



**EUROPEAN NEW CAR ASSESSMENT PROGRAMME
(Euro NCAP)**

**FULL WIDTH FRONTAL IMPACT
TESTING PROTOCOL**

Version 1.2
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Preface

During the test preparation, vehicle manufacturers are encouraged to liaise with the laboratory and to check that they are satisfied with the way cars are set up for testing. Where a manufacturer feels that a particular item should be altered, they should ask the laboratory staff to make any necessary changes. Manufacturers are forbidden from making changes to any parameter that will influence the test, such as dummy positioning, vehicle setting, laboratory environment etc.

It is the responsibility of the test laboratory to ensure that any requested changes satisfy the requirements of Euro NCAP. Where a disagreement exists between the laboratory and manufacturer, the Euro NCAP secretariat should be informed immediately to pass final judgment. Where the laboratory staff suspect that a manufacturer has interfered with any of the set up, the manufacturer's representative should be warned that they are not allowed to do so themselves. They should also be informed that if another incident occurs, they will be asked to leave the test site.

Where there is a recurrence of the problem, the manufacturer's representative will be told to leave the test site and the Secretary General should be immediately informed. Any such incident may be reported by the Secretary General to the manufacturer and the person concerned may not be allowed to attend further Euro NCAP tests.

DISCLAIMER: Euro NCAP has taken all reasonable care to ensure that the information published in this protocol is accurate and reflects the technical decisions taken by the organisation. In the unlikely event that this protocol contains a typographical error or any other inaccuracy, Euro NCAP reserves the right to make corrections and determine the assessment and subsequent result of the affected requirement(s).

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1 VEHICLE PREPARATION

1.1 Unladen Kerb Mass

- 1.1.1 The capacity of the fuel tank will be specified by the manufacturer. This volume will be referred to throughout as the “fuel tank capacity”.
- 1.1.2 Syphon most of the fuel from the tank and then run the car until it has run out of fuel.
- 1.1.3 Calculate the mass of the fuel tank capacity using a density for petrol of 0.745g/ml or 0.840g/ml for diesel. Record this figure in the test details.
- 1.1.4 Put water, or other ballast, to this mass in the fuel tank.
- 1.1.5 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.
- 1.1.6 Ensure that the vehicle has its spare wheel on board along with any tools supplied with the vehicle. Nothing else should be in the car.
- 1.1.7 Ensure that all tyres are inflated according to the manufacturer’s instructions for half load.
- 1.1.8 Measure the front and rear axle weights and determine the total weight of the vehicle. The total weight is the ‘unladen kerb mass’ of the vehicle. Record this mass in the test details.
- 1.1.9 Measure and record the ride heights of the vehicle at all four wheels.

1.2 Reference Loads

- 1.2.1 Calculate 10 percent of the fuel tank capacity mass as determined in 1.1.3.
- 1.2.2 Remove this mass of ballast from the fuel tank, leaving 90 percent of the mass in the tank.
- 1.2.3 Place both front seats in their mid-positions. If there is no notch at this position, set the seat in the nearest notch rearward (this will be done more completely in Section 6).
- 1.2.4 Place a mass of equivalent to a Hybrid-III 05F dummy (57kg with instrumentation and cables) on the front driver seat and on the rear passenger seat at the opposite side.
- 1.2.5 Place 36kg in the luggage compartment of the vehicle. The normal luggage compartment should be used i.e. rear seats should 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.
- 1.2.6 For two seater vehicles only, the mass of the rear passenger shall not be included in the reference load. For vehicles with limited rear space, the rear passenger dummy shall be included in the reference load.
- 1.2.7 Roll the vehicle back and forth to ‘settle’ the tyres and suspension with the extra weight on board. Weigh the front and rear axle weights of the vehicle. These loads are the “axle reference loads” and the total weight is the “reference mass” of the vehicle.
- 1.2.8 Record the axle reference loads and reference mass in the test details.
- 1.2.9 Record the ride-heights of the vehicle at the point on the wheel arch in the same transverse plane as the wheel centres. Do this for all four wheels.
- 1.2.10 Remove the weights from the luggage compartment and the front and rear seats.

1.3 Vehicle Width

- 1.3.1 Determine the widest point of the vehicle ignoring the rear-view mirrors, side marker lamps, tyre pressure indicators, direction indicator lamps, position lamps, flexible mud-guards and the deflected part of the tyre side-walls immediately above the point of contact with the ground.
- 1.3.2 Record this width in test details.
- 1.3.3 Determine the centre-line of the vehicle and mark a line on the bonnet and bumper on the centre line of the car.
→ Take the pre-impact vehicle intrusion measurements at this point in time. See Chapter 2 for a full description of how to do this.

1.4 Vehicle Preparation

Care should be taken during vehicle preparation that the ignition is not switched on with the battery or airbag disconnected. This will result in an airbag warning light coming on and the airbag system will need to be reset. The manufacturer will need to be contacted if this occurs.

- 1.4.1 Ensure that the vehicle's battery is connected to the vehicle's electrical circuit in its standard position. Check that the dashboard light for the airbag circuit functions as normal. Alternatively, the vehicle battery acid may be drained or an additional live battery may be placed in the luggage compartment of the vehicle. If the supply from the drained battery is not supported by an additional battery, the test must be conducted within fifteen minutes after draining the battery. Where any additional battery is used it must be connected directly to the original battery so that the vehicle's original electrical system, cable routing and connections remain unaltered. The power cables connecting both batteries must be positioned on the non-struck side of the car in such a way to minimise the risk of the cable being cut during the impact. The cable used to connect both batteries must have a minimum cross section of 5mm^2 to ensure a minimum voltage drop. The current supplied to the vehicle must be monitored throughout the impact across the original battery. Where an additional battery is to be used the vehicle manufacturer will be required to indicate the minimum voltage/current needed during the test for all systems to operate as intended. The manufacturer will be asked to confirm that the laboratory modifications are suitable for use in the vehicle being tested and will not influence any of the vehicle systems.
- 1.4.2 In the event that the engine fluids are to be drained then drain the coolant, oil, air-conditioning (air conditioning refrigerant should be drained without venting it to the atmosphere) and Power Assisted Steering (PAS) fluids.
- 1.4.3 If the fluids are drained then measure the weights of each of these fluids, excluding the air conditioning fluid, and replace with an equivalent weight of water or other ballast.
- 1.4.4 Remove the luggage area carpeting, spare wheel and any tools or jack from the car. The spare wheel should only be removed if it will not affect the crash performance of the vehicle.
- 1.4.5 An emergency abort braking system may be fitted to the vehicle. This is optional; the test facility may elect to test without an abort system. Where such a system is fitted its inclusion shall not influence the operation or function of any of the foot controls, in particular the brake pedal. The position and the resistance to movement of the pedals shall be the same as prior to fitment of the system. Remove as little as possible of the interior trim; any mass compensation will be made when all equipment has been fitted.

