Informal document GRSP-51-16
(51st GRSP, 21–25 May 2012,
agenda item 5(a))

Submitted by the expert from Australia

DRAFT PROPOSAL FOR A GLOBAL TECHNICAL REGULATION ON POLE SIDE IMPACT

Introduction

At its fourth and fifth meetings in Seoul in October 2011 and London in March 2012 the Informal Group on a Pole Side Impact GTR developed a draft proposal for the GTR, with drafts and comments also being considered out of session.

The purpose of this document is to provide GRSP with a copy of the draft GTR as it currently stands and invite members to comment either at this meeting or in writing to the Informal Group Secretariat (thomas.belcher@infrastructure.gov.au; cc robert.hogan@infrastructure.gov.au and mark.terrell@infrastructure.gov.au) by 7 June 2012. This will enable comments to be summarised and be considered by the Informal Group at its next meeting 20-21 June 2012 (dates to be confirmed).

Members of GRSP are also welcome to add their names to the mailing list of the Informal Group, so that they receive documents when they are emailed.

It is intended to submit the final proposal for the GTR (including the preamble) and technical report to GRSP in December 2012. This is with the aim of seeking adoption of the GTR at Working Party 29 in June 2013.

Issues

The Informal Group is still considering a number of major issues in the text of the regulation. These include:

- The purpose of the GTR (paragraph 1), particularly so that it does not appear to preclude other side impact tests
- The application/scope of the GTR and possible exemptions (paragraph 2)
- Injury criteria - determination of the best injury predictors and threshold values (paragraph 4.2)
- Fuel ballast requirements (Annex 1, paragraph 3.1-3.2)

- Impact velocity – this needs to be addressed in a way which caters for both self-certification and type approval systems, while not requiring manufacturers to undertake multiple tests to obtain type approval (Annex 1, paragraph 6.1)
- Drafting of provision to enable testing of Kei-car type vehicles to, initially at least, be conducted at a lower speed (26 km/h) (text to follow current Annex 1, paragraph 6.1
- WorldSID 50th percentile adult male dummy seating procedure to be drafted and agreed (Annex 2)

Members may particularly wish to comment on these issues.

Other issues will need to be thoroughly considered in development of the preamble such as safety need, benefits and costs and work is continuing on these.

A. STATEMENT OF TECHNICAL RATIONALE AND JUSTIFICATION

[to be drafted]

B. TEXT OF THE REGULATION

1. PURPOSE

The purpose of this regulation is to reduce the risk of serious and fatal injury of vehicle occupants in side impact crashes by limiting the forces, accelerations and deflections measured by anthropomorphic test devices in pole side impact crash tests. This may complement other side impact tests.

A Contracting Party may continue to apply any pre-existing domestic pole side impact requirements[1] using a 5th percentile adult female side impact dummy

Comment [tb21]: NHTSA to provide feedback and/or suggestions regarding suitability of this wording.

2. APPLICATION / SCOPE

This regulation shall apply to all Category 1-1 vehicles; Category 1-2 vehicles with a Gross Vehicle Mass of up to 4,500 kg; and Category 2 vehicles with a Gross Vehicle Mass of up to 4,500 kg.

A Contracting Party may restrict application of the requirements in its domestic legislation if it decides that such restriction is appropriate.

Comment [tb22]: Exemptions left out of draft for now – subject to ongoing discussions.

3. DEFINITIONS

3.1 ["Door Latch System" consists, at a minimum, of a latch and a striker].

3.2 "Fully Latched Position" is the coupling condition of the latch that retains the door in a completely closed position.

3.3 "Hinge" is a device used to position the door relative to the body structure and control the path of the door swing for passenger ingress and egress.

3.4 "H-point" means the pivot centre of the torso and thigh of the H-point machine when installed in a vehicle seat in accordance with Annex 2. Once determined in accordance with the procedure described in Annex 2, the "H" point is considered fixed in relation to the seat-cushion structure and is considered to move with it when the seat is adjusted.

