4.2.2 Place the head restraint in the Highest Use and mid-tilt position (see definitions and 3.6.4).

3.6.3.4.2.3 On the surface given by the C/LO line, find the highest point and record the related X-coordinate.

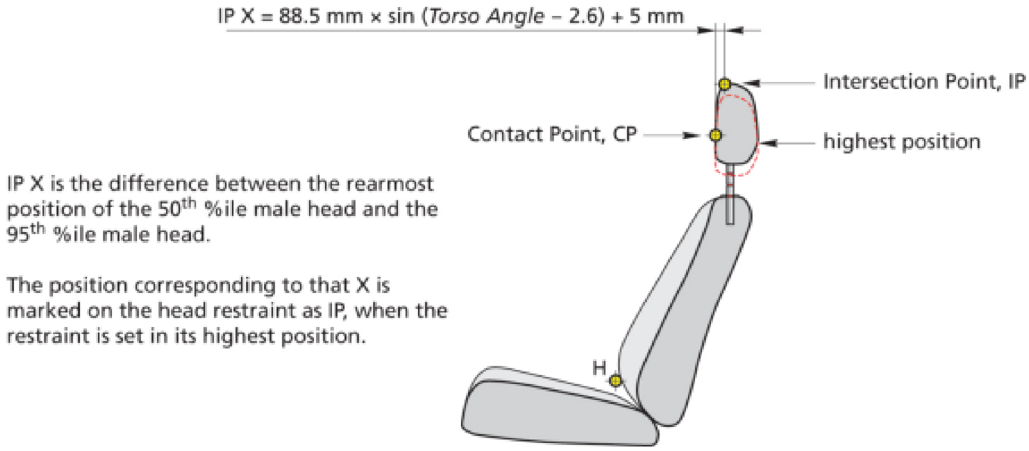


Figure 4 Intersection Point

3.6.3.4.2.4 Use a CMM or other means to mark the IP X-coordinate in 3.6.3.4.2.1 (±2.5mm) on the C/LO line. If the IP X-coordinate is rearward of the X-coordinate value in 3.6.3.4.2.3, record the X-coordinate in 3.6.3.4.2.3 as IP X.

3.6.3.4.2.5 On the surface given by the C/LO line and the IP X point, record the Z-coordinate of the IP X mark (3.6.3.4.2.4). Record this point as Intersection Point Z (IP Z).

3.6.3.4.2.6 Calculate the IP X-coordinate relative to the HPM X-coordinate, $(\Delta \text{IP X})_{\text{high}}$.

$$(\Delta \text{IP X})_{high} = IP\ X - HPM\ X$$

3.6.3.4.2.7 Calculate the IP Z-coordinate relative to the HPM Z-coordinate, $(\Delta \text{IP Z})_{\text{high}}$.

$$(\Delta \text{IP Z})_{high} = IP\ Z - HPM\ Z$$

3.6.3.4.2.8 Place the head restraint in the Lowest Use and most rearward position (see definitions and 3.6.4).

3.6.3.4.2.9 Using the same method as above, calculate ΔIP X and ΔIP Z for this head restraint position and record as $(\Delta \text{IP X})_{\text{WC}}$ and $(\Delta \text{IP Z})_{\text{WC}}$.

3.6.3.4.3 Effective height

The effective height of the Intersection Point is determined in the highest and in the worst-case (lowest and most rearward) head restraint positions.

3.6.3.4.3.1 Calculate the Effective Height for the highest and for the worst-case (lowest, most rearward) in-use positions, using the appropriate values determined in sections 3.6.3.4.2.6 to 3.6.3.4.2.9.

Effective height = (ΔIP X)sin(torso angle) + (ΔIP Z)cos(torso angle)

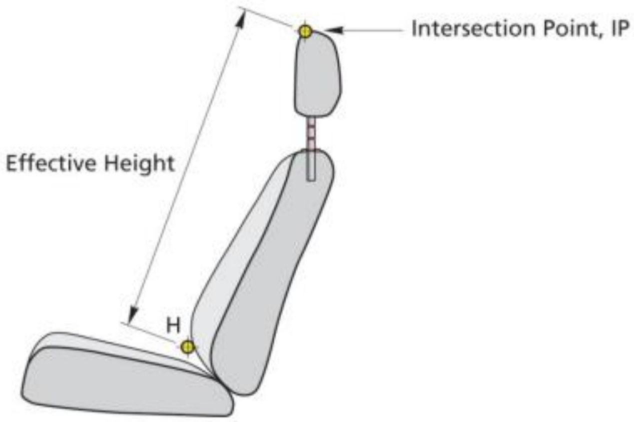


Figure 5 Effective Height

3.6.3.4.3.2 Record the values as (Effective Height) $_{high}$ and (Effective Height) $_{WC}$.

3.6.3.5 Non-use Position Measurement

The non-use position assessment does not apply to the first-row seats in heavy-duty vehicles according to section 1.4.

3.6.3.5.1 Automatic return head restraints

3.6.3.5.1.1 Weight-based systems

3.6.3.5.1.1.1 Set the head restraint in the non-use position

3.6.3.5.1.1.2 Position a Hybrid III 5th percentile adult female dummy in the seat aligned with the CL/O and parallel to the XZ-plane.

3.6.3.5.1.1.3 Hold the dummy's thighs down and push rearward on the upper torso to maximize the dummy's pelvic angle.

3.6.3.5.1.1.4 Place the tibias as near to 90° to the thighs as possible. Push rearward on the dummy's knees to force the pelvis into the seat so there is no gap between the pelvis and the seat back or until the back of the dummy's calves touch the front of the seat cushion.

3.6.3.5.1.1.5 Start the vehicle engine. Record whether or not the head restraint moves to a use position.

3.6.3.5.1.2 Capacitance-based systems

3.6.3.5.1.2.1 Set the head restraint to the non-use position.

3.6.3.5.1.2.2 Turn on the ignition or start the vehicle engine.

3.6.3.5.1.2.3 Sit a person weighing 75±10kg in the seat.

3.6.3.5.1.2.4 Record whether or not the head restraint moves to a use position.

3.6.3.5.1.2.5 Repeat 3.6.3.5.1.2.3 and 3.6.3.5.1.2.4 in different types of clothing (light summer clothing; thick, padded winter clothing) to ensure repeatable operation of the automatic return system.

3.6.3.5.2 60° Rotation Evaluation

3.6.3.5.2.1 Set the head restraint in the lowest use locking position.

3.6.3.5.2.2 Position a digital inclinometer (which can measure to a precision of 0.1°) on a suitable surface of the head restraint. Record the angle measurement.

3.6.3.5.2.3 Fold or retract the head restraint forwards to the non-use position and record the angle again.

3.6.3.5.2.4 Subtract the angle recorded in 3.6.3.5.2.3 from the angle recorded in 3.6.3.5.2.2.

3.6.3.5.3 10° Torso Line Change

3.6.3.5.3.1 Set the head restraint into the non-use position.

3.6.3.5.3.2 Install the HPM following procedures in 3.6.3.2.1 to 3.6.3.2.17 and record the torso angle.

3.6.3.5.3.3 Subtract the torso angle measured in 3.6.3.5.3.2 from the torso angle measured in 3.6.3.3.3 and record the value.

3.6.3.5.4 Discomfort metric

3.6.3.5.4.1 Set the head restraint into the non-use position.

3.6.3.5.4.2 On the surface given by the C/LO line, find the lowest point on the head restraint (TH) and record the related X-coordinate and Z-coordinate.

3.6.3.5.4.3 Calculate the X-coordinate recorded in 3.6.3.5.4.2 relative to the HPM X-coordinate, (ΔX).

$\Delta X = X_{3.6.3.5.4.2} - \text{HPM } X$

3.6.3.5.4.4 Calculate the Z-coordinate recorded in 3.6.3.5.4.2 relative to the HPM Z-coordinate, (ΔZ).

$\Delta Z = Z_{3.6.3.5.4.2} - \text{HPM } Z$

3.6.3.5.4.5 Calculate the H_{LE} (Height of the lowest point (T_H) on the head restraint relative to the HPM H-point) using:

$H_{LE} = \Delta X \cdot \sin(\text{torso angle}) + \Delta Z \cdot \cos(\text{torso angle})$

3.6.3.5.4.6 Using the measuring device in 3.6.5 determine the thickness(S).

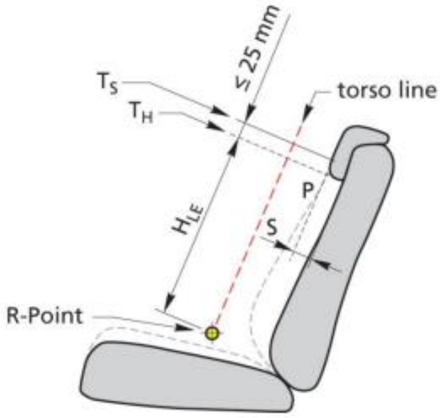


Figure 6 Discomfort metric geometric requirements

3.6.4 Head Restraint Position Definitions

The protocol refers to several head restraint positions – highest, lowest, mid, most rearward etc. This section defines how to establish these positions of the restraint.

3.6.4.1 Vertical Adjustments

3.6.4.1.1 Highest Use Position

3.6.4.1.1.1 The highest position is considered to be the highest locking position. If a restraint has a non- locking position above the highest locking position, then the highest locking position is still considered as the highest position.

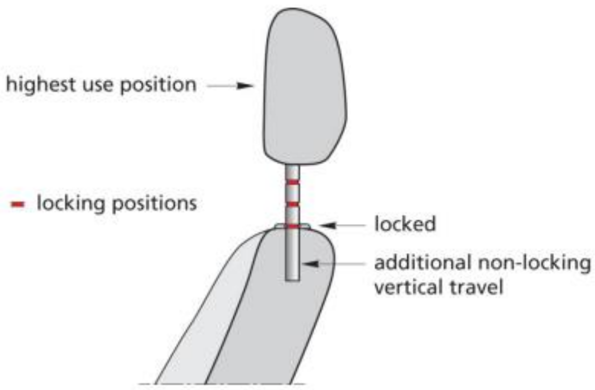


Figure 7 Highest Use Position

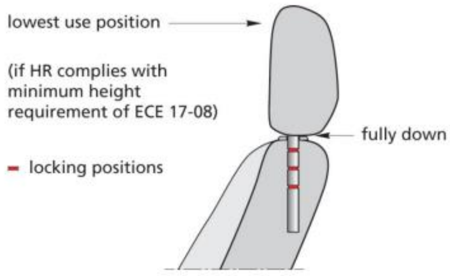
3.6.4.1.2 Lowest Use Position

3.6.4.1.2.1 The lowest in-use position is considered to be the lowest locking or stowed position in which the restraint meets the minimum height requirements specified in the Vehicle Safety Testing Directions "50-2, Head Restraint" or in UN R17-08. See Figure 8.

3.6.4.1.3 Mid Position

3.6.4.1.3.1 Mark a repeatable reference point on the top of the head restraint. This point is typically the highest point on the centreline of the head restraint.

3.6.4.1.3.2 Place the head restraint in the lowest Use position as defined in 3.6.4.1.2.



The fully down position complies with ECE 17-08 height requirement and is therefore the Lowest Use position.

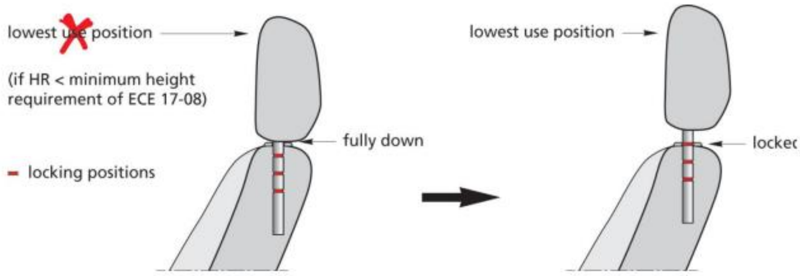


Figure 8 Examples of setting lowest use position

3.6.4.1.3.3 Using a coordinate measurement device, measure the reference point in the Lowest Use position as defined in 3.6.4.1.3.2, and then in the Highest Use position (section 3.6.4.1.1)without altering tilt or any other seat settings.

3.6.4.1.3.4 Midrange height position is determined by calculating the geometric mid point between the lowest position, and highest locking vertical adjustments, considering only the vertical component of measurement. The test position will then be selected based on the following conditions:

3.6.4.1.3.5 Place the head restraint at the geometric mid point if a locking position exists there.

3.6.4.1.3.6 If there is no locking position at the geometric mid point, raise the head restraint by up to 10mm. If a locking position exists within this 10mm of travel, that position will be the test position.

3.6.4.1.3.7 If there is no locking position within 10mm above the geometric mid point, lower the head restraint to the next lowest locking position.

3.6.4.1.3.8 If there is no locking position before the lowest or stowed position is reached, then the head restraint shall be positioned fully down. This will only be the case if the head restraint complies with the height requirements specified in the Vehicle Safety Testing Directions “50-2, Head Restraint” or in UN R17-08 in the fully down position (i.e. fully down is the Lowest Use position)

3.6.4.1.3.9 Once the vertical test position has been determined, ensure the head restraint is returned to rearmost tilt position.

3.6.4.1.4 Examples of Single Notch Head Restraint

(1) Lowest/stowed position meets the height requirements specified in the Vehicle Safety Testing Directions “50-2, Head Restraint” or in UN R17-08.

(A) The highest use position is at the locking notch.

(B) In the fully lowered/stowed position, the head restraint complies with the height requirements specified in the Vehicle Safety Testing Directions “50-2, Head Restraint” or in UN R17-08. Therefore, this position is the lowest use position.

(C) There is no notch at the geometric mid between Highest Use and Lowest Use positions.

(D) The method of 3.6.4.1.3.6 is followed: if the notch is within 10mm upward of the geometric mid, the notch position becomes the Mid Position (as well as being the Highest Use position); otherwise the Mid Position becomes the fully lowered/stowed position.

(2) The lowest/stowed position does not meet the height requirements specified in the Vehicle Safety Testing Directions “50-2, Head Restraint” or in UN R17-08.

(A) The highest use position is at the locking notch.

(B) In the fully lowered/stowed position, the head restraint does not complies with the height requirements specified in the Vehicle Safety Testing Directions “50-2, Head Restraint” or in UN R17-08. If the head restraint's first locking position complies with the requirements specified in the Vehicle Safety Testing Directions “50-2, Head Restraint” or in UN R17-08. The notch position therefore becomes the Lowest Use position.

(C) The notch position is both the Highest Use and Lowest Use positions.

(D) The notch position also becomes the Mid Position.

3.6.4.2 Tilt Adjustment

3.6.4.2.1 The following procedure shall be used for locking horizontal adjustments only. For non-locking tilt adjustments, the head restraint shall always be tilted fully rearward.

3.6.4.2.1.1 Most rearward tilt position shall be that which results in greatest backset measurement of the Contact Point CP. In the situation where the head restraint cannot be placed at most rearward tilt (e.g. due to a return spring), the most "most rearward tilt" shall be the most rearward position in which the tilt can be locked.