- 1.4.6 Fit the on-board data acquisition equipment in the boot of the car. Also fit any associated cables, cabling boxes and power sources.
- 1.4.7 Place weights equivalent to a Hybrid-III 05F dummy (57kg) on the front driver seat and on the rear passenger seat at the opposite side of the car (with the seats in their test positions).
- 1.4.8 Weigh the front and rear axle weights of the vehicle. Compare these weights with those determined in Section 1.2.7.
- 1.4.9 If the axle weights differ from those measured in Section 1.2.7 by more than 5% (of the axle reference loads) or by more than 20kg, remove or add items which do not influence the structural crash performance of the vehicle. Similarly, if the total vehicle mass differs by more than 25kg from the reference mass, non-structural items may be removed or added. The levels of ballast in the fuel tank (equivalent in mass to 90% capacity of fuel) may also be adjusted to help achieve the desired axle weights. Any additional mass that is added to the vehicle should be securely and rigidly attached.
- 1.4.10 Repeat Sections 1.4.8 and 1.4.9 until the front and rear axle weights and the total vehicle weight are within the limits set in 1.4.9. Record the final axle weights in the test details.
- 1.4.11 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.
- 1.4.12 The vehicle manufacturer will be required to inform Euro NCAP and the test laboratory of the presence of any pre-crash systems that must be disabled prior to impact. Disabling information shall be provided to the laboratory prior to impact. It is the responsibility of the vehicle manufacturer to ensure that the disconnection of the system does not influence the performance of any systems that are intended to function during the impact.

2 INTRUSION MEASUREMENTS

For vehicle deformation and intrusion measurements a 3D measuring system which is capable of recording 3 dimensional co-ordinates of a point in space can be used. A tolerance of +/- 1mm is applicable to such a system. The system requires an axis system to be set up relative to the object to be measured, typically the transverse, longitudinal and vertical directions of a vehicle. An origin is first needed, followed by a point on the positive x axis and then a point in the positive x-y plane. Since the front of the vehicle is highly deformed after the impact, it is simplest to use some structure at the rear of the vehicle as a reference for measurement; this obviates the need to level the car after testing, the accuracy of which is limited. Most of the procedure which follows relates to the setting up of these axes.

2.1 Before Test

- 2.1.1 Determine and mark the centre of the clutch, brake and accelerator pedals.
- 2.1.2 Set the steering wheel to its mid-position, if it is adjustable for either rake or reach (for full description of how to do this, see Chapter 5).
- 2.1.3 Remove the centre of the steering wheel or, if fitted, the airbag assembly to expose the end of the steering column. When doing this, carefully note the connections to the airbag which will need to be remade on re-assembly. Follow the manufacturer's instructions when removing the airbag and/or steering wheel assemblies.
- 2.1.4 Determine and mark the centre of the top of the steering-column.
- 2.1.5 Remove the carpet, trim and spare wheel from the luggage compartment. The plastic trim or rubber seals that might influence the latching mechanism should be re-fitted once the intrusion measurements have been recorded. This is to ensure that any opening of the rear door during the impact is not caused by the omission of some part of the trim around the latching mechanism.
- 2.1.6 Locate the vehicle axis reference frame (see Figure 1) centrally to the rear of the vehicle.



Figure 1. Setting up axis reference frame.

- 2.1.7 Level the reference frame.
- 2.1.8 Measure and record the stud heights of the reference frame. These will be used after the test to help reset the reference frame, if required.
- 2.1.9 If it is necessary to lean on the vehicle to reach the following points, the vehicle should be supported to maintain the ride heights during measuring.
- 2.1.10 Set up the vehicle co-ordinate axes in the 3D arm or similar device.

- 2.1.11 Mark and record the position of at least 5 datum points on the rear of the vehicle. These points should be on structures which are not expected to be deformed in the test and should be positioned such that they have wide spaced locations in three dimensions and can all be reached with the 3D measuring system in one position.
- 2.1.12 Working on the passenger side of the vehicle determine and mark the positions on the B-post which are:
- a) at a distance of 100 mm above the sill.
 - b) at a distance of 100 mm beneath the lowest level of the side window aperture.
- All points should be as close as possible to the rubber sealing strip around the door aperture.
- 2.1.13 Measure and record the pre-impact positions of the two door aperture points.
- 2.1.14 Working on the driver's side of the vehicle determine and mark the positions on the A and B posts which are:
- a) at a distance of 100 mm above the sill.
 - b) at a distance of 100 mm beneath the lowest level of the side window aperture.
- All points should be as close as possible to the rubber sealing strip around the door aperture.
- 2.1.15 Use the arm to measure the pre-impact positions of the centre of the top of the steering-column and the four door aperture points.
- 2.1.16 Record the position of the centre of the un-depressed clutch, brake and accelerator pedals and where applicable foot operated parking brake. If the pedal is adjustable, set it to the mid position or a reasonable variation from this in accordance with the manufacturer's recommendations for the 5th percentile position.
- 2.1.17 Replace the steering wheel and airbag assembly. Check that all bolts are securely fastened. Ensure that all connections to the airbag are replaced and check the dashboard light to confirm the circuit is functional.