3.5 "Impact Reference Line" is the line formed on the impact side of the test vehicle by the intersection of the exterior surface of the vehicle and a vertical plane

[1] Pre-existing pole side impact requirements are regulations or standards implemented in domestic legislation at the time this Global Technical Regulation is established in the Global Registry.

passing through the centre of gravity of the head of the dummy positioned in accordance with Annex 2, in the front row outboard designated seating position on the impact side of the vehicle. [The vertical plane forms an angle of [75°] with the vehicle longitudinal centreline. The angle is measured as indicated in Annex 4, Figure 4-1 (or Figure 4-2) for left (or right) side impact.]

3.6 "Latch" is a device employed to maintain the door in a closed position relative to the vehicle body with provisions for deliberate release (or operation).

3.7 ["Latched" means any coupling condition of the door latch system, where the latch is in a fully latched position, a secondary latched position, or between a fully latched position and a secondary latched position.]

3.8 ["Pitch Angle" is the angle of a front left or right door sill (as applicable) reference relative to a level surface or horizontal reference plane.]

3.9 "Pole" means a fixed rigid vertically oriented metal structure with a continuous outer cross section diameter of 254 mm ± [6] mm, beginning no more than 102 mm above the lowest point of the tyres on the impact side of the vehicle in its test reference mass condition, and extending at least above the highest point of the roof of the test vehicle.

3.10 "Rated Cargo and Luggage Mass" (RCLM) means the cargo and luggage carrying capacity of the vehicle, which is the mass obtained by subtracting the unladen vehicle mass and the rated occupant mass from the gross vehicle mass.

3.11 "Rated Occupant Mass" is the mass obtained by multiplying the total number of designated seating positions in the vehicle by 68 kg.

3.12 ["Roll Angle" is the angle of a front or rear bumper (as applicable) reference relative to a level surface or horizontal reference plane.]

3.13 "Striker" is a device with which the latch engages to maintain the door in the fully latched or secondary latched position.

3.14 "Three-dimensional H-point machine" (SAE H-point machine) means the device used for the determination of "H-points" and actual torso angles. This device is defined in Annex 3.

3.15 ["Test Reference Attitude" means the pitch/roll angle attitude of the test vehicle with all tyres fitted and inflated as recommended by the vehicle manufacturer and loaded to unladen vehicle mass, plus 136 kg or the rated cargo and luggage mass (whichever is less), secured in the cargo/luggage carrying area, plus the mass of the necessary anthropomorphic test device. The mass placed in the cargo/luggage carrying area is centred over the longitudinal centreline of the

vehicle. The mass of the necessary anthropomorphic test device is centred over the front outboard designated seating position on the impact side of the vehicle.]

3.16 "Test Reference Mass" means unladen vehicle mass, plus 136 kg or the rated cargo and luggage mass (whichever is less), plus the mass of the necessary anthropomorphic test device.

Comment [tb23]: NHTSA to consider use of SR1 unladen mass definition to define vehicle test mass.

3.17 ["Unladen Attitude" means the pitch/roll angle attitude of the unladen vehicle with all tyres fitted and inflated as recommended by the vehicle manufacturer].

3.18 "Useable Fuel Tank Capacity" means the fuel tank capacity specified by the vehicle manufacturer.

3.19 "Vehicle Reference Coordinate System" means an orthogonal coordinate system consisting of three axes, a longitudinal axis (X), a transverse axis (Y), and a vertical axis (Z). X and Y are in the same horizontal plane and Z passes through the intersection of X and Y. The X-axis is parallel to the longitudinal centre plane of the vehicle. [The vehicle reference co-ordinate system is established relative to defined vehicle reference points.]

3.20 ["Vehicle Master Control Switch" means the device by which the vehicle's on-board electronics system is brought from being switched off, as is the case when the vehicle is parked without the driver present, to the normal operating mode.]

3.21 "Vehicle Reference Fuel" means the fuel recommended by the vehicle manufacturer for the normal operation of the vehicle.

3.22 ["Vertical Longitudinal Plane" means a vertical plane parallel to the vehicle longitudinal centreline.]