3.6.4.2.1.2 Most forward tilt position shall be that which results in the smallest backset measurement of the Contact Point CP. It shall be determined by finding the most forward locking tilt position. Non-locking positions located further forward than the most forward lock are disregarded.

3.6.4.2.1.3 Midrange tilt position is determined by calculating the geometric mid point between the most rearward tilt and most forward locking horizontal adjustments, considering the backsets measured. Midrange tilt setting shall be undertaken using the same rationale as used in 3.6.4.1.3. A locking position shall be sought within a window 10mm forwards from the geometric mid point. If a lock is found within this window, that position shall be considered the test position. In the absence of a lock within this range the head restraint shall be moved rearwards until the next locking position is reached. If no locking positions are reached before the fully rearward tilt position, then fully rearward tilt shall be the position used.

3.6.5 Discomfort Metric Measuring Device

Example of a pass/fail gauge to be used with an inclinometer to examine if a shingled head restraint in the non-use position meets the thickness requirement (S), at a height of 25mm above the lowest point on the head restraint along the torso angle line.

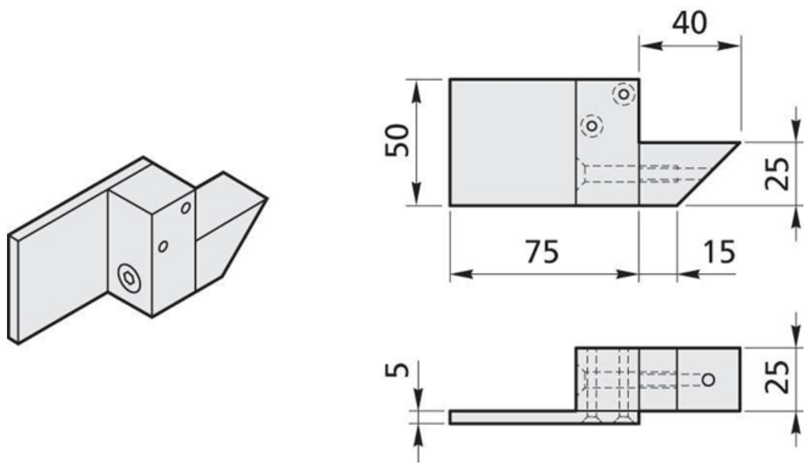


Figure 9 Discomfort metric gauge design example (all dimension in mm)

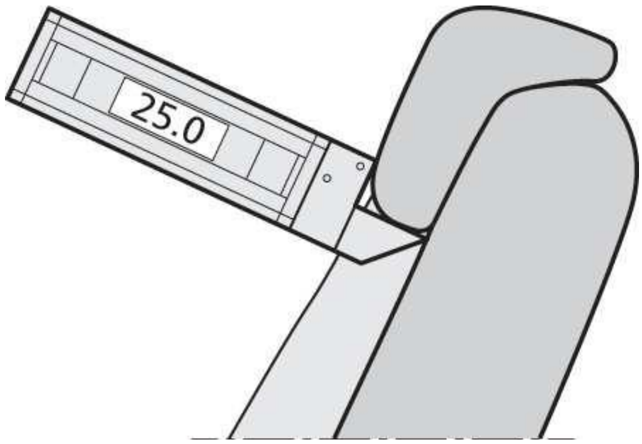


Figure 10 Using the gauge with an inclinometer

Ministry of Transportation and Communications

Taiwan New Car Assessment Program (TNCAP)

3.7 Sled Test Procedure for Assessing Knee Impact Areas

V2.0
May 2024

TABLE OF CONTENTS

3.7.1 Introduction....................3
3.7.2 Prerequisites for Knee Mapping....................4
3.7.3 Hardware Setup....................4
3.7.4 Validation Test....................5
3.7.5 Main Test Program....................7
3.7.6 Photographic Record....................10
3.7.7 Data Processing and Reporting....................11
3.7.8 Knee Airbags....................12
3.7.9 Interaction with TNCAP....................13
3.7.10 Sled Pulse....................13

3.7.1 Introduction

3.7.1.1 When knee airbags are fitted to a car, the standard method for assessing the knee contact zone becomes impractical. Seat belt systems with devices such as double pretensioners may also make the conventional assessment inappropriate. In other cases, the judgement may be marginal and manufacturers may wish to check potentially hazardous areas dynamically.

3.7.1.2 A generic pulse, determined from a representative batch of LHD and RHD Euro NCAP ODB 64km/h tests, has been developed which can be used for any knee mapping tests, either on driver or front passenger seats. The corresponding acceleration and velocity change curves are attached in Section 3.7.10.

3.7.1.3 Where a manufacturer requests, TNCAP would accept a full series of knee mapping tests to be performed using the pulse from a full scale 64km/h ODB impact test instead of the generic pulse. ALL knee mapping tests must be done using the same pulse whether it be the generic or vehicle pulse.

3.7.1.4 The manufacturer must demonstrate, for the areas in question, that femur loads are less than 3.8kN and knee slider values are less than 6mm in order to avoid knee modifiers. It shall be noted that under normal circumstances, where the variable load modifier is not applied, the concentrated load modifier is also not applied.

3.7.1.5 The TNCAP executive agency assessment for knee modifiers considers occupants of larger/smaller stature and weight than the 50th percentile Hybrid III used in the TNCAP full vehicle test. The use of the 95th percentile dummy for knee mapping ensures that a penetration deeper than that of the 50th percentile is achieved. Therefore, the full depth of the assessment zone (50th percentile penetration + 20mm) is covered by the test. Additionally, a 5th percentile female dummy may be required to asses those areas where the 95th dummy leg is unable to contact the hazards in the facia due to space restrictions.

3.7.1.6 In normal circumstances, the tests can be conducted prior to the full vehicle test based on a Manufacturer’s assessment of the knee inspection zone. However, there is the possibility that not all hazards are identified beforehand and additional hazards may be highlighted for assessment in the inspection report.

3.7.1.7 A validation test will be required by the TNCAP executive agency if certain preconditions are not met (see Section 3.7.4.1) to ensure that the test configuration is fully representative of the full scale TNCAP test. Test houses shall also be familiar with the TNCAP testing protocols, which are frequently referenced in this procedure. Details of the validation test requirements are in Section 3.7.4. The components used in the testing must be of the same design, specification, feature content and quality as those used in the official TNCAP test.

3.7.2 Prerequisites for Knee Mapping

3.7.2.1 Vehicles that show large structural post test distortion are not eligible for knee mapping. Any of the following post test conditions disqualify the vehicle from knee mapping for any frontal occupants:

(1)Femur loads >3.8kN in the full vehicle test (driver or passenger)

(2)Knee Slider >6mm in the full vehicle test (driver or passenger)

(3)Vehicles that qualify for the application of a structural modifiers i.e. Integrity of the passenger compartment and/or footwell rupture

(4)Vehicles with A-pillar displacements above 65mm (using the standard TNCAP measurement)

(5)Where any frontal impact restraining devices, such as airbags & pretensioners, deploy incorrectly, knee mapping data may not be accepted for that occupant

3.7.2.2 The presence of any particular technology to limit knee loads is not a pre-requisite for knee mapping.

3.7.3 Hardware Setup

3.7.3.1 Sled Facility

3.7.3.1.1 An acceleration or deceleration based sled rig may be used. A “body in white” buck of the car model being assessed shall be mounted on the sled. All features which may influence knee impact protection must be installed in the body in white.

3.7.3.2 Body Preparation

3.7.3.2.1 The body shell shall be mounted on the sled such that there will be no permanent deformation of the body or its mounts, during the test program. This is necessary to help ensure good repeatability. The pitch angle of the body shell shall be set to 0 degrees, according to the manufacturer’s specification.

3.7.3.2.2 The default yaw angle for the sled shall be 0 degrees. If the vehicle manufacturer can identify the need for a yaw angle other than 0 degrees in order to enable a stable contact with an identified hard point, this can be used throughout the main test program. In no cases, would the TNCAP executive agency allow the yaw angle to be greater than 30 degrees.

3.7.3.2.3 Parts can be removed from the body in white, provided that there is no question that their removal could influence the performance of the knee impact area. Any structural or inertial support of the knee impact area shall be fully simulated. This would include the support given by the steering column or loads transmitted through it.

3.7.3.2.4 The doors may be removed and the door aperture reinforced, to provide a clear view for the cameras. All components added to the body shell shall be to the same specification as those used in the TNCAP ODB frontal impact test. The restraint system and any active devices shall be replaced for each individual test.

3.7.3.2.5 Intrusion may occur which does not directly affect the knee impact area but which might provide additional support to structures supporting the knee impact area. These shall be identified in the TNCAP inspection. For the sled tests, it may be acceptable for this type of intrusion to be simulated statically e.g. wooden spacers.

3.7.3.3 Active Restraints

3.7.3.3.1 Any active components of restraint systems shall be identical to those used in the TNCAP ODB frontal impact test. However, it is acceptable for them to be triggered remotely to match the TNCAP ODB frontal impact test firing times within ± 3ms. Where remote triggering is used, full details of the firing time, proportion of charge used and any other relevant details shall be supplied, along with a comparison with relevant data from the TNCAP ODB frontal impact test.

3.7.4 Validation Test

3.7.4.1 Exemption from the validation test

3.7.4.1.1 Where all of the following test conditions are met by the driver (only) in the nominated full scale test, a validation test is not required:

(1)Pillar displacement below 35mm (using the standard TNCAP measurement)

(2)No significant seat, seat mounting or floor deformation that cannot be replicated in the main test program.

(3)Driver compressive femur loads below 1.0kN and passenger femur loads below 2.0kN.

3.7.4.2 Sled Acceleration

3.7.4.2.1 It needs to be demonstrated that the sled test sufficiently replicates a 64km/h ODB frontal impact of the subject vehicle. Therefore, the test can either be conducted with the pulse of the official TNCAP crash test or a representative development test. The vehicle used in the representative full scale test shall be similar to that intended for assessment in the official TNCAP test in terms of engine, transmission and safety equipment. If the specification of vehicle for the official test is not known, or a different hand of drive is used, the manufacturer shall provide data from a range of at least three different vehicle specifications. The manufacturer may then choose the representative test from the various examples provided and use it for the validation.

3.7.4.2.2 The sled acceleration shall be measured and compared with that measured, at the base of the impact side B-pillar, in the representative full scale test selected by the manufacturer.

3.7.4.2.3 The suitability of the correlation between the vehicle and sled pulses will be checked according to the method detailed in Section 3.7.10.

3.7.4.3 Steering column adjustment

3.7.4.3.1 The steering column shall be positioned the same as was the case in the TNCAP frontal ODB frontal impact test.

3.7.4.4 Dummy and Instrumentation

3.7.4.4.1 The validation test shall be performed using the driver dummy only regardless of whether driver or passenger knee mapping is to be performed. A Hybrid III 50th percentile dummy shall be placed in the driver's seat.

3.7.4.4.2 The dummy shall be instrumented to the same level or greater to that specified for the TNCAP ODB frontal impact test. Although the principal comparisons will be made using knee and femur responses, this additional data can aid understanding and explain any anomalies.

3.7.4.5 Seat Position

3.7.4.5.1 The seat shall be positioned as in the TNCAP ODB frontal impact test.

3.7.4.6 Dummy Positions

3.7.4.6.1 The dummy shall be positioned as in the TNCAP ODB frontal impact test, with extra care taken to ensure that the knee impact areas will be comparable.

3.7.4.7 Performance Criteria

3.7.4.7.1 The knee impact locations and loads shall be comparable to those occurring in the full scale test. To determine that this is so, the femur loads, the knee slider displacements and the damage to the facia will all need to be compared. Overall, the severity shall be at least as severe as that in the representative test.

3.7.4.7.2 In order to achieve the above, it might be necessary for the structural deformation to be simulated statically or, where sled test technology allows, dynamically. Furthermore, it might be necessary to introduce an alternative yaw angle of the body shell, see Section 3.7.3.2.

3.7.5 Main Test Program

3.7.5.1 Sled Acceleration

3.7.5.1.1 The pulse performed on the sled facility shall be at least as severe as the generic or the representative 64km/h ODB test pulse, whichever is used, and will be assessed according to the method detailed in Section 3.7.10.

3.7.5.2 Steering Column Adjustment

3.7.5.2.1 The angular adjustment shall be positioned fully upwards with the axial adjustment in the mid position.

3.7.5.3 Dummy and Instrumentation

3.7.5.3.1 95th percentile male Hybrid III dummy shall normally be used. However, where it is not possible for the 95th percentile knee to contact the hazard due to its size, the 5th percentile female shall be used. The specific dummy to be used will be confirmed during the TNCAP inspection.

3.7.5.3.2 Whichever stature of dummy is to be used, it shall be equipped with at least instrumentation to record femur axial force and knee slider displacement for both legs. Shoulder belt loads shall also be recorded to demonstrate that the pre-tensioning and load limiting characteristics of the restraint system are similar to those in the TNCAP ODB frontal impact test.

3.7.5.3.3 Additional instrumentation may be necessary in order to establish knee penetration.

3.7.5.4 Driver Seat Position

3.7.5.4.1 For 95th percentile dummies, adjust the vehicle seat according to the procedure described in Section 3.1.5 of the TNCAP ODB frontal crash test protocol.

3.7.5.4.2 Use the procedure described in Section 3.1.6.1 or 3.1.6.2 respectively of the frontal crash test protocol to determine the H-point.

3.7.5.4.3 Then move the seat rearward by 30mm. If the seat has no locking position 30mm reward choose the next notch forward.

3.7.5.4.4 In the event that the dummy is installed in the vehicle and there is insufficient space between the knee and facia to position the knee in the desired area, then the H-point shall be moved rearward to allow correct position. Shall this be insufficient, the seat shall be moved rearward until there is sufficient space up to the 95th percentile seating position.

3.7.5.4.5 For 5th percentile dummies, the seat shall be positioned to the manufacturers 5th percentile seating position in the fore/aft direction.

All other seat adjustments shall be set to enable a stable knee contact with the target point.

3.7.5.5 Driver Dummy Positioning

3.7.5.5.1 The tolerances below detail the standard dummy position in the test program. If the point cannot be contacted by the knee after following the steps detailed below, it may be necessary to deviate from one or all of these values. In particular, the foot position must be such that the correct knee impact area will be reached. Care shall be taken that deviation from the original position is as small as possible.

3.7.5.5.2 Initial H-point of the HIII-95M dummy:

(1) The HIII 95th dummy H-point shall be within 13mm horizontally of a point 30mm rearward of the H-point measured with the SAE J826 device during seat adjustment.

(2) If the target H-point in the horizontal direction cannot be achieved with the given seat position move the seat one notch in the appropriate direction and try to position the dummy again.

3.7.5.5.3 Pelvic Angle

The pelvic angle measurement gauge shall read 22.5° ± 2.5° from the horizontal.

3.7.5.5.4 Head

The transverse instrumentation platform of the head shall be within 2.5° of horizontal.