2.2 After Test

- 2.2.1 Before dummy removal measure the distance between all foot pedals and a fixed point in the footwell, e.g. seat runner, seat mounting bolt. If access cannot be gained remove the dummies, according to Section 7.4, taking care not to disturb any pedals and then record the measurement. This measurement should be re-checked before the pedals are measured with the 3D measuring system. If the pedal has moved re-position the pedal using the measurement taken previously.
- 2.2.2 Remove the dummies according to Section 7.4 and remove the data acquisition and emergency abort equipment (if fitted) from the luggage compartment.
- 2.2.3 Remove the centre of the steering wheel or airbag assembly.
- 2.2.4 Use any 3 of the 5 datum points at the rear of the vehicle, and their pre-impact measurements, to redefine the measurement axes.
- 2.2.5 If the axes cannot be redefined from any 3 of the datum points relocate the axis reference frame in the same position as in Section 2.1.6. Set the studs of the frame to the same heights as in Section 2.1.8 (Figure 2). The frame should now be in the same position relative to the car as it was before impact. Set up the measurement axes from the frame.
- 2.2.6 Record the post-impact positions of the B-post points on the passenger's side of the vehicle.
- 2.2.7 Compare the vertical co-ordinate of the B-post sill point before and after the test.

- 2.2.8 Find the angle θ that best satisfies the following equation: $z = -x'\sin\theta + z'\cos\theta$ for the B-post sill point (where z = pre impact vertical measurement and x',z' = post-impact longitudinal and vertical).
- 2.2.9 Working on the passenger's side of the vehicle, record the post-impact co-ordinates of the centre of the steering column, the centre of the clutch, brake and accelerator pedals, and where applicable a foot operated parking brake, with no load applied to them and in the blocked position (loaded with 200N to produce the maximum moment about the pedal pivot), the door aperture points. Prior to the 'blocked' pedal measurement, i.e. with the 200N applied, the brake fluid shall be removed to avoid the build-up of hydraulic pressure. If the steering column has become detached during impact due to the operation of the shear capsules, the column should be repositioned before measurement in the upward and lateral directions so that it is in contact with whatever structure(s) last constrained it from further movement. If any of the foot pedals become detached do not take a measurement of that pedal.
- 2.2.10 Transform the post impact longitudinal and vertical measurements (x',z') using the following equations.

$$\begin{bmatrix} X' \\ Z' \end{bmatrix} = \begin{bmatrix} \cos\theta & \sin\theta \\ -\sin\theta & \cos\theta \end{bmatrix} \begin{bmatrix} x' \\ z' \end{bmatrix}$$

- 2.2.11 Where θ is the angle determined in Section 2.2.8. X and Z should now be in the same frame of reference as the pre-impact measurements, assuming that the point on the passenger's side B-post sill is not displaced vertically or laterally during the impact.
- 2.2.12 From the pre-impact and adjusted post-impact data collected, determine
- the longitudinal, lateral and vertical movement of the centre of the top of the steering column.
 - the longitudinal and vertical movement of all of the foot operated pedals.
 - the rearward movement of the A-post at waist level.
 - the reduction in width of the door aperture at waist and sill levels.
- 2.2.13 Record these intrusion measurements in the test details.



Figure 2. Re-setting axis reference frame after test.

3 DUMMY PREPARATION AND CERTIFICATION

3.1 General

Hybrid III 05F test dummies should be used for the front driver seat and the second-row passenger seat, on the opposite side to the driver. They should conform to U.S. Department of transportation, Code of Federal Regulations Part 572 Subpart O, except for modifications and additions stated later. The parts of the dummy should be following the latest agreed brand harmonised design:

Part	Original manufacturer
Head	Denton
Neck	Denton
Upper Torso	FTSS
Arms	FTSS
Hands	Denton
Lower Torso	FTSS
Legs & Feet	FTSS

3.2 Additions and Modifications to the Hybrid III Dummies

The additions and modifications which will change the dynamic behaviour of the test dummies from Part 572 O specification dummies are:

- 3.2.1 Neoprene neck shields, with part number ABA-211-DN, must be fitted to the driver and rear passenger.
- 3.2.2 The harmonized jacket, according to SAE J2921, must be fitted to the driver and rear passenger.
- 3.2.3 The “Denton” lower leg cavity must be fitted to the driver and passenger.

3.3 Dummy Certification

Full details of the certification procedure for the Hybrid-III 05F dummy are available elsewhere (see Part 572 Subpart O of US Department of Transportation Code of Federal Regulations). No manufacturer shall have access to any pre-test information regarding any of the test equipment to be used by Euro NCAP, or be permitted to influence its selection in any way.

- 3.3.1 The Hybrid-III 05F dummies shall be re-certified after every THREE impact tests.
- 3.3.2 The chest shall be certified according to the frequency above and should meet both the low speed thorax test as prescribed by SAE J2878, as well as the full certification test detailed in CFR572. Additionally, chest potentiometer calibration and polynomial post processing shall also be performed as detailed in SAE J2517.
- 3.3.3 If an injury criterion reaches or exceeds its normally accepted limit (eg. HIC₁₅ of 700) then that part of the dummy shall be re-certified.
- 3.3.4 If any part of a dummy is broken in a test then the part shall be replaced with a fully certified component.
- 3.3.5 Copies of the dummy certification certificates will be provided as part of the full report for a test.

3.4 Dummy Clothing and Footwear

- 3.4.1 Each dummy will be clothed with formfitting cotton stretch garments with short sleeves and pants which should not cover the dummy's knees.
- 3.4.2 Each dummy shall be fitted with shoes equivalent to those specified in MIL-S-21711E (size 7½W).

3.5 Dummy Test Condition

- 3.5.1 Dummy Temperature
- 3.5.2 The dummy shall have a stabilised temperature in the range of 19°C to 22°C.
- 3.5.3 A stabilised temperature shall be obtained by soaking the dummy in temperatures that are within the range specified above for at least 5 hours prior to the test.
- 3.5.4 Measure the temperature of the dummy using a recording electronic thermometer placed inside the dummy's thorax. The temperature should be recorded at intervals not exceeding 10 minutes.
- 3.5.5 A printout of the temperature readings is to be supplied as part of the standard output of the test.
- 3.5.6 Dummy Joints
- 3.5.7 All constant friction joints should have their 'stiffness' set by the following method:
- 3.5.8 Stabilise the dummy temperature by soaking in the required temperature range for at least 5 hours.
- 3.5.9 The tensioning screw or bolt which acts on the constant friction surfaces should be adjusted until the joint can just hold the adjoining limb in the horizontal. When a small downward force is applied and then removed, the limb should continue to fall.
- 3.5.10 The dummy joints stiffness should be set as close as possible to the time of the test and, in any case, not more than 24 hours before the test.
- 3.5.11 Maintain the dummy temperature within the range 19°C to 22°C between the time of setting the limbs and up to a maximum of 10 minutes before the time of the test.
- 3.5.12 Dummy face painting
- 3.5.13 With the exception of the Hybrid-III face, the dummies should have masking tape placed on the areas to be painted using the size table below. The tape should be completely covered with the following coloured paints. The paint should be applied close to the time of the test to ensure that the paint will still be wet on impact.