3.23 ["Vertical Plane" means a vertical plane, not necessarily parallel to the vehicle longitudinal centreline.]

4. REQUIREMENTS

4.1 A vehicle tested in accordance with Annex 1, using a WorldSID 50th percentile adult male dummy[2], must meet the requirements of paragraphs 4.2, 4.4, and 4.5.

4.2 [WorldSID 50th Percentile Adult Male Performance Requirements

4.2.1 The injury criteria response values measured by a WorldSID 50th percentile adult male dummy in the front row outboard seating position on the impact side of a vehicle tested in accordance with Annex 1, must meet the requirements of paragraphs 4.2.2 to 4.2.6.

4.2.2 Head Injury Criteria

4.2.2.1 The HIC36 must not exceed [1000] when calculated in accordance with paragraph 1 of Annex 6.

4.2.2.2 [The BRIC must not exceed 1 when calculated in accordance with paragraph 2.1 of Annex 6.]

4.2.3 [Shoulder Performance Criteria

4.2.3.1 Shoulder rib deflection must not exceed [65] mm when calculated in accordance with paragraph 3.1 of Annex 6.

4.2.3.2 The lateral shoulder force (F_Y) must not exceed [2.56] kN when calculated in accordance with paragraph 3.2 of Annex 6.]

4.2.3.3

4.2.4 Thorax Performance Criteria

4.2.4.1 The maximum thorax rib deflection must not exceed [51][58] mm when calculated in accordance with paragraph 4.1 of Annex 6.

4.2.4.2 [The peak thorax viscous criterion must not exceed [0.82] m/s when calculated in accordance with paragraph 4.2 of Annex 6.]

4.2.5 Abdomen Performance Criteria

4.2.5.1 The maximum abdomen rib deflection must not exceed [58] mm when calculated in accordance with paragraph 5.1 of Annex 6.

4.2.5.2 [The peak abdomen viscous criterion must not exceed [0.82] m/s when calculated in accordance with paragraph 5.2 of Annex 6.

4.2.5.3 The lower spine acceleration must not exceed [75g] (1g = the acceleration due to gravity = 9.81 m/s^2), except for intervals whose cumulative duration is not more than 3ms, when calculated in accordance with paragraph 5.3 of Annex 6.]

[2] The technical specifications, detailed drawings and adjustment requirements of the WorldSID 50th percentile adult male dummy are specified in Special Resolution 2, Annex X.

Comment [tb24]: NHTSA proposed criteria to detect brain injury risks using dummy head rotation instrumentation and which may not otherwise be predicted by a translational acceleration based injury criteria such as HIC36.

Comment [tb25]: Some support to include a shoulder performance criteria to prevent excessive loading of the shoulder. Some reluctance in group to include shoulder performance criteria that may give shoulder injury risk reduction a higher priority than higher priority body regions such as the head and thorax.

Comment [tb26]: Medical College of Wisconsin likely to have further research completed on shoulder forces and shoulder injury risk for June WorldSID meeting.

Comment [tb27]: Shoulder injury risk curves available for AIS 2+ injury risk only.

Comment [tb28]: 30% AIS 3+ thorax injury risk threshold value for 45 year old male.

Comment [tb29]: 50% AIS 3+ thorax injury risk threshold value for 45 year old male.

Comment [tb210]: Subject to ongoing discussions regarding feasibility and the relative benefits to be achieved from using either thorax performance criteria requirement in the GTR.

Comment [tb211]: Australia and NHTSA to investigate benefits that may be obtained by using a lower thorax rib deflection threshold than 50% AIS 3+ injury risk for a 45 year old male.

Comment [tb212]: ISO group did not consider VC to be most reliable injury risk predictor. Some support for VC to be retained, perhaps with a higher limit value. NHTSA doing some work on VC for next meeting – research data may be able to be used to improve robustness of the VC injury risk curves.

Comment [tb213]: ISO injury risk curve group are recommending that deflection is the most suitable predictor of thorax and abdominal injury risk.