3.7.5.5.5 Arms and Hands

(1) For driver testing, place hands on the steering wheel in a similar fashion to that of the TNCAP test. However, minor adjustments on the arm and hand positions are allowed if this allows for better camera views of the knee impact area.

(2) For passenger testing, place the arms as in the TNCAP test setup.

3.7.5.5.6 Torso

The torso shall line up with the centre of the seat. However, the torso might have to be twisted to one side to allow for the knees to strike the points indicated in the TNCAP inspection. During twisting it is acceptable for the H-point location to change.

3.7.5.5.7 Legs

The legs shall initially be positioned according to the TNCAP ODB frontal test protocol, but then their position shall be modified laterally so that the main load bearing knee will come into contact with the potential hard-point as indicated in the inspection report. The other knee shall be aimed at an area where it would be expected to receive experience little or no loading. Frequently, this would be achieved by positioning it laterally where it has the greatest spacing from the facia. The lateral position of the knees can be achieved with a variation of the knee spread and/or a twist of the torso.

3.7.5.5.8 Feet

The feet shall be placed as flat as possible on the toe board parallel to the centreline of the vehicle. If either of the feet comes into contact with a footrest or a wheel arch, place the foot fully onto that rest. It is permissible to adjust the foot position to ensure that the correct knee impact location can be obtained. In order to ensure a stable knee contact, it may also be necessary to prevent the relevant foot from moving forwards in the footwell.

3.7.5.6 Passenger Dummy Positioning

3.7.5.6.1 The minimum knee penetration required for all of the passenger femur load tests within main test program is based on the limit of the inspection zone. This will be detailed in the inspection report and be based upon the penetration of the passenger knee obtained in the official TNCAP test including an additional 20mm.

3.7.5.6.2 The passenger dummy positioning procedure will follow the procedure described in Sections 3.7.5.4 & 3.7.5.5. However, if this seating/dummy position does not achieve a minimum knee penetration equal to that of the limit of the inspection zone, the seat and dummy shall be adjusted so that this limit is reached by the knee throughout the main test program.

3.7.5.6.3 The penetration of the passenger knee will be established using high speed video footage and/or pelvic displacement calculations. Alternative measurement methods for establishing pelvic displacement will also be accepted which can be shown to be of equal accuracy as using pelvis acceleration to establish knee penetration. If the position of the dummy is limited by the knees contacting the hazard and/or the amount of available seat travel, that most forward position shall be used.

3.7.5.6.4 Situations were potential hazards for knee slider are highlighted are treated equivalent to test for potential knee hazards. The dummy positioning procedure will follow the procedure described in Sections 3.7.5.4 & 3.7.5.5. However, if this seating/dummy position does not achieve a minimum knee displacement equal to that of the limit of the inspection zone (20mm), the seat and dummy shall be adjusted so that this limit is reached. If knee slider is a concern it needs to be ensured that there is stable contact between the tibia and potential hazard. It may be necessary to make small adjustments to the angel of the Tibia to ensure contact with the correct location.

3.7.5.7 Ensure a stable knee contact with the potential hard point.

3.7.5.7.1 In order for a knee mapping sled test to be valid, it needs to be ensured that the main load bearing knee remains in stable contact with the potential hard point during the impact sequence. If the knee is deflected, the test will not be accepted as a valid measure of the potential hazard. It is important that the other knee is loaded as little as possible by either not contacting the facia or impacting the least supported area of the facia.

3.7.5.7.2 In order to ensure this it is allowable for the knee spread to be artificially fixed (i.e. by the application of structural foam or similar, between the legs). Furthermore, it might be necessary to prevent the feet from moving forward during crash in order to prevent a dynamic drop of the knee during the impact sequence.

3.7.5.7.3 If a stable contact cannot be achieved with artificial knee spreading alone it is allowable to use an appropriate yaw angle of the sled other than 0 degrees to assess an individual hard point.

3.7.5.7.4 In any case, it is essential to confirm the stable knee contact with the use of appropriate high speed camera footage.

3.7.5.8 Dummy Painting

3.7.5.8.1 If the absence of acceptable camera evidence, paint or other suitable alternatives may be used in order to identify that the correct point has been contacted.

3.7.5.9 Performance Criteria

3.7.5.9.1 In the TNCAP inspection, the potential hazards will be identified and it will be necessary for all of them to be fully explored in the test program.

3.7.5.9.2 The performance criteria used for the assessment will be femur forces below 3.8kN and the knee slider responses shall be less than 6mm. No adjustment to the performance criteria is made for any change in dummy size.

3.7.6 Photographic Record

3.7.6.1 High Speed Film

3.7.6.1.1 High speed film is required for ALL knee mapping testing including the validation test.

3.7.6.1.2 Sled mounted high speed cameras shall be used to record the whole of the relevant scene. This would include the seat, seat belt system, facia, steering column, door aperture and dummy trajectory from both left and right sides. It shall record the knee impact location and provide verification that the knee was not deflected from the chosen location and that the feet remained stable on the toe board. This shall include a camera view showing the knees and a camera view that shows the feet for the complete impact sequence. The high speed camera frame rate shall be of the order of 1000 frames per second.

3.7.6.2 Still Photography

3.7.6.2.1 In order for any knee mapping results to be accepted by the TNCAP executive agency, it is essential that adequate photographic evidence of the test is provided by the manufacturer.

3.7.6.2.2 Pre and post test still photography is required to clearly show the sled set-up and BIW construction. Still photographs shall show the fixings of the body in white to the sled, in particular the steering column and facia mounting and the appropriate body reinforcements before and after the series of tests. Additionally, any structures added to simulate intrusion which could support the knee impact area shall also be recorded.

3.7.6.2.3 The structures present in the facia shall be clearly visible to provide evidence that the sled set-up is representative of a production vehicle and that all required components have been included.

3.7.6.2.4 It is essential that the position of the dummy and particularly its knees shall be clearly shown, along with a photographic record of the paint applied to the knees. After each test, a record shall be made of the knee contact area, any paint transfer marks, and any damage to any of the knee impact area components.

3.7.6.2.5 Any broken, damaged or fatigued components shall also be fully recorded using photographs. In some cases it will be necessary to remove these from the facia after the tests in order to provide the best view.

3.7.6.3 Insufficient high speed or still photography could result in the knee mapping not being accepted by the TNCAP executive agency.

3.7.7 Data Processing and Reporting

3.7.7.1 Data Processing

3.7.7.1.1 The test data shall be sampled and filtered as specified in the TNCAP ODB frontal impact test protocol.

3.7.7.2 Reporting

3.7.7.2.1 Full information about the test set up shall be supplied to TNCAP executive agency. This shall include details of any work that has been done to compensate for supportive intrusion, how the steering column lower mass and attachments have been simulated and any special arrangements related to dummy positioning. Anything which could influence the assessment shall be fully reported.

3.7.7.2.2 For the validation test, a comparison shall be provided to satisfy the TNCAP executive agency that the test set up and pulse is suitable for the assessment work.

3.7.7.2.3 For the main test program, the locations being investigated shall be detailed and the outcome from each test shall be given. In both cases, full data shall be supplied, including graphical plots. A full explanation and comparative analysis shall be supplied.

3.7.8 Knee Airbags

3.7.8.1 The test set-up and the assessment criteria described above are also applicable for vehicles with knee airbags. Knee mapping test data must be provided in order to avoid the variable load modifier. However, it is assumed that a properly deploying knee airbag substitutes the function of foam and load spreader in order to avoid the concentrated load modifier. The presence of a knee airbag will not automatically lead to the removal of the concentrated load modifier; knee mapping data will be required to prove the effectiveness of the system. The presence of a knee airbag will not automatically lead to the removal of the concentrated load modifier; knee mapping data will be required to prove the effectiveness of the system.

3.7.8.2 Where the measured femur force is less than 3.8kN and the knee slider displacement is below 6mm, the variable contact and concentrated load modifiers will not be applied provided that, there is no bottoming out of the knee airbag.

3.7.8.3 It must be clear that there is no risk associated with the presence of the airbag module or its support structures.

3.7.8.4 Where a knee airbag does bottom out in the official ODB test, an additional sled test with the 50% percentile dummy in the ODB test seating position (setup as of validation test) is required with an airbag deployment time 10ms later than that used in the official ODB test. Where the femur loads or/and knee slider displacement exceed the acceptance criteria in Section 3.7.8.2, the variable load modifier will be applied.

3.7.8.4.1 Bottoming out of the knee airbag will be identified from the femur tracesusing sharp increases in femur load of at least 1kN in 5ms, and an accompanying increase in pelvis acceleration. There may also be physical damage to any underlying structures and evidence from high speed film.

3.7.8.4.2 If a knee airbag is deemed to have bottomed out in any of the tests and the femur loads and/or knee slider results exceed the acceptance criteria in Section 3.7.8.2, the variable load modifier will be applied.

3.7.9 Interaction with TNCAP

3.7.9.1 Any manufacturer who intends to present knee mapping test results to the TNCAP executive agency is required to advise the TNCAP executive agency upon completion of the vehicle matrix form and submit the knee mapping test data before conducting the frontal offset impact test. If the data cannot be submitted within the aforementioned timeframe, it must be provided no later than six weeks after the frontal offset impact test.

3.7.9.2 Where additional the TNCAP inspector or the TNCAP executive agency time or resources are required to consider knee mapping data or to hold additional meetings, the costs will have to be funded by the manufacturer.

3.7.10 Sled Pulse

3.7.10.1 The pulse performed on the sled facility shall be close to or more severe as the generic test pulse. To validate this point, the following process shall be used:

(1) Change the orientation to have sled pulse and generic pulse in globally positive values

(2) Calculate by integration the Delta V from generic pulse DV1(t), setting the initial velocity to 0

(3) Calculate by integration the Delta V from sled test DV2(t), setting the initial velocity to 0

(4) Calculate the difference DV = DV1 – DV2

(5) Calculate by integration of DV1 the X displacement from generic pulse DX1(t), setting the initial value to 0

(6) Calculate by integration of DV2 the X displacement from sled test DX2(t), setting the initial value to 0

(7) Calculate the difference DX(t) = DX1(t) – DX2(t)

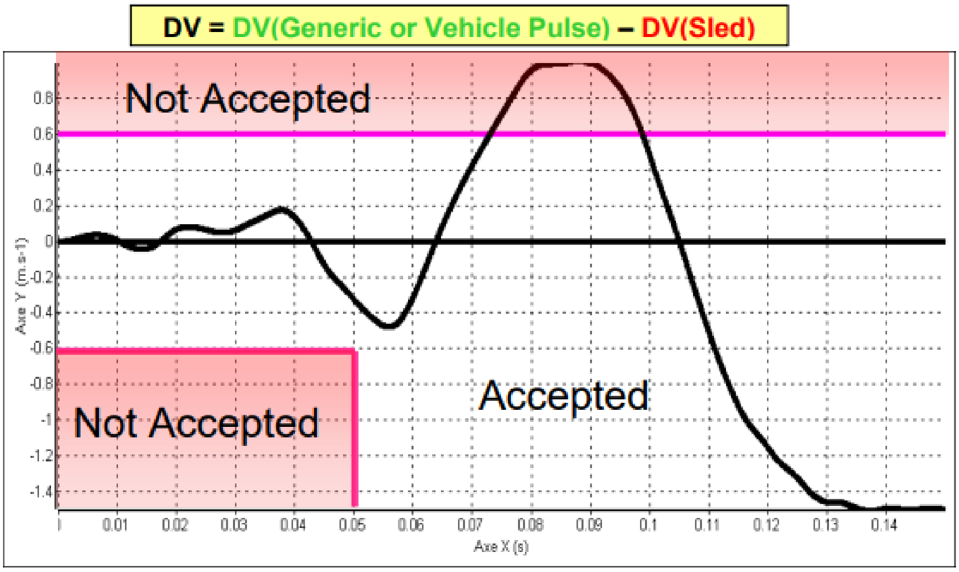
(8) Calculate DX at 120 ms

3.7.10.2 Requirement #1:

(1) If all the DV values up to 120 ms are in the zone as shown below, requirement #1 is OK – check requirement #2.

(2) If some DV values up to 120 ms are outside the zone, requirement #1 is not OK.

Sled test is less severe than the generic or ODB test pulse and cannot be accepted for knee mapping.

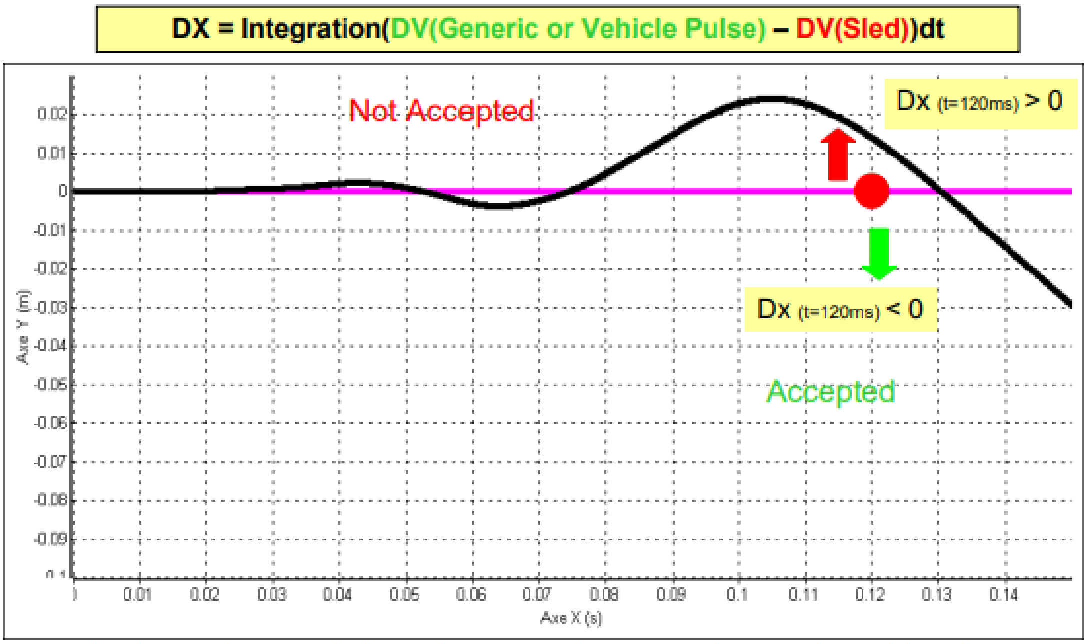


Example: Sample pulse showing a sled test that cannot be accepted as parts of DV are outside the acceptable zone

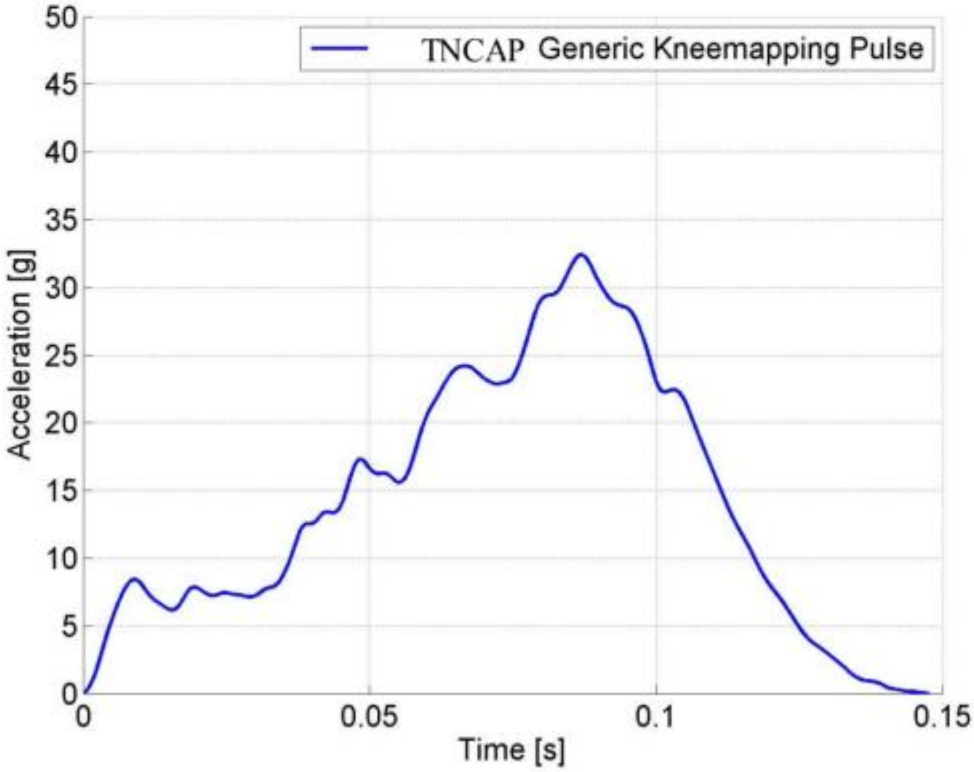
3.7.10.3 Requirement #2:

(1) If DX value at 120 ms is negative, requirement #2 is OK, sled test is accepted for knee mapping.