Eyebrows (left and right)	Red
Top of head (rear passenger only)	Blue
Nose	Green
Chin	Yellow
Left Knee	Red
Right Knee	Green
Left Tibia (top to bottom)	Blue, Green, Red, Yellow
Right Tibia (top to bottom)	Yellow, Red, Green, Blue

Paint Area Sizes:

Eyebrow (L/R)	(25/2) x 50mm.
Top of Head	50 x 50mm square.
Nose	25 x 40mm strip, down nose centre line.
Chin	25 x 25mm square, centre line of chin.
Knee (L/R)	45 x 45mm square, knee centre line with bottom edge level with top of tibia flesh.
Tibia (L/R)	25mm x 50mm, 4 adjacent areas down leg centre line with top edge level with top of tibia flesh.

3.6 Post Test Dummy Inspection

The dummies should be visually inspected immediately after the test. Any lacerations of the skin or breakages of a dummy should be noted in the test specification. A dummy may have to be re-certified in this case.

4 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 should 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 should be supplied as part of the standard results of the test. Transducer mounting and sign convention is in accordance with SAE J211 (1995).

4.1 Dummy Instrumentation

The HIII-05F dummies shall be instrumented to record the channels listed below.

Location	Parameter	Minimum Amplitude	Driver No of channels	Rear Passenger No of channels
Head	Accelerations, $A_x A_y A_z$	250g	3	3
Neck	Forces	$F_x F_y$	2	2
		F_z	1	1
	Moments, $M_x M_y M_z$	290Nm	3	3
Chest	Accelerations, $A_x A_y A_z$	150g	3	3
	Deflection, D_{chest}	100mm	1	1
Pelvis	Accelerations, $A_x A_y A_z$	150g	3	3
Iliac (L & R)	Force, F_x	9kN	2	2
	Moment, M_y	220Nm	2	2
Lumbar Spine	Force, F_x, F_z	13kN	2	2
	Moment, M_y	500Nm	1	1
Femurs (L & R)	Forces, F_z	20kN	2	2
Knees (L & R)	Displacements, D_{knee}	19mm	2	
Upper Tibia (L & R)	Forces, $F_x F_z$	12kN	4	
	Moments, $M_x M_y$	400Nm	4	
Lower Tibia ¹ (L & R)	Forces, $F_x F_z (F_y)$	12kN	4	
	Moments, $M_x M_y$	400Nm	4	
Total Channels per Dummy			43	25
Total Channels			68	

1. Note that for both dummies the measurement of F_y is at the laboratory's discretion.

4.2 Vehicle Instrumentation

- 4.2.1 The vehicle is to be fitted with an accelerometer on each B-post. The accelerometers are to be fitted in the fore/aft direction (A_x).
- 4.2.2 Remove carpet and the necessary interior trim to gain access to the sill directly below the B-post.
- 4.2.3 Securely attach a mounting plate for the accelerometer horizontally on to the sill, without adversely affecting seat belt retractors and/or pretensioners.
- 4.2.4 Fix the accelerometer to the mounting plate. Ensure the accelerometer is horizontal to a tolerance of ± 1 degree and parallel to the X-axis of the vehicle.
- 4.2.5 Attach lightweight ($<100\text{g}$) seatbelt loadcells to the shoulder section of the driver and passenger seatbelts. The calibration procedure for the loadcells is detailed in Technical Bulletin 16.

Location	Parameter	Minimum Amplitude	No of channels
B-Post LHS	Accelerations, A_x	150g	1
B-Post RHS	Accelerations, A_x	150g	1
Driver Seatbelt Shoulder Section	Force, F_{diagonal}	16kN	1
Rear Passenger Seatbelt Shoulder Section	Force, F_{diagonal}	16kN	1
Battery (including any secondary batteries)	Supply voltage, V	15V	1
Total Channels per Vehicle			5

Where loadcells are to be placed on any seatbelts equipped with pretensioners, ensure that the loadcell is placed far enough away from the D-loop to ensure there is no interaction as the pretensioner fires.

4.3 Summary of Total Channels

1× Driver Hybrid-III	43
1× Rear Passenger Hybrid-III	25
1× Vehicle	5
Total Channels per Test	73

5.1 Driver Compartment Adjustments

Adjustment	Required Setting	Notes	Methods
Seat Fore/Aft	Initially Manufacturer's 5 th percentile design position	Permissible between fully forward and 25% of travel, measured in lowest position. Otherwise most forward.	Ensure feet position requirement
Seat Base Tilt	Manufacturer's 5 th percentile design position	Permissible up to mid position, when in 5 th percentile for/aft position Otherwise mid position	
Seat Height	Initially Manufacturer's 5 th percentile design position	Permissible between fully upward and 75% travel downwards, when in 5 th percentile for/aft position. Otherwise mid position	
Seat Back Angle	Manufacturer's 5 th percentile design position	Otherwise 23° to vertical, as defined by Torso angle	
Head Restraint Height	Lowest position		
Head Restraint Tilt	Manufacturer's 5 th percentile design position	Otherwise mid position	
Seat Lumbar Support	Manufacturer's 5 th percentile design position	Otherwise fully retracted	
Arm-rests (Front seats)	In-use position	May be stowed if dummy positioning does not allow in-use position	
Steering wheel - vertical	Mid position		
Steering wheel - horizontal	Manufacturer's 5 th percentile design position	Otherwise Mid position with a minimum horizontal distance to the dummy of 250mm measured from the centre of the steering wheel*	
Seat belt anchorage (where adjustable)	Initially Manufacturer's 5 th percentile design position	If no design position then set to lowest position	

* When below 250mm, first adjust the steering forward. If not sufficient, move seat rearward to achieve the minimum distance but ensure that the right foot maintains contact with the pedal as detailed in 6.4.8. The foot contact has a higher priority.