(2) If DX value at 120 ms is positive, requirement #2 is not OK, sled test cannot be accepted for knee mapping.



Example: Sample picture shows a sled test that cannot be accepted for knee mapping as DX is positive @ 120 ms


TNCAP Generic Kneemapping Pulse
Acceleration [g]
Time [s]
50
45
40
35
30
25
20
15
10
5
0
0
0.05
0.1
0.15

Ministry of Transportation and Communications

Taiwan New Car Assessment Program (TNCAP)

3.14 Blind Spot Assist Systems Testing Protocol

V2.0

May 2024

TABLE OF CONTENTS

3.14.1 Definitions..3

3.14.2 Reference System..3

3.14.3 Measuring Equipment..4

3.14.4 Test Conditions 5

3.14.5 Blind Spot Detection System Test Procedure 5

3.14.6 Illustration..10

3.14.7 Blind Spot Visualization System Test Procedure...........................13

3.14.8 Illustration..16

3.14.1 Definitions

3.14.1.1 Subject vehicle (SV) – Vehicle equipped with the system in question and related to the topic of discussion.

3.14.1.2 Target vehicle (TV) – Motorcycle that is closing in on the subject vehicle from behind, or any vehicle that is located in one of the adjacent zones.

3.14.1.3 Coverage zone – The entire area to be monitored by a BSS. A system's coverage zone comprises a specific subset of the following zones: left adjacent zone, right adjacent zone, left rear zone and right rear zone.

3.14.1.4 Adjacent zones – Zones to the left and right of the subject vehicle.

3.14.1.5 Closing speed – ⟨of a target vehicle⟩ the difference between the target vehicle's speed and the subject vehicle's speed.

Note: This definition applies to target vehicles in the rear zones only. A positive closing speed indicates that the target vehicle is closing in on the subject vehicle from the rear.

3.14.1.6 Overtaking speed – ⟨of the subject vehicle⟩ the difference between the subject vehicle's speed and the target vehicle's speed when the subject vehicle is overtaking the target vehicle.

3.14.1.7 Blind spot warning function – Function that detects the presence of target vehicles in one or more of the adjacent zones and warns the subject vehicle driver in accordance with the requirements given in section 3.14.2.1.

Note: A target vehicle located within the coverage zone will thus be detected by the system.

3.14.1.8 Visual function – As for non-detection type, the system shall be able to provide a live visual of the vehicles moving in the same direction, and on the side and/or rear of the subject vehicle which can be activated manually or via turn signal action.

Note: A target vehicle located within the coverage zone will thus be visualized by the system.

3.14.2 Reference System

The International Standard specifies system requirements and test methods for Lane Change Decision Aid Systems (LCDAS). LCDAS is fundamentally intended to warn the driver of the subject vehicle against potential collision with vehicles to the side and/or to the rear of the subject vehicle, and moving in the same direction as the subject vehicle during lane change maneuvers.

3.14.2.1 Type I Systems

Provide the blind spot warning function only. These systems are intended to warn the subject vehicle driver of target vehicles in the adjacent zones. These systems are not required to provide warnings of target vehicles that are approaching the subject vehicle from the rear. If the installed system does not warn of the approaching target vehicles, the subject vehicle driver shall be made aware of the limitations of this type of system, at least in the owner's manual. In particular, the owner's manual shall include the following statement: "This system provides support only within a limited area beside the vehicle. The system may not provide adequate warning for vehicles approaching from the rear."

3.14.3 Measuring Equipment

The basic measurements include vehicle speed (using GPS-based vehicle speed sensors), video logger and performance meter for event recording, and BSS alert signal lamp indicators.

3.14.3.1 Zone Instrumentation

3.14.3.1.1 Blind Spot Assist Systems (BSS) assessment jig

The setup process includes preliminary plotting of blind spot zone, fitment angle of video logger and performance meter camera and onboard equipment. Precise and accurate measurement is essential to ensure superior and reliable output from the assessment.

Referring to Figure 1, BSS jig setup is divided into two parts; part A and B.

Part A is a video logger jig frame for outside camera and is located on the top side of main windshield.

Part B is a jig for pre-setup of blind spot zone level 3 which views live-feed video recording taken by video logger and performance meter.

The assessment will be based on video recording system using video logger and performance meter applications which require pre-setup of zone area level 3 in the live-feed view. These two parts are designed to be used in any passenger car and are removable with static measurement at any flat surface.

Figure 1: Blind spot zone setup

As shown in Figure 2, the main components to complete the jig structure are:

(1) Component A- Black metal connector pipe C1-24 (Length 130mm x diameter 33mm x hollow 38mm) x 5 pcs.

(2) Component B- Black metal connector pipe C2-5 (Length 130mm x diameter 33mm x hollow 33mm) x 4 pcs.

(3) Component C- Black metal connector pipe C3-11 (Length 84mm x diameter 33mm x hollow 36mm) x 4 pcs and the last component is a standard steel pipe (diameter 28mm) with 2 different length 1465mm (10 pcs) and 1965mm (2 pcs).

Tools required for setup process: Allen-key size 3mm to tighten the connector and aluminum hollow pipe.

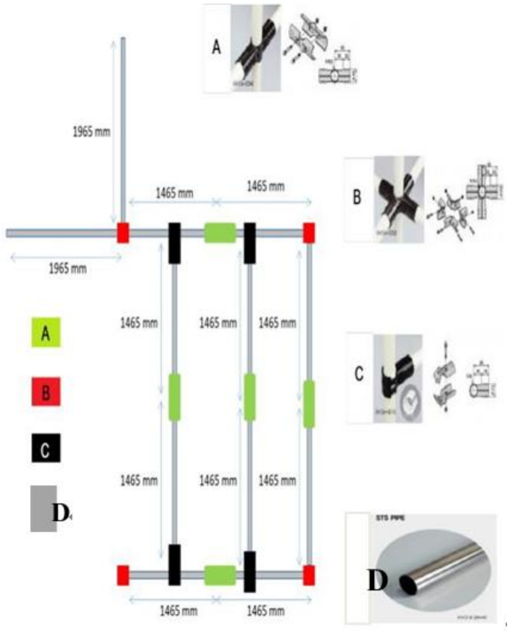


Figure 2: Blind spot coverage zone jig

3.14.4 Test Conditions

3.14.4.1 The test location shall be on a flat, dry asphalt or concrete surface. The ambient temperature during testing shall be within the range of 5°C - 40°C. The horizontal visibility range shall be greater than 1 km (ISO17387 Sec. 5.2). The test shall be conducted during the day.

3.14.4.2 Test Track

3.14.4.2.1 The tests are done on a dry (no visible moisture on the surface), uniform, solid-paved surface with a consistent slope between level and 1%.

3.14.4.2.2 The surface must be paved and may not contain any irregularities (e.g. large dips or cracks, manhole covers or reflective studs) that may give rise to abnormal sensor measurements within a lateral distance of 3.0m to either side of the test path and with a longitudinal distance of 10m ahead of the VUT when the test ends.

3.14.5 Blind Spot Detection System Test Procedure

3.14.5.1 Conditioning

3.14.5.1.1 Vehicle Preparation

Prepare the on-board test equipment and instrumentation in the vehicle. Also fit any associated cables, cabling boxes and power sources.

3.14.5.1.2 Test Target Vehicle

The primary objective of BSS testing is to detect motorcycles.

Thus, the dimension of target vehicle used in this protocol will be as follows:

Table 1: Target vehicle dimension

	Dimensions (m)
Length	1.8 - 2.0
Width	0.6 - 0.8
Height	1.0 - 1.4

3.14.5.2 Test Scenarios

The assessment is to evaluate that the blind spot warning system gives warnings when required as the target vehicle overtakes the subject vehicle. Referring to Figure 3 and the line definitions in 4, the test shall be conducted as follows.

On a straight and flat test course, the test Subject Vehicle (SV) shall be driven in a straight line at a maximum steady speed of 40 km/h±2 km/h. The test Target Vehicle (TV) shall be ridden in a straight line as shown in Figure 3 so that its closing speed is 10 km/h±2 km/h.

Both vehicles shall be driven/ridden such that the lateral distance between the outermost edge of the subject vehicle's body (excluding the exterior mirror) and the centreline of the TV is between 2.0 to 3.0 meter for true warning test and at 6.5 meter for false warning test.

The assessment will start when both vehicles reach a steady speed of 40 km/h±2 km/h and the TV shall be completely behind line A (> 30-meter distance).

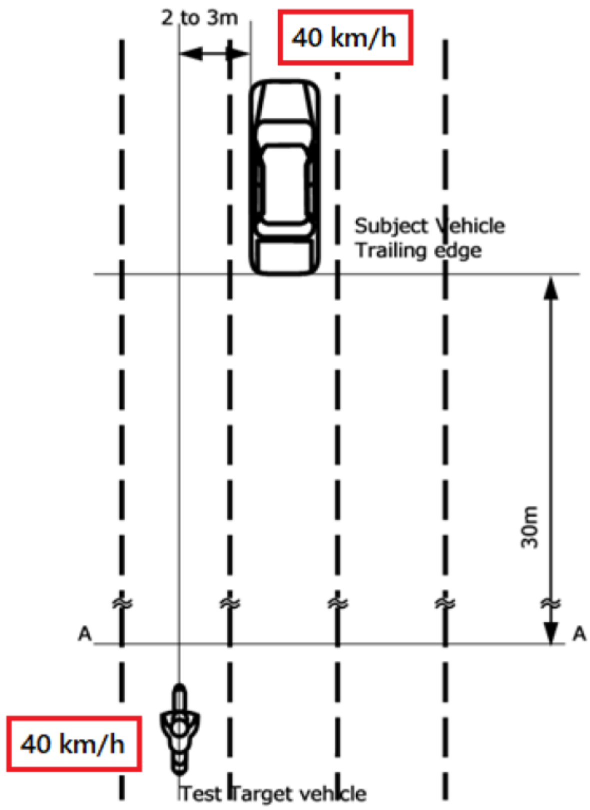


Figure 3: Target Vehicle entering 30-meter zone with steady speed

3.14.5.3 Test Conduct

3.14.5.3.1 Straight-Lane Tests

The test SV is subjected to one type of performance test: the straight-lane test. In the straight-lane test series, both SV and TV are driven and ridden in separate but parallel, lanes with the target vehicle riding longitudinally past the subject vehicle. TV is ridden on the lane next to the SV either on the driver's or passenger's side as depicted in Figure 4.

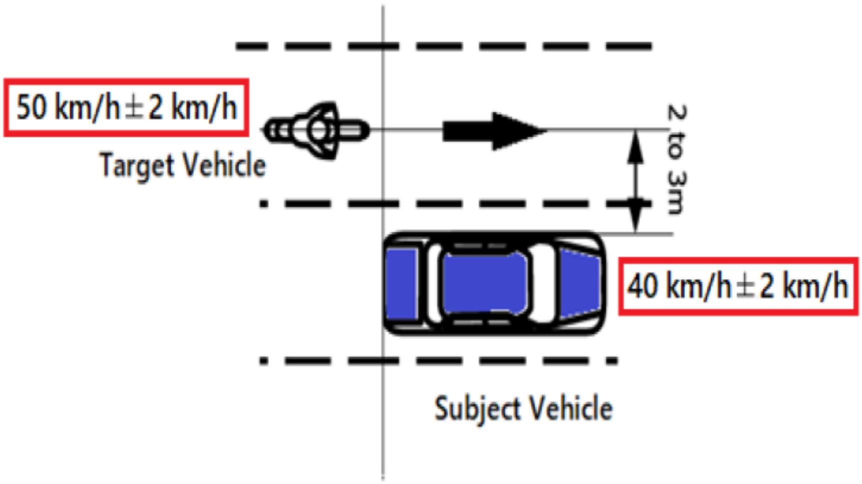


Figure 4: Target Vehicle overtaking Subject Vehicle speed

The straight-lane tests are performed on a controlled straightaway test facility containing equal or more than three parallel lanes of concrete surface roadway. All tests are performed during the day.

Once these measurements are completed for the passenger's side, the entire test is repeated for the driver's side sensor.

3.14.5.3.2 Functionality Check and Scoring

Check the functionality whether the BSS system gives warnings when test is performed according to the test procedure with test conditions and the target vehicle described in sections 3.14.4 and 3.14.5.1.2.

3.14.5.3.3 True Warning Test

In the true warning test, target vehicle overtaking subject vehicle in between 2 to 3 meters adjacent as described in section 3.14.5.3.

BSS warning requirements are divided into three sections; must give warning, might give warning and must not give warning. The result shall be based on Table 2. The subject vehicle must be in fully prepared condition while running at 40 km/h±2 km/h. The target vehicle speed is 50 km/h±2 km/h to overtake the subject vehicle. All tests cover both driver and passenger sides of subject vehicle.

Table 2: BSS warning requirements

BSS indicator/audible/visual warning	**Must not on**	**Might be on**	**Must be on**
Distance	Beyond 30 meter behind car	In 30 meter zone behind car	In 3 meter zone behind car to 95th percentile eyellipse

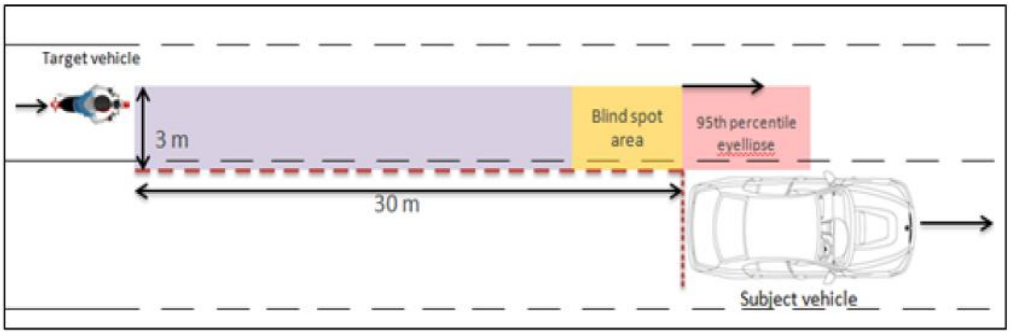


Figure 5: Must not give blind spot warning to the driver

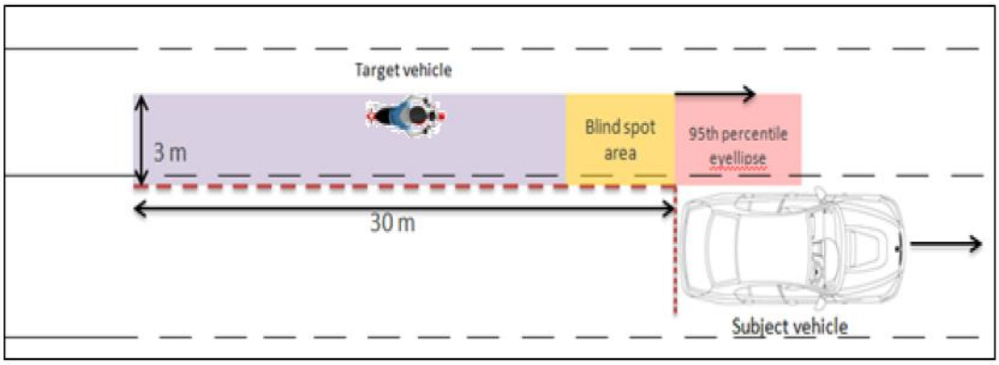


Figure 6: Might give blind spot warning to the driver

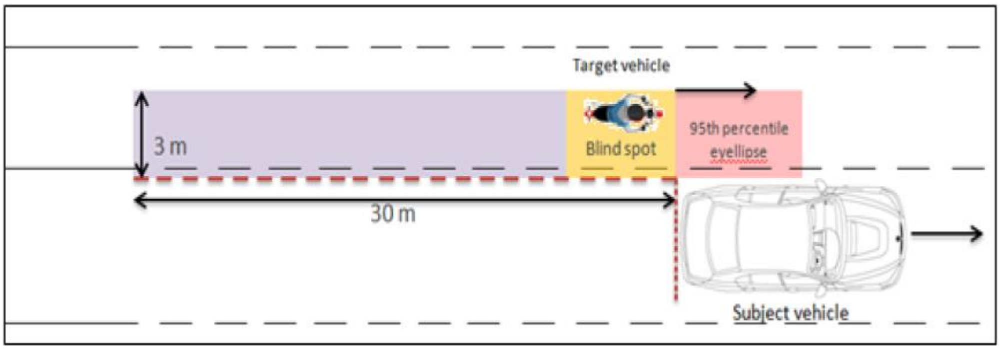


Figure 7: Must give blind spot warning to the driver

Three (3) repeated runs of each side sequence are completed to determine sensitivity and repeatability.

If subject vehicle does not meet the requirements for all 3 runs as described in Table 2, no point will be rewarded.

3.14.5.3.4 False Warning Test

The purpose of this test is to determine that the lane change warning system gives no warning when the target vehicle is in the lane beyond the adjacent lane. In each test, the lateral distance between the outermost edge of the subject vehicle's body (excluding the exterior mirror) and the centerline of the test target vehicle shall be maintained at 6.5 meters.

The system shall give no warning signal during these trials. All tests cover both the left and right side of subject vehicle. Single test run is adequate to complete the assessment.

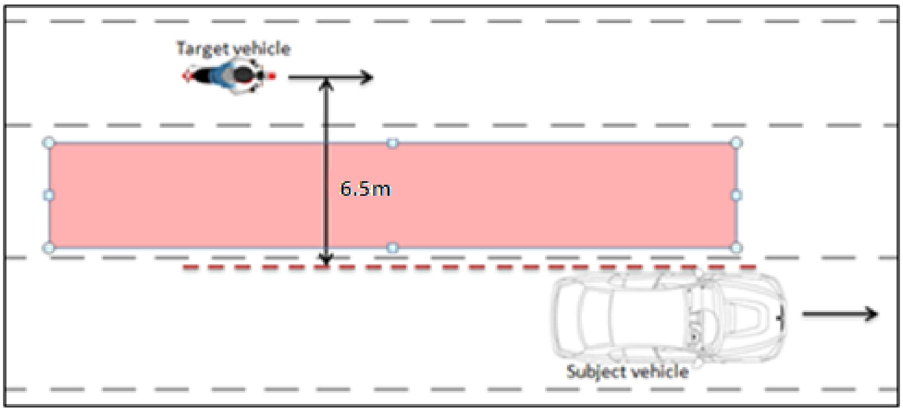


Figure 8: Target vehicle shall be maintained at 6.5 meters during test

3.14.5.3.5 Test Facility Layout

Based on Figure 9, it shows the layout of BSS test facility. This layout area includes length (minimum) of 700-meter and 11-meter wide; sufficient for the testing. This layout is divided into three zone A, B and C.

(1) A is the starting area for the test vehicle.

(2) B is the bypass area where the target vehicle needs to overtake the subject vehicle.

(3) C is for braking area and U-turn.

Subject and target vehicle start moving at the same time laterally and achieve constant/steady speed at 40 km/h±2 km/h, before entering Zone B.

In Zone B, the target vehicle needs to accelerate to 50 km/h±2 km/h to overtake the subject vehicle within 500-meter range. Zone B is a critical area for the test where the blind spot assist systems needs to function and give warning to driver. Both vehicles need to slow down and make a U-turn when entering Zone C and return to the starting line for the next run. Minimum repetition is four (4) runs for each side.

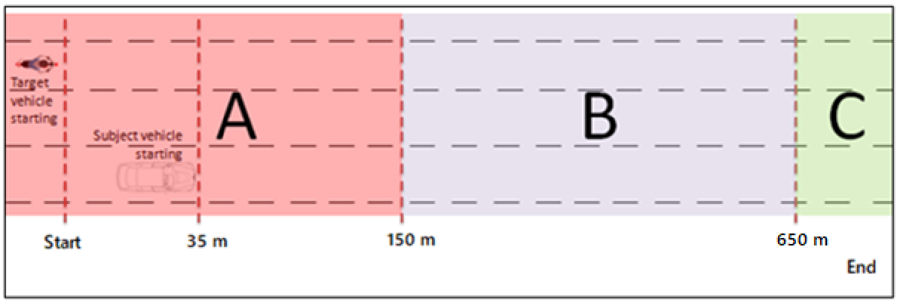
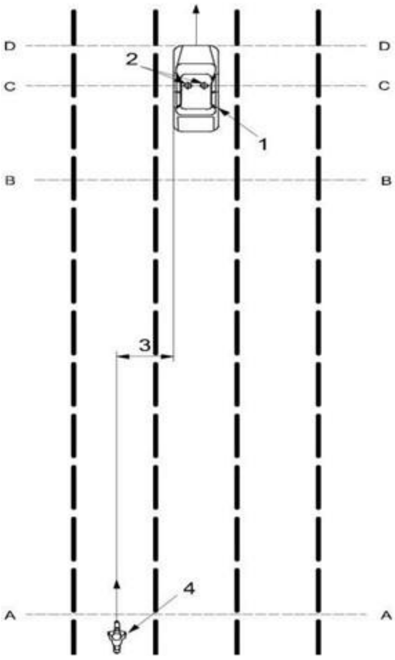


Figure 9: Test facility layout

3.14.6 Illustration

ISO 17387:2008(E)



(1) Subject vehicle

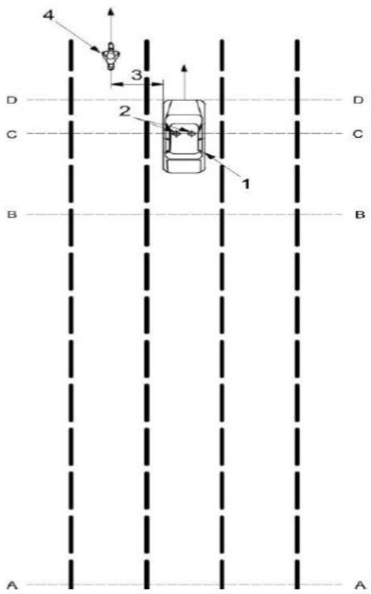
(2) Centre of the 95th percentile eyellipse

(3) Lateral distance

(4) Target vehicle

Figure 10: Target and subject vehicle starting point

ISO 17387:2008(E)



(1) Subject vehicle

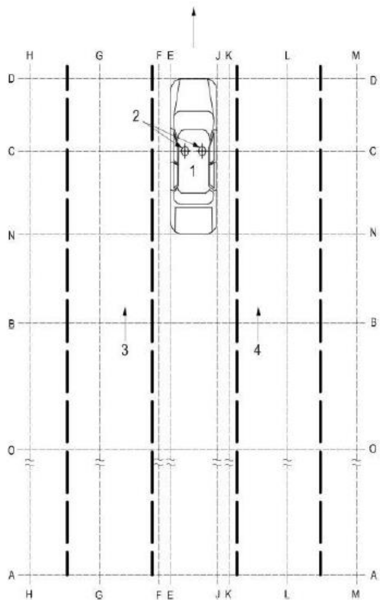
(2) Centre of the 95th percentile eyellipse

(3) Lateral distance

(4) Test target vehicle

Figure 11: Target vehicle overtaking subject vehicle

ISO 17387:2008(E)



(1) Subject vehicle

(2) Centre of the 95th percentile eyellipse

(3) Left adjacent zone

(4) Right adjacent zone

Figure 12: Warning requirements diagram

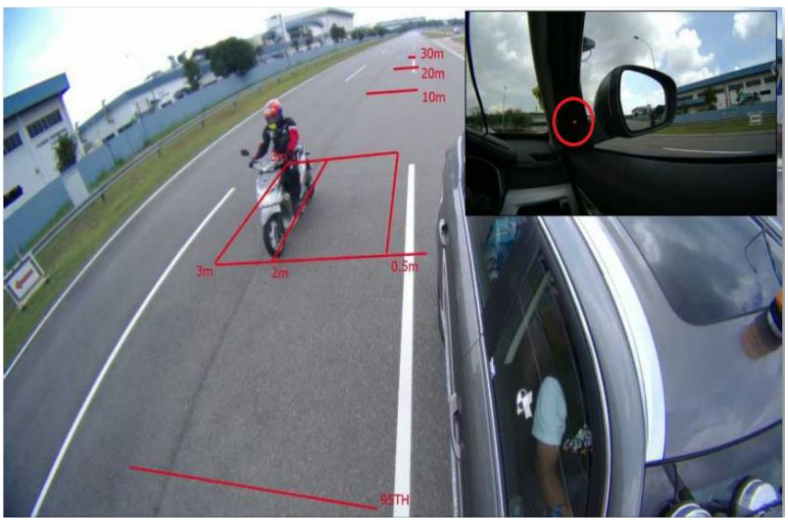


Figure 13: Video logger image of BSS test

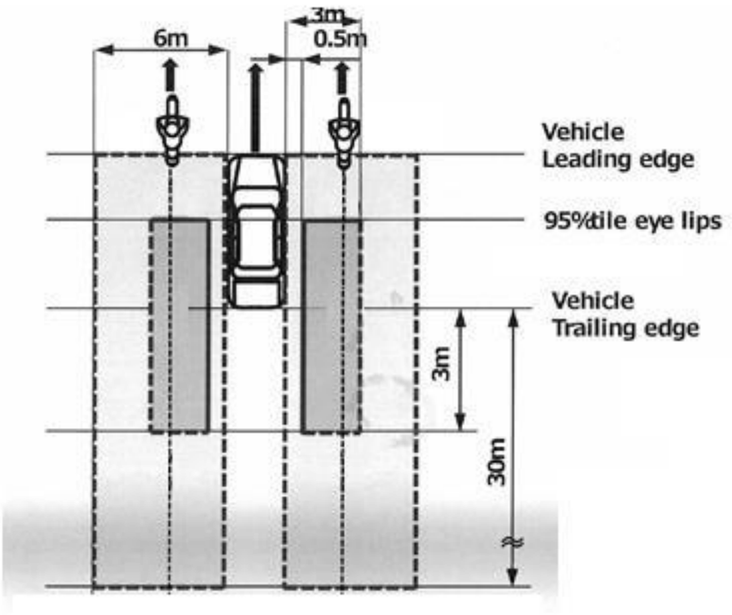


Figure 14: Blind Spot Zone

3.14.7 Blind Spot Visualization System Test Procedure

3.14.7.1 Conditioning

3.14.7.1.1 Vehicle Preparation

Setup the on-board test equipment and instrumentation in the vehicle. Also fit any associated cables, cabling boxes and power sources.

3.14.7.1.2 Test Target Vehicle

The primary objective of the BSV System test is to display motorcycle images. Thus, the dimension of target vehicle used in this protocol will be as follows:

Table 3: Target vehicle dimension

	Dimensions (m)
Length	1.8to 2.0
Width	0.6 to 0.8
Height	1.0 to 1.4

3.14.7.2 Test Conduct

3.14.7.2.1 Static Straight-Lane Tests

The test SV is subjected to one type of performance tests namely static straight-lane tests.

In the static straight-lane test series, both SV and TV are placed on separate but parallel lanes with the target vehicle positioned in the lane next to the SV either on the driver or passenger side as depicted in Figure 15.

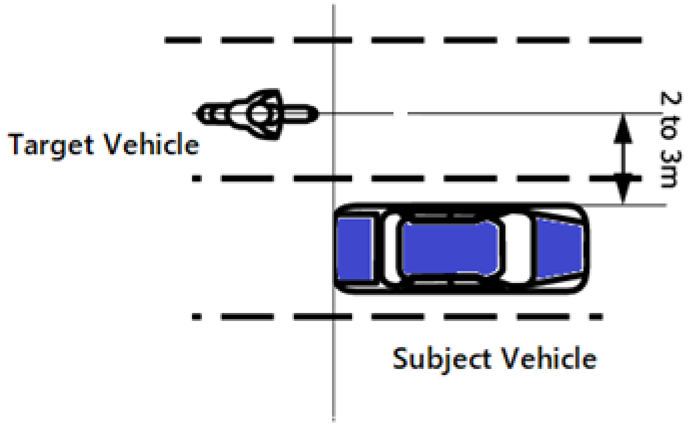


Figure 15: Target Vehicle and Subject Vehicle position

The static straight-lane tests are performed on a controlled straightaway test facility containing equal or more than three parallel lanes of concrete surface roadway. All tests are performed during the day or/and at night.