5.2 Rear Passenger Seat Adjustments

Adjustment	Required Setting	Notes	Methods
Rear Seat Facing	Forwards		
Rear Seat Lateral position	Most Outboard		
Rear Seat Fore/Aft	Manufacturer's design position	Where no details are provided in the handbook, set to mid	
Rear Seat Height	Manufacturer's design position	Feet need to be flat on the floor, if not or no design position set seat to lowest position	
Rear Seat Base Tilt	Manufacturer's design position	Permissible up to Mid Position	
Rear Seat Lumbar Support	Manufacturer's design position	Otherwise fully retracted	
Rear Seat Back Angle	Manufacturer's design position	Otherwise 23° to vertical or as close as possible to 23°, as defined by Torso angle	
Rear Head Restraint Height	Lowest in-use position		
Rear Head Restraint Tilt	Manufacturer's design position	Otherwise mid position	
Rear Seat Arm-rests	Stowed position		
Seat belt anchorage (where adjustable)	Initially, manufacturer's 5th percentile design position	If no design position then set to lowest position	

5.3 Other Vehicle Adjustments

Adjustment	Required Setting	Notes	Methods
Glazing	Front – Lowered Rear - Lowered or removed	This applies to opening windows only	
Gear change lever	In the neutral position		
Pedals	5th female position		
Doors	Closed, not locked	For automatic door locks, refer to the Rescue and Extrication protocol.	
Roof	Lowered	Where applicable	
Sun Visors	Stowed position		
Rear view mirror	Normal position of use		
Front passenger airbag	Disabled using vehicle switch where possible	Enable when testing with FSP	

5.4 Driver Seating Position for Test

- 5.4.1 Position the test seat's adjustable lumbar supports so that the lumbar supports are in the lowest, retracted or deflated adjustment positions.
- 5.4.2 Position any adjustable parts of the seat that provide additional support so that they are in the lowest or most open adjustment position.
- 5.4.3 Position an adjustable seat cushion length to the retracted position.
- 5.4.4 Position an adjustable leg support system in its rearmost position.
- 5.4.5 Place adjustable pedals in the full forward position (towards the front of the vehicle.)
- 5.4.6 Identify one seat cushion reference point at the rear side of the seat cushion (SCR_{REAR}).
- 5.4.7 Locate and mark the longitudinal centreline of the seat cushion.
- 5.4.8 Use the seat control that primarily moves the seat vertically to adjust the SCR_{REAR} to the upper most vertical location.
- 5.4.9 Use the seat control that primarily moves the seat fore-aft to adjust the SCR_{REAR} to the rear most location.
- 5.4.10 Use the seat control that primarily moves the seat vertically to adjust the SCR_{REAR} to the lowest vertical location.
- 5.4.11 Use the seat control that primarily moves the seat fore-aft to adjust the SCR_{REAR} to the rear most location. Record the position XRD.
- 5.4.12 Use the seat control that primarily moves the seat fore-aft to adjust the SCR_{REAR} to the forward most location. Record the position XFD.
- 5.4.13 Measure and mark the position at the manufacturer design position X05. If no design position given, X05 is the forward most location.
- 5.4.14 Use the seat control that primarily moves the seat fore-aft to adjust the SCR_{REAR} to the X05 position marked in 5.4.13.
- 5.4.15 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 manufactures design position. If no design position given, set cushion pitch to mid-angle. Note, for some vehicles this step may change the X05 position as established in 5.4.13, this is acceptable.
- 5.4.16 Use the seat control that primarily moves the seat vertically to adjust the SCR_{REAR} to the lowest vertical location. Record the position Z05D.
- 5.4.17 Use the seat control that primarily moves the seat vertically to adjust the SCR_{REAR} to the highest vertical location. Record the position Z05U.
- 5.4.18 Measure and mark a position at the manufacturer design position Z05. If no design position given, Z05 is the mid position of the vertical range.
- 5.4.19 Use the seat control that primarily moves the seat vertically to adjust the SCR_{REAR} to the Z05 position marked in 5.4.18. Note, for some vehicles this final step may change the X05 position established in 5.4.13 and/or the cushion pitch as established in 5.4.15, this is acceptable.
- 5.4.20 Record test seat base position co-ordinates of the SCR_{REAR}.

5.5 Front Passenger Seating Position for Test

- 5.5.1 The driver and passenger seatback angle and seat base position shall be set to the same position.
- 5.5.2 Where one seat is height adjustable and the other is fixed, the relative angle between the

seat back and the ground should be the same for both seats.

- 5.5.3 Repeat the steps in 5.4 to set the front passenger seat to the 05F seating position, identical to the driver.

5.6 Setting the Steering Wheel Horizontal Adjustment

- 5.6.1 Choose a part of the facia that is adjacent to the steering column and can be used as a reference.
- 5.6.2 Move the steering wheel to the most forward position of its travel.
- 5.6.3 Mark the steering column in line with an unmoving part of the facia. This corresponds to the most forward travel of the steering wheel.
- 5.6.4 Move the steering wheel to the most rearwards position of its travel.
- 5.6.5 Mark the steering column in line with an unmoving part of the facia. This corresponds to the most rearwards travel of the steering wheel.
- 5.6.6 Measure the distance between the forwards and rearwards marks on the steering column. Place a third mark on the steering column at the manufacturers design position. If no position is given, place a mark mid-way between the forwards and rearwards marks, which corresponds to the centre of travel of the steering wheel.
- 5.6.7 Move the steering wheel so that the mark on the steering column as established 5.6.6 aligns with the facia.
- 5.6.8 Lock the steering column at this position. The vehicle will be tested with the steering wheel in this position.

5.7 Setting the Steering Wheel Vertical Adjustment

The same method as in Section 5.6 should be used to find and set the steering wheel vertical adjustment to the mid position. It is unlikely that the same part of the facia used during the setting procedures for the horizontal adjustments could be used for the vertical adjustment. Care should be taken to avoid unintentional adjustment of the horizontal setting during the vertical adjustment procedure.

5.8 Setting the Rear Seat (if adjustable)

The same method as in 5.4 should be used to find and set the rear seat position to the specifications as detailed in 5.2.

5.9 Marking the Rear Dummy Head Excursion Lines

- 5.9.1 The Head Excursion Lines are:

- 450 mm forward of the rear dummy H-point $X_{AF05,dummy}$ as determined in section 6.1.2 (-2 points line)
- 550 mm forward of the rear dummy H-point $X_{AF05,dummy}$ as determined in section 6.1.2 (-4 points line)

However, none of the head excursion lines shall be more forward than the most rearward point on the seatback of the front passenger seat, when in the 5th female position. In this case the head excursion line(s) aligns with the most rearward point on the seatback of the front passenger seat, when in the 5th female position.

- 5.9.2 The rear passenger excursion lines shall be marked on the vehicle interior and exterior.

6 DUMMY POSITIONING AND MEASUREMENTS

The following chapter deals with all aspects of seating the dummy in the vehicle to be tested.

6.1 Determine the H-point

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 $75 \pm 10\text{kg}$ should 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.

6.1.1 Driver seat

6.1.1.1 Set the seat back so that the torso of the H-point machine is as close as possible to the manufacturer's reasonable recommendations for normal use or to the standard setting as detailed in 5.1

6.1.1.2 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.

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

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

6.1.1.3.2 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.

6.1.1.3.3 If the C/LO cannot be found with the procedures 6.1.1.3.1 through 6.1.1.3.3 the C/LO is located 381mm outboard from the vehicle centreline.

6.1.1.4 Apply thigh weights. Do not install legs and/or T-bar.

6.1.1.5 Tilt the back pan forwards to the end stop and draw the machine away from the seat-back. If required, it is allowed to temporarily adjust the steering wheel position to allow installation of the H-point machine. If the steering wheel is interfering with the H-point machine, the seat may be positioned more rearward or the steering wheel may be removed to allow installation of the H-point machine.

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

6.1.1.7 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.

6.1.1.8 Return the machine back to the seat back.

6.1.1.9 Install the right and left buttock weights.

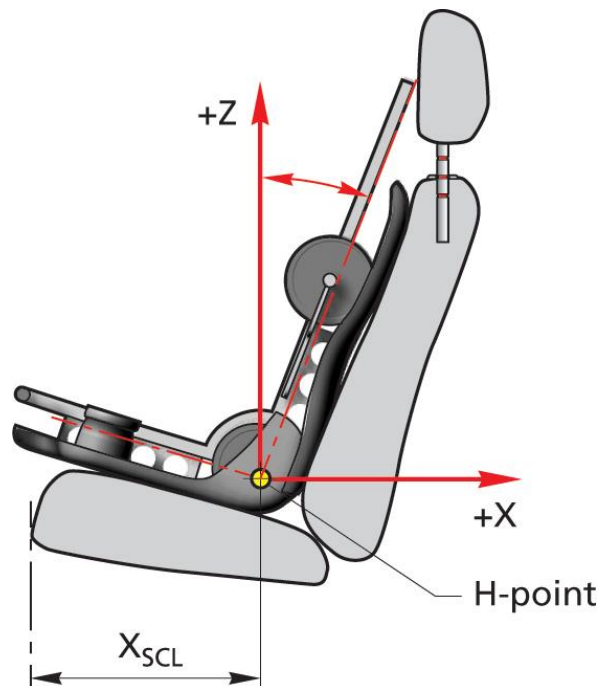
6.1.1.10 Apply the torso weights alternately left and right.

6.1.1.11 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. After rocking the T-bar should be parallel to the ground.

6.1.1.12 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.

6.1.1.13 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.

- 6.1.1.14 Adjust the seat back angle to the angle determined in 6.1.1.1, 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.
- 6.1.1.15 Measure and record in the test details the position of the H-point relative to some easily identifiable part of the vehicle structure
- 6.1.1.16 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
- 6.1.1.17 Use the following measurement and formula to calculate the H-point coordinates for the HIII-05F, where X_{SCL} is defined as the horizontal distance between the H-point and the most forward point on the seatbase cushion. Note that X_{AF05} should always be more forward than the X_{AM50} .



$$X_{AF05,dummy} = X_{AM50,H-point\ manikin} + (93mm - 0.323 \times X_{SCL})$$

$$Z_{AF05,dummy} = Z_{AM50, H-point\ manikin} - 6mm$$

- 6.1.2 Determine the H-point of the Rear Passenger's Seat
Follow the same procedure as described in 6.1.1 for the determination of the rear passenger's H-point.

6.2 Dummy Installation

It is the intention that the dummy should 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 than 1 hour prior to test. It is not acceptable for the dummy to be left in the vehicle overnight or for a similarly lengthy period.

6.3 Dummy Placement

If the vehicle has only two side doors, it may be necessary to fit the rear passenger

dummy before setting up the Hybrid-III 05F dummy in the front seat.

6.3.1 Ensure that the seat is in the correct position as defined by Section 6.1.

6.3.2 Place the dummy in the seat with the torso against the seat back, the upper arms against the seat back and the lower arms and hands against the outside of the upper leg.

6.4 Driver Dummy Positioning

Dummy positioning should be carried out immediately before the test and the vehicle should not be moved or shaken thereafter until the test has begun. If a test run is aborted and the vehicle brought to a standstill using an emergency braking method, the dummy placement procedure should be repeated. If the dummy, after three attempts cannot be positioned within the tolerances below then it is to be placed as close to the tolerance limits as possible. Record this in the test details.

6.4.1 H-point

The dummy's H-point shall be within 13mm in the vertical dimension and 13mm in the horizontal dimension of the H-point as determined in Section 6.1. Record the position of the dummy H-point in the test details.

6.4.2 Pelvic Angle

The pelvic angle measurement gauge should read $20^{\circ} \pm 2.5^{\circ}$ from the horizontal. Record the measured angle in the test details.

6.4.3 Head

The transverse instrumentation platform of the head shall be horizontal to within 2.5°

Levelling of the head shall be carried out in this order:

- Adjust the H-point within the limit
- Adjust the pelvic angle within the limits
- Adjust the neck bracket the minimum to ensure that the transverse instrumentation platform is level within limits.

Record the measured angle in the test details.

6.4.4 Arms

The driver's upper arms shall be adjacent to the torso as far as is possible

6.4.5 Hands

The driver dummy's hands shall have their palms placed against the steering wheel at a position of a quarter to three. The thumbs should be lightly taped to the wheel.