Once these measurements are completed for the passenger-side, the entire test is repeated for the driver-side sensor.

* In order to identify the system's interaction with the application of the SV's turn signals, the test series are repeated with the turn signal activated.

Note: Manufacturer is required to provide information for specific model.

3.14.7.2.2 Functionality Check and Scoring

Check the functionality whether the BSV system provides adequate live visual of static vehicle when test is performed according to the test procedure with the target vehicle described in the 3.14.7.2.2.1.

3.14.7.2.2.1 Static Test

In the static test, the target vehicle will be positioned at 5 different locations in the lane next to the subject vehicle in between 2 to 3 meters adjacent as described in Figure 16. Confirm that the target vehicle is visible at each place and distance.

The locations of target vehicle must be as follows (in respect to subject vehicle rear);

(1) 30m zone

(2) 20m zone

(3) 10m zone

(4) 3m zone, and

(5) Blind spot zone

For BSV type system, the system must be able to provide a live visual of the static vehicle in the same direction, and on the adjacent side of the subject vehicle. The result shall be based on the following Table 4.

Table 4: BSS Visualization type requirements

Live visual video	Must be clearly visible
Distance	In 30-meterzone from SV trailing edge to blind spot zone

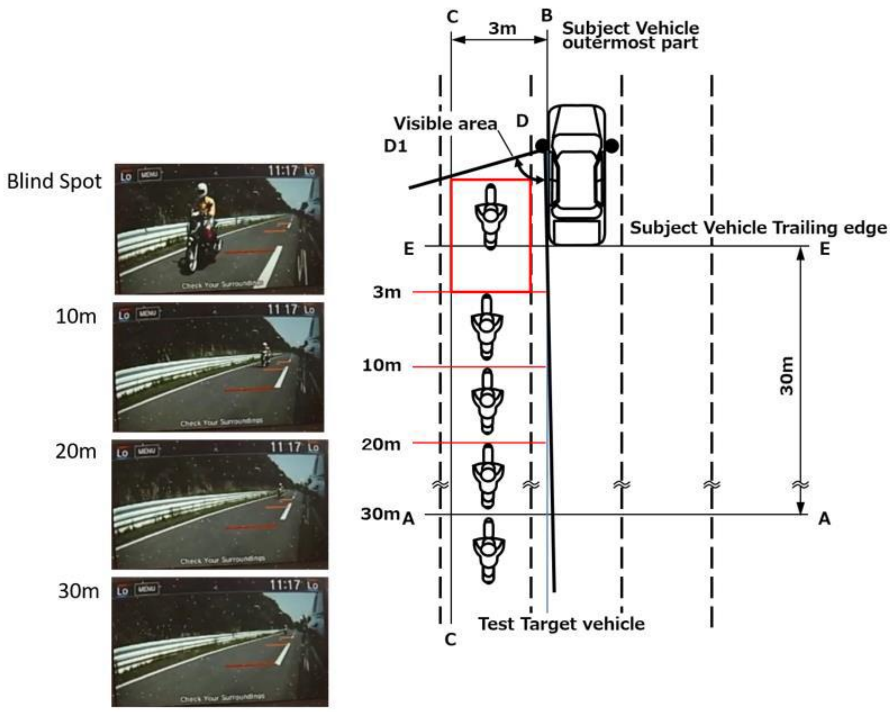


Figure 16: Functionality check and score

If the subject vehicle does not meet all the requirements as described in Table 4, no point will be rewarded.

The subject vehicle shall be able to visualize other vehicles in the blind spot zones, especially smaller ones such as motorcycles (target vehicle) and provide adequate visibility as described in Figure17.

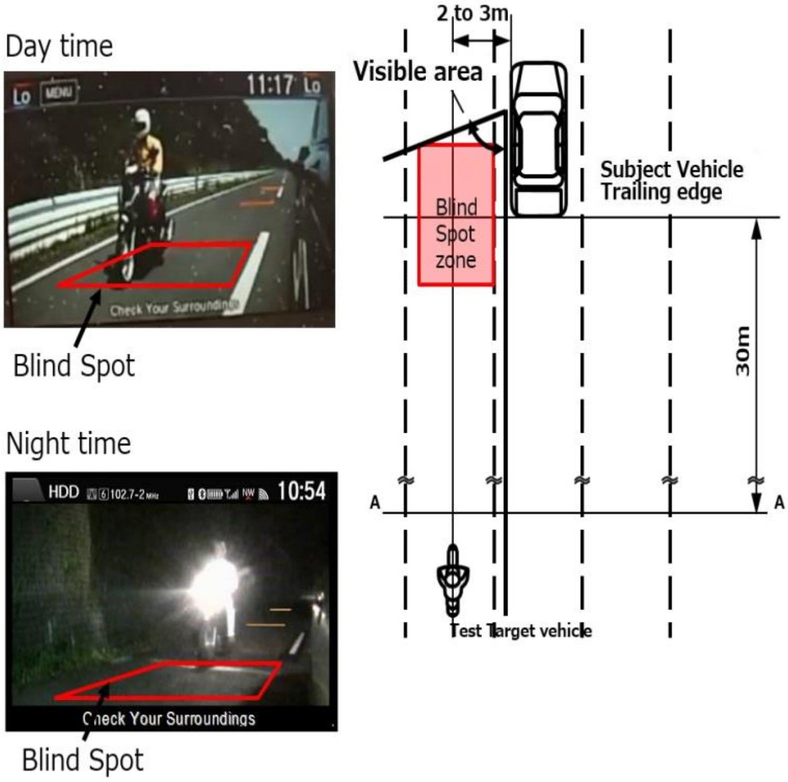


Figure 17: Zone requirements for BSV system live visual

* For assessment at night, the test needs to be conducted with a motorcycle with the head-light turned on.

3.14.8 Illustration

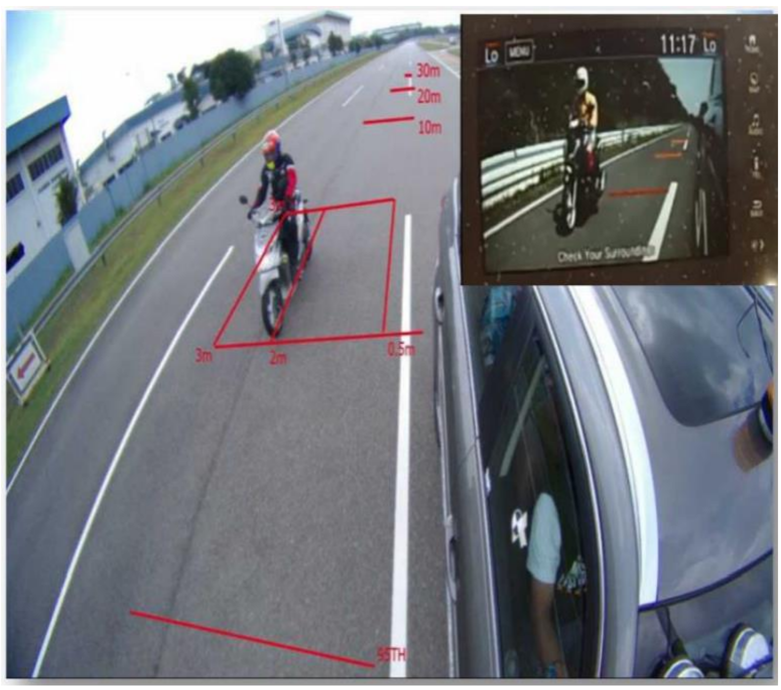


Figure 18: Video logger image of BSV test

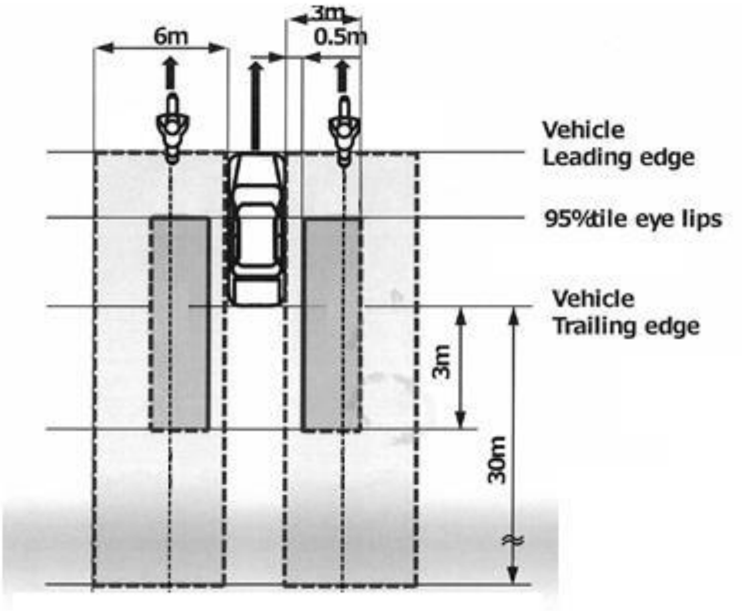


Figure 19: Blind Spot Zone

Ministry of Transportation and Communications

Taiwan New Car Assessment Program (TNCAP)

3.15 Electric Vehicle Post-Collision Electric Shock Protection Testing Protocol

V2.0
May 2024

TABLE OF CONTENTS

3.15.1 Introduction 3

3.15.2 Definition of Terms 3

3.15.3 Test Preparation 5

3.15.4 Test Conditions 5

3.15.5 Recording, Measurement Items, and Measurement Range 7

3.15.6 Treatment of Measured Values 9

3.15.7 Evaluation of Electrical Shock Protection Performance during Collision Test for Electric Vehicles 9

3.15.8 Protection from Direct Contact with Live Parts of Power System 10

3.15.9 Measurement of Isolation Resistance 12

3.15.10 Measurement of Residual Voltage 15

3.15.11 Measuring Residual Energy 16

3.15.1 Introduction

This test procedure and assessment apply to Performance Tests for Protection from Electrical Shock after a Collision of the tests conducted by TNCAP which are applicable to M1 category electric vehicles (excluding motor vehicles of which the electric motor operates at a working voltage of less than AC 30 V or DC 60 V).

The test shall be conducted as prescribed herein and according to the provisions of the Offset Frontal Impact Testing Protocol, Full Width Frontal Impact Testing Protocol, Side Impact Testing Protocol, and Pole Side Impact Testing Protocol.

3.15.2 Definition of Terms

3.15.2.1 "Power system": Electric circuits including those described in Section 3.15.2.1.1 to 3.15.2.1.6:

3.15.2.1.1 Traction motor, its accessory wire harness, connectors, etc.

3.15.2.1.2 Rechargeable energy storage system (REESS)

3.15.2.1.3 Electrical energy conversion system

3.15.2.1.4 Electronic converter (meaning devices capable of controlling or converting electric power, such as electronic control of the traction motor and DC/DC converters)

3.15.2.1.5 Auxiliaries related to running (heaters, defrosters, power steering systems, etc.)

3.15.2.1.6 Coupling system for the charging system

3.15.2.2 "High Voltage": The classification of an electric component or circuit, if its working voltage is direct current (DC) of > 60 V and ≤ 1,500 V or alternating current (AC) of 30 V and ≤ 1,000 V root mean square (rms).

3.15.2.3 "Working Voltage": The highest value of the voltage root mean square (rms) of an electric circuit, specified by the manufacturer, which may occur between any conductive parts in open circuit conditions or under normal operating conditions. If the electric circuit is divided by galvanic isolation, the working voltage is defined for each divided circuit, respectively.

3.15.2.4 "Rechargeable Energy Storage System (REESS)": The rechargeable energy storage system which provides electrical energy to the electric motor for propulsion.

3.15.2.5 "Coupling System for the Charging System": The electric circuit mainly used for charging the rechargeable energy storage system (REESS) from an external electrical power supply and is divided from the power system by galvanic isolation except when connected with an external power supply with a contactor or isolation transformer that opens or closes the electric circuit that includes the items indicated in Section 3.15.2.5.1 to 3.15.2.5.3 below:

3.15.2.5.1 Vehicle inlet (meaning part of the vehicle connected to the external power supply)

3.15.2.5.2 Wire harness, connectors, etc. between the vehicle inlet and the power system

3.15.2.5.3 Electric circuits galvanically connected to the electric circuits prescribed in Section 3.15.2.5.1 and 3.15.2.5.2.

3.15.2.6 "External Power Supply": Alternating or direct current electric power supply outside the vehicle.

3.15.2.7 "Cabin": The space for occupant accommodation, bounded by the roof, floor, side walls, doors, outside glazing, front bulkhead, and rear bulkhead, or rear gate as well as the electrical protection barriers and enclosures provided for protecting the occupants from direct contact with the live parts of the power system.

3.15.2.8 "Direct Contact": The contact of persons with the live parts of the power system.

3.15.2.9 "Live Parts": Conductive part(s) intended to be electrically energized in normal use.

3.15.2.10 "Indirect Contact": The contact of persons with exposed conductive parts.

3.15.2.11 "Protection Degree IPXXB": What is defined in Section 3.15.8, "Protection from Direct Contact with Live Parts of Power System."

3.15.2.12 "Exposed Conductive Part": Among the conductive parts which normally are not electrically energized but may become so under isolation failure conditions ("potential conductive parts"), those which can be easily touched without using tools. In such a case, whether the part can be easily touched or not is judged based on whether the part has a structure of protection degree IPXXB.

3.15.2.13 "Isolation Resistance": Isolation between the live parts of the power system and exposed conductive parts that can be touched and isolation between the live parts of the power system and electrical chassis.

3.15.2.14 "Residual Voltage": The voltage between (Vb) the positive side (V2) and the negative side (V1) of a high-voltage bus prescribed in Section 3.15.10 (on a vehicle with an automatic disconnect, the electric circuit on the side of the traction motor) and the electrical chassis; and the voltage between the positive side (V2) and the negative side (V1) of a high-voltage bus (on a vehicle with an automatic disconnect, the electric circuit on the side of the traction motor), measured between 5 and 60 seconds after a collision.

3.15.2.15 "Residual Energy": The energy present in the high-voltage parts of the power system measured between 5 and 60 seconds after a collision.

3.15.2.16 "Electrical Circuit": An assembly of connected live parts of the power system which is designed to be electrically energized in normal operation.

3.15.2.17 "High-Voltage Bus": The electric circuit, including the coupling system for charging the REESS, that operates on a high voltage.

3.15.2.18 "Electrical Circuit on the REESS Side": The part of the power system electric circuits, disconnected by the automatic disconnect, which includes the coupling system for charging the REESS.