6.4.6 Torso

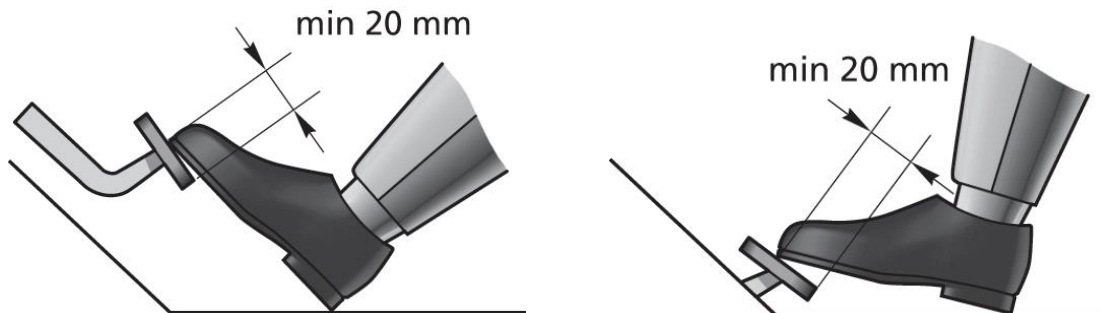
The dummy's backs should be in contact with the seat back and the centre line of the dummies should be lined up with the centre line of their respective seats.

6.4.7 Legs

The upper legs of the dummy shall be in contact with the seat cushion as far as possible. The initial distance between the knees of the dummy shall be $210\text{mm} \pm 5\text{mm}$ when measured at the outside metals surface of the knees. When the left foot is placed on a footrest or the right foot is positioned onto the accelerator pedal as described in 6.4.8 below, the distance between the knees may be altered. The legs of the dummies should be in vertical longitudinal planes as far as is possible.

6.4.8 Feet

The driver dummy's right foot shall be placed on the undepressed accelerator pedal with the heel on the floor. The right foot should overlap the accelerator pedal with at least 20mm.



When this is not the case and the seat is not in the foremost for/aft position, move the seat forward until sufficient contact between right foot and accelerator pedal can be achieved.

When it is not possible to achieve sufficient contact, follow the FMVSS 208 small female seating positioning procedure, where a support block is used to ensure contact with the pedal and floor.

If the right knee has been moved in order to place the right foot on the accelerator pedal, move the left knee and foot an equal distance so that the legs are symmetrical.

The left foot should be placed as flat as possible on the toe-board parallel to the centre line of the vehicle. If any part of the left foot is in contact with a foot-rest or wheel arch when in this position then place the foot fully on this rest providing a normal seating position can still be achieved. Keep the legs in the same vertical longitudinal plane. The knee gap requirement may be ignored in this case. Note the final knee gap in the test details.

6.4.9 Seat belt

6.4.9.1 Where possible, initially position the upper seat belt anchorage in the manufacturer's 5th percentile design position. If no design position is provided, set the adjustable upper seat belt anchorage to the lowest position.

6.4.9.2 Carefully place the seat belt across the dummy and lock as normal. It will be necessary to re-position the hands as described in Section 6.4.5.

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

6.4.9.4 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.

6.4.9.5 After following the above steps, the seatbelt should lie in a natural position across the dummy sternum assembly and shoulder clavicle. Where this is not the case, for example the belt is close to or in contact with the neck shield or the belt is above the shoulder rotation adjustment screw, and the upper belt anchorage is adjustable the anchorage should be lowered and steps 6.4.9.3 and 6.4.9.4 repeated.

- 6.4.9.6 The upper anchorage should be lowered by a sufficient amount to ensure a natural belt position following the repetition of steps 6.4.9.3 and 6.4.9.4 repeated. This may require multiple attempts.
- 6.4.9.7 Once the belt is positioned the location of the belt should 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.
- 6.4.9.8 Where the fitment of the shoulder belt loadcell significantly influences the natural position of the belt, the loadcell may be supported from above with the use of a weak non metallic wire or thread.

6.5 Rear Passenger Dummy Positioning

6.5.1 H-point

The dummy's H-point shall be within 13mm in the vertical dimension and 13mm in the horizontal dimension of the H-point as determined in Section 6.1.2. Record the position of the dummy H-point in the test details.

6.5.2 Pelvic Angle

The pelvic angle measurement gauge should read $20^{\circ} \pm 2.5^{\circ}$ from the horizontal. Record the measured angle in the test details. If pelvic angle cannot be achieved, use the design torso angle as a reference value.

6.5.3 Head

The transverse instrumentation platform of the head shall be horizontal to within 2.5°

Levelling of the head shall be carried out in this order:

- Adjust the H-point within the limit
- Adjust the pelvic angle within the limits
- Adjust the neck bracket the minimum to ensure that the transverse instrumentation platform is level within limits

Record the measured angle in the test details.

6.5.4 Upper limbs

The upper arms shall be positioned in contact with the seatback. The forearms and the hands shall be positioned as close as possible to the outer sides of the thighs while the little fingers are lightly in contact with the seat cushion. If there is interference by trim or other interior parts, the interfered upper limb shall be placed on the armrest of the same side to avoid any interference.

6.5.5 Torso

The dummy's backs should be in contact with the seat back and the centre line of the dummies should be lined up with the centre line of their respective seats.

6.5.6 Lower limbs

The upper legs of the dummy shall be in contact with the seat cushion as far as possible. The distance between the knees of the dummy shall be $210\text{mm} \pm 5\text{mm}$ when measured at the outside metal surfaces of the knees. The legs of the dummies should be in vertical longitudinal planes as far as is possible.

The legs shall be positioned as distant as possible from the front end of the rear seat cushion while the thighs are kept in contact with the seat cushion.

Each leg shall be lowered until the foot comes in contact with the floor while the foot and tibia are kept in a right angle to one another and the thigh inclination angle kept constant. When each heel is in contact with the floor, the foot shall be rotated so that the toe comes as much in contact as possible with the floor.

If it is not possible to have each foot in contact with the floor, the foot shall be lowered until the calf comes in contact with the front end of the seat cushion or the back of the foot comes in contact with the vehicle interior. The foot shall be kept as parallel as possible to the floor.

In case of interference by front seat anchorages or by a vehicle body protrusion, the foot shall be rotated as minimally as possible around the tibia. In case interference still remains, the femur shall be rotated to resolve or minimize the interference. The foot shall be moved inward or outward while the separation distance between the knees is kept constant.