3.15.2.19 "Electrical Circuit on the side of the Traction Motor": The part of the power system electric circuits disconnected by the automatic disconnect which includes the traction motor.

3.15.2.20 "Automatic Disconnect": A device that, when sensing an impact from a collision, separates the RESS side circuits from the traction motor side circuits.

3.15.2.21 "Electrical Chassis": A set made of conductive parts electrically linked together, whose electrical potential is taken as a reference.

3.15.2.22 "Electrical Energy Convergence System": A system (e.g. fuel cell) that generates and provides electrical energy for electrical propulsion.

3.15.2.23 "Electrical Protection Barrier": The part providing protection against direct contact, from any direction, with the high-voltage live parts.

3.15.2.24 "Enclosure": The part enclosing the internal units and providing protection against contact from any direction.

3.15.2.25 "Open Type Traction Battery": A type of battery requiring liquid and generating hydrogen gas released to the atmosphere.

3.15.3 Test Preparation

3.15.3.1 Data Provision from the Manufacturer

Manufacturers shall submit to TNCAP in advance the following data necessary to prepare the test.

(1) Specifications of the electric vehicle under test.

(2) Special matters to be confirmed concerning the test preparation and measurement procedure (confirmation relating to the test preparation and measurement method specific to the vehicle type being tested or certain vehicle types including the vehicle type.)

3.15.4 Test Conditions

3.15.4.1 Test Vehicle Conditions

3.15.4.1.1 Rechargeable Energy Storage System (REESS): The rechargeable energy storage system (REESS) shall be charged to its normal state of operation prescribed by the manufacturer, etc. Furthermore, if the RESS is an open type traction battery that is open to the atmosphere and needs water refilling, it shall be filled with electrolyte to the prescribed maximum amount.

3.15.4.1.2 Electronic Converter: The vehicle shall be subjected to a collision test with the electronic converter turned off, the working principle of the electronic converter having been clearly presented. To do so, other than turning the electronic converter off, necessary modification may be added such as modification of software programs.

3.15.4.1.3 Automatic Disconnect: The automatic disconnect shall operate normally upon collision; provided, however, that, in conducting the test, if TNCAP finds that operating conditions of the automatic disconnect prescribed by the manufacturer are not satisfied, the test may be conducted with the electric circuit on the REESS side disconnected from the electric circuit on the side of the traction motor.

3.15.4.2 Preliminary Preparations

3.15.4.2.1 Indicator Lamp Confirming the Operation of the Automatic Disconnect: A lamp allowing the state of operation of the automatic disconnect to be confirmed from outside the vehicle shall be provided at a conspicuous location on the side rear part of the vehicle to be tested; provided, however, that this shall not apply when the state of operation of the automatic disconnect can be confirmed easily with an operation indicator lamp provided inside the compartment.

3.15.4.2.2 Requirements for Protection from Electric Shock: Before conducting the test, the technical service shall make the preparations prescribed in paragraph 3.15.4.2.2.1; provided, however, that when offered by the manufacturer, the preparations prescribed in Section 3.15.4.2.2.2 to 3.15.4.2.2.4 shall be made.

3.15.4.2.2.1 Preparing for Measuring Indirect Contact

3.15.4.2.2.1.1 Points for measuring the resistance between conductive parts (except for the coupling system for the charging system) and the electrical chassis shall be determined. Necessary modifications may be made as appropriate so that resistance can be measured easily after the test.

3.15.4.2.2.1.2 The value of resistance shall be measured between the measurement points determined above and recorded in the test result record sheet.

3.15.4.2.2.2 Preparing for Measuring Isolation Resistance

3.15.4.2.2.2.1 The points for measuring the isolation resistance between the live part of the power system (except for the coupling system for the charging system) and exposed conductive parts that might come into contact with the test probe, and between the live part of the power system and the electrical chassis, shall be determined. Modifications may be made as appropriate so that resistance can be measured easily after the test.

3.15.4.2.2.2.2 The value of isolation resistance shall be measured between the measurement points determined above and recorded in the test result record sheet.

3.15.4.2.2.2.3 Stabilizing the Isolation Resistance: When the values measured above are found to be unstable due to the operation of the isolation resistance drop alarm, etc., modifications necessary for measurement may be made as needed by turning off or removing such devices. When removing such a device, it shall be demonstrated with drawings, etc. that such removal does not affect the isolation resistance between the live part of the power system and the electrical chassis.

3.15.4.2.2.3 Measuring Residual Voltage

3.15.4.2.2.3.1 The points for measuring the voltage in the high-voltage bus shall be determined.

3.15.4.2.2.3.2 After consulting the manufacturer and TNCAP, a device shall be installed that allows the voltage in the high-voltage bus to be measured at any time and the results shall be recorded as necessary.

3.15.4.2.2.4 Measuring Residual Energy

3.15.4.2.2.4.1 The points for measuring the residual energy inside the high-voltage parts of the power system in the high-voltage bus shall be determined.

3.15.4.2.2.4.2 After consulting the manufacturer and TNCAP, a device shall be installed that allows the voltage in the high-voltage bus to be measured at any time and the results shall be recorded as necessary.

3.15.4.2.3 Electrical Protection Barriers and Enclosures: An appropriate paint shall be applied to the electrical protection barriers and enclosures to allow checking for the leakage of electrolyte from the rechargeable energy storage system (REESS) after a collision as necessary.

3.15.4.2.4 Electrolyte and Other Aggregates: Aggregates other than electrolyte (substitute liquids for oil, fuel, etc.) shall be colored so that they can be distinguished or separated from electrolyte as necessary.

3.15.5 Recording, Measurement Items, and Measurement Range

3.15.5.1 Activation of Automatic Disconnect: After the collision test, whether the automatic disconnect was activated or not shall be checked and the result shall be recorded.

3.15.5.2 Requirements for Protection from Electric Shock

3.15.5.2.1 Requirements Regarding Direct Contact: After the collision test, it shall be checked whether the test probe came in direct contact with the live parts (except for the coupling system for the charging system) of the power system (except for the coupling system for the charging system) according to Section 3.15.8: Protection from Direct Contact with Live Parts of Power System, and the results shall be recorded; provided, however, that this shall not apply when protection from electric shock is checked as prescribed in Section 3.15.5.2.4 and 3.15.5.2.5.

3.15.5.2.2 Requirements Regarding Indirect Contact: After the collision test, measurements shall be made of resistance between the conductive parts determined before the test and the electrical chassis, except for the coupling system for the charging system, and it shall be checked where the conductive parts are located (whether there are inside or outside the cabin) as well as whether they are exposed conductive parts or not, and the results shall be recorded.

3.15.5.2.3 Requirements Regarding Isolation Resistance: If necessary from Section 3.15.4.2.2, after the collision test, the isolation resistance between the live parts of the power system (except for the coupling system for the charging system) determined before the test and the exposed conductive parts that came into contact with the test probe, and between the live parts of the power system (except for the coupling system for the charging system) and the electrical chassis, except for the coupling system for the charging system, shall be measured according to Section 3.15.9: Measurement of Isolation Resistance, and the results shall be recorded.

3.15.5.2.4 Requirements Regarding Residual Voltage: If necessary from Section 3.15.4.2.2, the maximum voltage shall be measured at a point in time between 5 seconds and 60 seconds after the collision and recorded. However, this excludes cases where protection from electric chock is confirmed as per Section 3.15.5.2.1.

3.15.5.2.5 Requirements Regarding Residual Energy: If necessary from Section 3.15.4.2.2, the maximum energy shall be measured and recorded at a point in time between 5 seconds and 60 seconds after the collision. However, this excludes cases where protection from electric chock is confirmed as per Section 3.15.5.2.1.

3.15.5.3 Requirements Regarding Electrolyte Leakage from the Rechargeable

Energy Storage System (REESS): The state of electrolyte leakage from the rechargeable energy storage system (REESS) shall be checked and recorded. Furthermore, if the system is an open type traction battery, this fact shall be recorded.

3.15.5.4 Requirements Regarding Fixation of the Rechargeable Energy Storage System (REESS): The state of fixation of the rechargeable energy storage system (REESS) shall be checked and recorded.

3.15.5.5 Photographed Data: Immediately after the test, characteristic parts of the rechargeable energy storage system (REESS) that are associated with its safety (e.g. fixation of the system) and their state shall be observed and recorded (photographs taken).

3.15.6 Treatment of Measured Values

3.15.6.1 The measured values of exposed amount of electrolyte shall be rounded off to one decimal place in units of L.

3.15.6.2 The resistance between the exposed conductive parts and the electrical chassis shall be rounded off to four decimal places in units of Ω.

3.15.6.3 The working voltage shall be rounded off to one decimal place in units of V.

3.15.6.4 The isolation resistance for 1 V of working voltage shall be rounded off to three significant figures.

3.15.6.5 The residual voltage shall be rounded off to one decimal place in units of V.

3.15.6.6 The residual energy shall be rounded off to two decimal places in module.

3.15.7 Evaluation of Electrical Shock Protection Performance during Collision Test for Electric Vehicles

3.15.7.1 Evaluation Procedure:

(1) Electrical Shock Protection Performance

(A) Direct contact: Protection against live parts of power systems shall meet IP code IPXXB.

(B) Indirect contact: The value of resistance to the electric chassis connected to exposed conductive parts and the electrical chassis that is accessible shall be less than 0.1 Ω with a current of 0.2 A or higher.

(C) Insulation resistance: The operating voltage of an AC circuit and a circuit that includes an AC circuit shall be 500 Ω / V or higher. The operating voltage shall be 100 Ω / V or higher when satisfying the requirements of IP code IPXXB and when the voltage of AC parts is 30 V or less. The operating voltage of a DC circuit shall be 100 Ω / V or higher.

(D) Residual voltage: Residual voltage of high-voltage parts as of 5 to 60 seconds after a collision shall be AC 30 V or less or DC 60 V or less.

(E) Residual energy: Energy of the high voltage parts of power systems as of 5 to 60 seconds after a collision shall be 2.0J or less.

(2) REESS Electrolyte Leakage Performance

(A) Electrolyte shall not leak into the passenger compartment.

(B) When there is electrolyte leakage to the outside of the passenger compartment, the amount of leakage in 30 minutes from the collision shall be 7% or less of the total electrolyte amount. However, for open-type traction batteries, the amount shall be 7% or less of the total electrolyte amount or 5 L or less.

(3) REESS Anchorage Performance

(A) For the REESS inside the passenger compartment, it shall be anchored in a prescribed position.

(B) For the REESS outside the passenger compartment, it shall not penetrate into the passenger compartment.

(4) Checking the Operation of Automatic Shutoff Device

(A) During a collision, the automatic shutoff device shall be activated and the high voltage circuit shut off.

3.15.7.2 Evaluation Results: When the vehicle meets the requirements for electric shock protection performance, REESS electrolyte leakage performance, REESS anchorage performance and operational check of the automatic shutoff device, compliance label (Figure 1) is given.

Figure 1: TNCAP Electric Vehicle Electrical Shock Protection Compliance Label

3.15.8 Protection from Direct Contact with Live Parts of Power System

3.15.8.1 Overview

Protection degree IPXXB regarding direct contact with the live parts of the power system (excluding the coupling system for the charging system) is as defined in this Attachment. Further, this Attachment applies to power systems of which the working voltage is not more than 1000 V for AC and 1500 V for DC. Furthermore, for the purpose of this Attachment, besides the live parts of the power system prescribed in Section 3.15.8.3.1 of the main text, the parts prescribed in Section 3.15.8.1.1 and 3.15.8.1.2 below are also regarded as live parts of the power system and judged as such.

3.15.8.1.1 The live parts of the power system that are coated with varnish or paint alone; provided, however, that this shall not apply to those which use varnish or paint for isolation.

3.15.8.1.2 The live parts of the power system that are protected by oxidization or similar treatment.

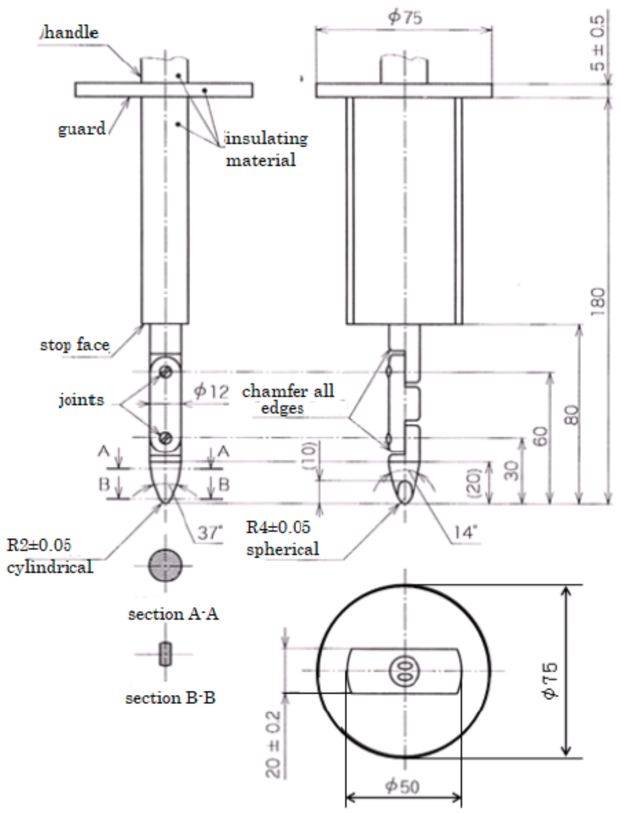
3.15.8.2 Testing Conditions

In principle, the test vehicle shall be in the state it was in immediately after the collision test.

3.15.8.2.1 Test Probe

3.15.8.2.1.1 The test probe to be used to check the protection degree is as prescribed in Table 1.

Table 1: Test Probe

<table>
<tr><th></th><th>Test Probe</th><th>Test Force</th></tr>
<tr><td>When testing in relation to protection degree IPXXB</td><td>

Materials: Metal, except where otherwise specified.
Linear dimensions in millimeters.
Tolerances on dimensions without specific tolerance:
On angles: +0' / -10'
On linear dimensions: when <25mm: +0mm / -0.05mm
when >25mm: ±0.2mm
Both joints shall permit movement in the same plane and the same direction through an angle of 90 degrees with a 0 to +10 degrees tolerance.</td><td>10N±10%</td></tr>
</table>

3.15.8.2.1.2 When checking the contact of the test probe with high-voltage live parts inside the electrical barriers, enclosures, etc. by a signal indication circuit method, a low voltage power supply (of not less than 40 V and not more than 50 V) in series with a suitable lamp shall be connected between the test probe and high-voltage live parts.

3.15.8.2.1.3 Additionally, when a signal indication circuit method is used, the parts prescribed in Section 3.15.8.1.1 and 3.15.8.1.2 above shall be covered with a conductive metallic film before the collision test and the metallic film shall be electrically connected to normal high-voltage live parts.