In case of significant interference by the front seat in its test position or by a vehicle body protrusion, the leg shall be moved toward the occupant side by lifting and keeping the thigh as much in contact as possible with the rear seat cushion.

6.5.7 Finalization of torso position and readjustment of foot position (if any)

After manipulation of the lower limbs according to 6.5.6, the dummy position has to be reconfirmed in accordance with the prescriptions in 6.5.1 (H point), 6.5.2 (pelvic angle) and 6.5.3 (head angle). Any foot displacement during the final positioning of the torso should be undone.

6.5.8 Seat belt

6.5.8.1 Where possible, initially position the upper seat belt anchorage in the manufacturers 5th percentile design position. If no design position is provided, set the adjustable upper seat belt anchorage to the lowest position.

6.5.8.2 Carefully place the seat belt across the dummy and lock as normal. It will be necessary to re-position the upper limbs as described in Section 6.5.4

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

6.5.8.4 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.

6.5.8.5 After following the above steps, the seatbelt should lie in a natural position across the dummy sternum assembly and shoulder clavicle. Where this is not the case, for example the belt is close to or in contact with the neck shield or the belt is above the shoulder rotation adjustment screw, and the upper belt anchorage is adjustable the anchorage should be lowered and steps 6.5.8.3 and 6.5.8.4 repeated.

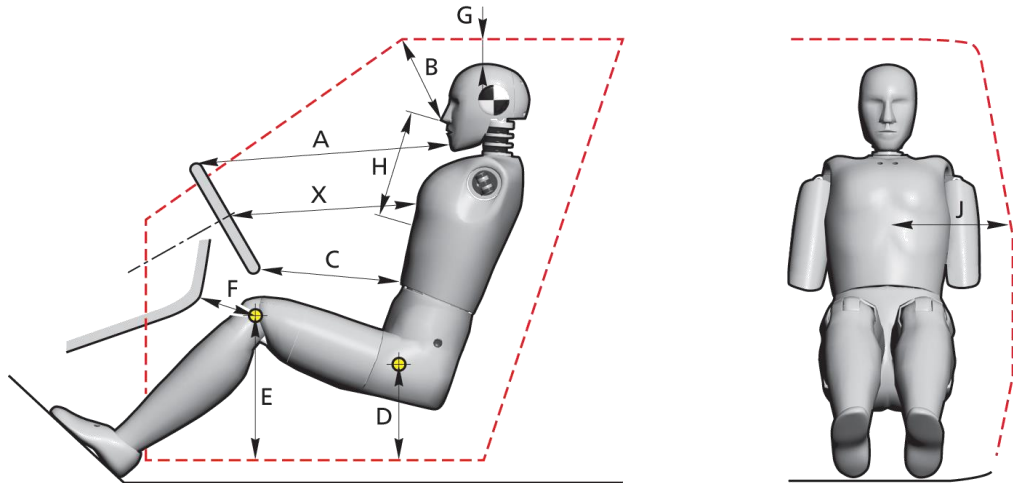
6.5.8.6 The upper anchorage should be lowered by a sufficient amount to ensure a natural belt position following the repetition of steps 6.5.8.3 and 6.5.8.4 repeated. This may require multiple attempts.

6.5.8.7 Where the fitment of the shoulder belt loadcell significantly influences the natural

position of the belt, the loadcell may be supported from above with the use of a weak non metallic wire or thread.

6.6 Dummy Measurements

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



Driver's Side		Rear Passenger's Side	
A	Chin to top of rim	A	Chin to front passenger seat
B	Nose to top edge of glass		
C	Stomach to rim	C	Stomach to front passenger seat
D	H-point to top of sill	D	H-point to top of sill
E	Knee bolt to top edge of sill	E	Knee bolt to top edge of sill
F	Knee bolt to top edge of bolster	F	Knee bolt to rear of front seat
G	Head to roof surface	G	Head to roof surface
H	Nose to webbing (vertically)	H	Nose to webbing (vertically)
J	Belt webbing to door (horizontally)	J	Belt webbing to door (horizontally)
θ	Neck Angle	θ	Neck Angle
	H-Point Co-ordinates (to vehicle)		H-Point Co-ordinates (to vehicle)

α	Seat back angle (as defined by torso angle)	α	Seat back angle (as defined by torso angle)
X	Chest to centre of steering wheel	β	Pelvic angle
β	Pelvic angle		

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 20kHz (alternatively a sample rate of 10kHz may be used). The equipment conforms to SAE J211.

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 brake pedal retraction mechanism which requires a vacuum present in the brake system, the engine may be run for a predetermined time, specified by the manufacturer.

7.1 Barrier

The barrier shall consist of a block of reinforced concrete not less than 3 m wide in front and not less than 1.5 m high. The barrier shall be of such thickness that it weighs at least 70 metric tons. The front face shall be flat, vertical and perpendicular to the axis of the run-up track. It shall be covered with plywood boards 20 ± 2 mm thick, in good condition.

If available install a high resolution loadcell wall (LCW) to the concrete block, with the plywood in front of the LCW. The height of this LCW should be $80\text{mm} \pm 2\text{mm}$ from the ground.

7.2 Speed

7.2.1 Measure the speed of the vehicle as near as possible to the point of impact.

7.2.2 This speed should be $50\text{km/h} \pm 1\text{km/h}$. Record the actual test speed in the test details.

$$\text{TARGET SPEED} = 50\text{km/h} \pm 1\text{km/h}$$

7.3 Door Opening Force

7.3.1 Refer to the Rescue and Extrication protocol for further details of post-test assessment.

7.4 Dummy Removal

7.4.1 Before dummy removal, refer to the Rescue and Extrication protocol for seat belt buckle unlatching

7.4.2 Do not move the seats. Try to remove the dummies.

7.4.3 If the dummies cannot be removed with the seats in their original positions, recline the seat back and try again. Note any entrapment of the dummy.

7.4.4 If the dummies can still not be removed, try to slide the seats back on their runners.

7.4.5 If the dummies can still not be moved, the seats can be cut out of the car.

7.4.6 Record the method used to remove the dummies.

7.5 Intrusion Measurements

Take the vehicle intrusion measurements. See Section 2.2 for a full description of how to do this.