3.15.8.3 Test Method

3.15.8.3.1 Press the test probe against an opening of the electrical barriers, enclosures, etc. (meaning any gaps or openings in the electrical barriers, enclosures, etc. that are already present or that might be made when the test probe is pressed against them with the prescribed force) with the force prescribed in the "Test Force" column in Table 1.

3.15.8.3.2 If possible, the movable parts inside the enclosure shall be moved slowly.

3.15.8.3.3 If the test probe partially or fully penetrates into the opening, the probe shall be placed in every position that can be touched to check whether it can be touched or not (whether the lamp lights if the signal indicator lamp method is used; the same shall apply hereinafter in this Attachment). In such cases, starting from the straight position, both joints of the test finger shall be rotated progressively through an angle of 90 degrees with respect to the axis of the adjoining section of the finger and placed in every possible position to check whether it can touch them.

3.15.8.4 Criteria

3.15.8.4.1 The test probe shall not be able to contact high-voltage live parts.

3.15.8.4.2 The stop face of the test probe shall not be able to fully penetrate into the electrical protection barriers or enclosures through any opening.

3.15.8.4.3 When checking for contact by the signal indicator circuit method, the lamp shall not light.

3.15.9 Measurement of Isolation Resistance

Isolation resistance is measured by choosing either the method prescribed in Section 3.15.9.1 and 3.15.9.2 below as appropriate depending on the state of electric charge or isolation resistance of the live parts to be measured.

The range of electric circuits to be measured shall be clarified by submitting circuit drawings, etc. to TNCAP and the technical service in advance.

Additionally, modifications necessary for measuring the isolation resistance may be made as appropriate such as removing the cover, extracting measuring lines, and modifying software programs. When conducting the measurements, care shall be taken regarding the risk of short circuiting and electric shock because the method involves directly handling high-voltage circuits.

3.15.9.1 Measuring by Applying Direct Current from Outside

3.15.9.1.1 Measuring Tools: To measure the isolation resistance, an isolation resistance tester that can apply a direct current higher than the working voltage of high-voltage circuits shall be used.

3.15.9.1.2 Measuring Method

3.15.9.1.2.1 Connect an isolation resistance tester between the live parts and the electrical chassis or exposed conductive parts and apply a direct current higher than the working voltage of the high-voltage circuits; provided, however, that if parts may be damaged by overvoltage during measurement because the external direct current is combined with the voltage of the rechargeable energy storage system (REESS) or the isolation resistance tester cannot apply an appropriate voltage due to its properties, etc., measurements may be taken at a voltage lower than the working voltage or by removing relevant parts.

3.15.9.1.2.2 If measurement of the live parts of electric circuits to be measured shows that the requirement for isolation resistance is satisfied even taking the rechargeable energy storage system (REESS) into account or if the live parts to be measured are not charged, such measured values are regarded as values of isolation resistance. If the live parts to be measured are charged and the measured values do not satisfy the requirement for isolation resistance or the values of isolation resistance when the voltage of the REESS is taken into account do not satisfy the required isolation resistance, isolation resistance shall be measured by the method prescribed in Section 3.15.9.2.

3.15.9.2 Measurement Using Internal Power Supply for Direct Current: The isolation resistance between live parts (high-voltage bus) and the electrical chassis can be demonstrated either by measurement or by a combination of measurement and calculation.

3.15.9.2.1 When demonstrating isolation resistance by measurement, do the following:

3.15.9.2.1.1 Measure and record voltage (V_b) between the negative side and the positive side of the high- voltage bus. (See Figure 2)

3.15.9.2.1.2 Measure and record voltage (V_1) between the negative side of the high-voltage bus and electrical chassis. (See Figure 2)

3.15.9.2.1.3 Measure and record voltage (V_2) between the positive side of the high-voltage bus and the electrical chassis. (See Figure 2)

3.15.9.2.1.4 If V_1 is greater than or equal to V_2

3.15.9.2.1.4.1 Insert a standard known resistance (R_o) between the negative side of the high-voltage bus and the electrical chassis. With R_o installed, measure the voltage (V_1') between the negative side of the high-voltage bus and the vehicle electrical chassis. (see Figure 2)

Calculate the insulation resistance (R_i) using the formula:

$R_i = R_o \times (V_b/V_1' - V_b/V_1)$ or

$R_i = R_o \times V_b \times (1/V_1' - 1/V_1)$

3.15.9.2.1.4.2 Divide the result R_i, which is the electrical isolation resistance value in units of Ω, by the working voltage of the high-voltage bus in units of volt (V).

R_i (Ω / V) = R_i (Ω) / Working Voltage (V)

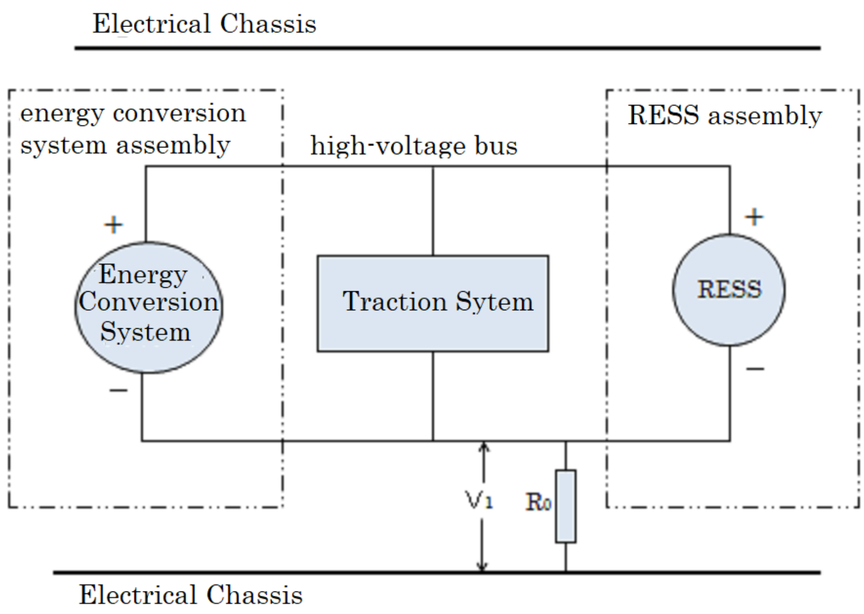


Figure 2: Measurement of V_1'

3.15.9.2.1.5 If V_2 is greater than V_1

3.15.9.2.1.5.1 Insert a standard known resistance (R_o) between the positive side of the high-voltage bus and the electrical chassis. With R_o installed, measure the voltage (V_2') between the positive side of the high-voltage bus and the vehicle electrical chassis (see Figure 3).

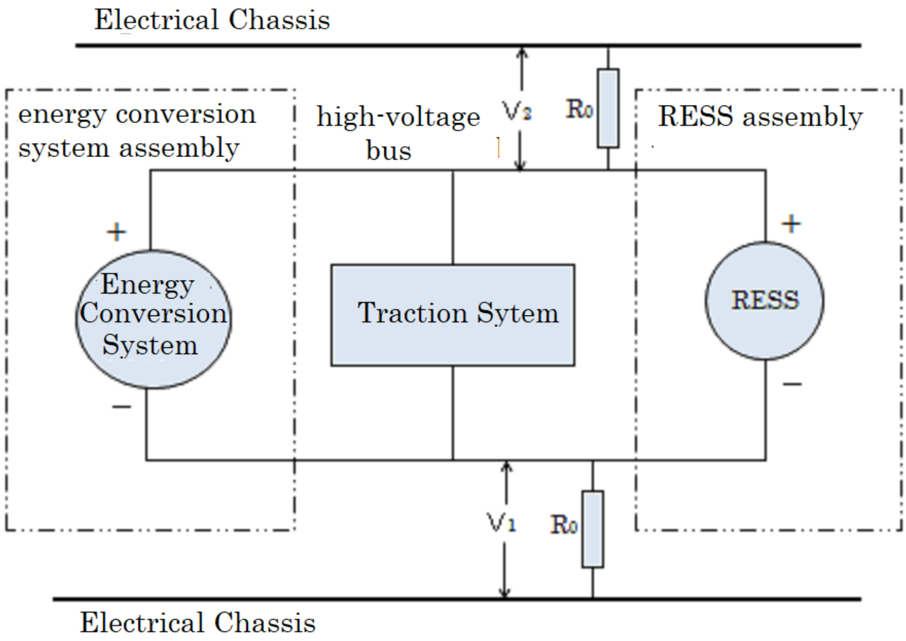
Calculate the insulation resistance (R_i) using the formula:

$R_i = R_o \times (V_b/V_2' – V_b/V_2)$ or

$R_i = R_o \times V_b \times (1/V_2' – 1/V_2)$

3.15.9.2.1.5.2 Divide the result R_i, which is the electrical isolation resistance value in units of Ω, by the working voltage of the high-voltage bus in units of volt (V).

$R_i\ (\Omega / V) = R_i\ (\Omega)$ / Working Voltage (V)



Note 1: Standard known resistance R_o (in units of Ω) is the value obtained by multiplying the minimum value of the required isolation resistance by the working voltage of the vehicle (in units of Ω/V) ±20%. Since this equation is valid for any R_o, R_o does not have to be strictly this value, but this range of R_o value provides a good resolution for voltage measurement.

Figure 3: Measurement of V_2'

3.15.10 Measurement of Residual Voltage

After the collision test, measure the voltages of the high-voltage bus (V_b, V_1, V_2) (see Figure 4). Voltage is measured at a point in time between 5 seconds and 60 seconds after the collision.

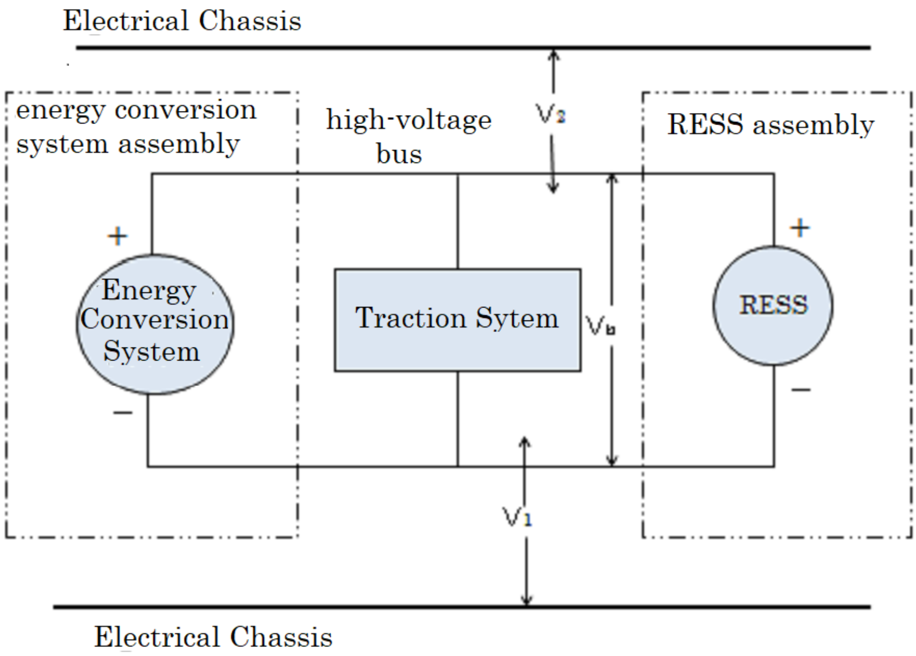


Figure 4: Measurement of V_b, V_1, and V_2

3.15.11 Measuring Residual Energy

Before conducting the collision test, connect switch S_1 and a known discharge resistance R_e with an appropriate capacitance in parallel (see Figure 5).

Close the switch S_1 at a point in time between 5 seconds and 60 seconds after the collision and measure and record voltage V_b and current I_e. Integrate the product of the voltage V_b and current I_e over the time elapsed between the moment switch S_1 is closed (t_c) and the moment voltage V_b falls below the high-voltage threshold 60 V DC (t_h).

$$(1) \qquad TE = \int_{tc}^{th} V_b \times I_e dt$$

When V_b is measured at a point in time between 5 seconds and 60 seconds after the collision and the capacitance of condenser X (C_x) is prescribed by the manufacturer, the total energy (TE) is calculated by the following formula:

$$(2) \qquad TE = 0.5 \times C_x \times (V_b^2 - 3{,}600)$$

When V_1 and V_2 (see Figure 5) are measured at a point in time between 5 seconds and 60 seconds after the collision and the capacitance of condenser Y (C_{y1}, C_{y2}) is prescribed by the manufacturer, the total energy (TE_{y1}, TE_{y2}) is calculated by the following formula:

$$(3) \qquad TE_{y1} = 0.5 \times C_{y1} \times (V_1^2 - 3{,}600)$$
$$TE_{y2} = 0.5 \times C_{y2} \times (V_2^2 - 3{,}600)$$

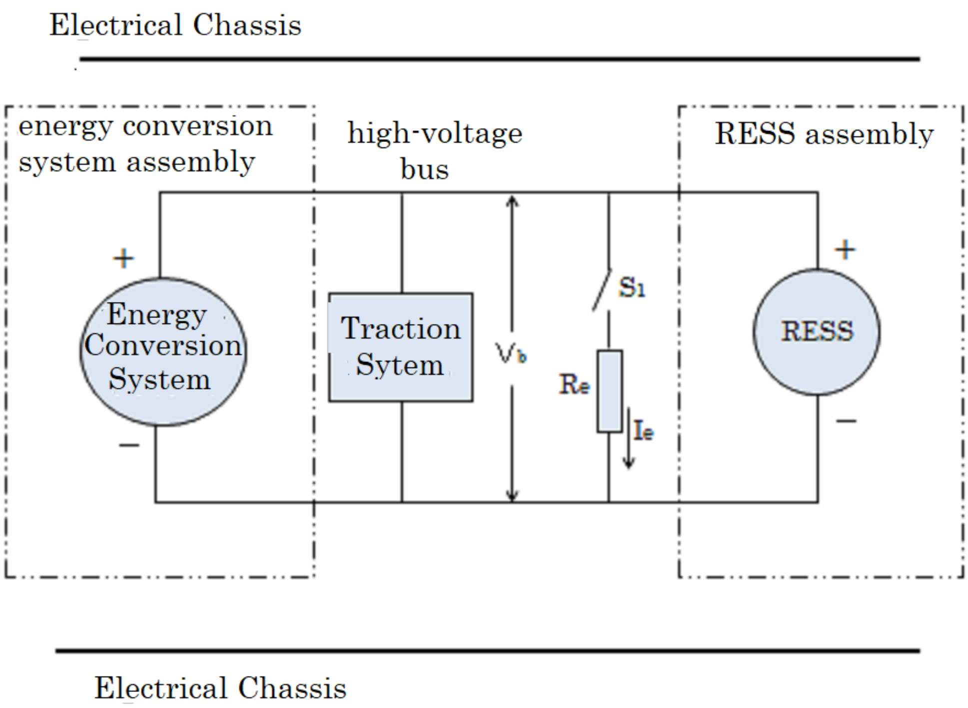


Figure 5: Measurement of high-voltage bus energy stored in condenser X