Comment [tb214]: Lower spine acceleration might detect injury risk transferred in a direction not measured by deflection sensor (e.g. late thorax airbag deployment to back of thorax).

4.2.6 Pelvis Performance Criteria

4.2.6.1 The pubic symphysis force must not exceed [3.36] kN when calculated in accordance with paragraph 6.1 of Annex 6.

4.2.6.2 [The pelvis acceleration must not exceed [111] g (1g = the acceleration due to gravity = 9.81 m/s^2), except for intervals whose cumulative duration is not more than 3ms, when calculated in accordance with paragraph 6.2 of Annex 6.]]

Comment [tb215]: NHTSA doing further work on pelvis acceleration for next meeting to see if there are any reasons for retention of a 3ms pelvis acceleration criteria.

Comment [tb216]: ISO injury risk curve group are recommending pubic symphysis force as the most suitable predictor of pelvis injury risk.

4.3 [Reserved].

4.4 Door Opening Requirements

4.4.1 Any side door that is struck by the pole shall not separate totally from the vehicle.

4.4.2 Any door (including a rear hatchback or tailgate) that is not struck by the pole shall meet the following requirements:

4.4.2.1 [The door shall remain latched];

4.4.2.2 The latch shall not separate from the striker;

4.4.2.3 The hinge components shall not separate from each other or from their attachment to the vehicle; and

4.4.2.4 Neither the latch nor the hinge systems of the door shall pull out of their anchorages.

4.5 Fuel System Integrity Requirements

4.5.1 [In the case of a vehicle propelled by fuel with a boiling point above 0 °C, liquid leakage from the fuel system[3] shall not exceed a total of [860g] during the 30 minute period following first vehicle contact with the pole].

Comment [tb217]: Revised wording proposed by Australia following review of FMVSS 301 requirements.

[3] [To ensure liquid leakage from the fuel system can be easily separated and identified, liquids from other vehicle systems may be replaced by the equivalent ballast mass (as per paragraph 3.3 of Annex 1).]

ANNEX 1

DYNAMIC POLE SIDE IMPACT TEST PROCEDURE

1. PURPOSE

1.1 Demonstration of compliance with the requirements of paragraph 4 of this regulation.

2. TEST EQUIPMENT

2.1 Test Vehicle Preparation Area

2.1.1 An enclosed temperature controlled area suitable for ensuring stabilization of the test dummy temperature prior to testing.

2.1.2

2.2 Pole

2.2.1 A pole satisfying the definition of paragraph 3.9 of this regulation, and offset from any mounting surface, such as a barrier or other structure, so that the test vehicle will not contact such a mount or support at any time within 100 ms of the initiation of vehicle to pole contact.

2.3 Anthropomorphic Test Devices

2.3.1 A WorldSID 50th percentile adult male dummy in accordance with Special Resolution 2, Annex [X] and fitted with (as a minimum) all instrumentation required to obtain the data channels necessary to determine the injury criteria response values listed in paragraph 4.2 of this regulation.

3. VEHICLE PREPARATION

3.1 [The fuel tank shall be filled with [water] [Stoddard Solvent] [water or Stoddard Solvent] of mass:

3.1.1 greater than or equal to the mass of the vehicle reference fuel required to fill [90] percent of the useable fuel tank capacity; and

3.1.2 less than or equal to the mass of the vehicle reference fuel required to fill [100] percent of the useable fuel tank capacity.

3.2 [Water] [Stoddard Solvent] [Water or Stoddard Solvent] shall be used to fill the entire fuel system from the fuel tank through to the engine induction system].

3.3 [The other (non-fuel) liquid containing vehicle systems may be empty, in which case, the mass of the liquids (e.g. brake fluid, coolant, transmission fluid) shall be replaced by the equivalent ballast mass].

Comment [tb218]: Subject to ongoing discussions regarding the equivalence of Water and Stoddard Solvent as fuel ballast.

3.4 The vehicle test mass, [including the mass of the necessary anthropomorphic test device and any necessary ballast mass, shall be within ±1 percent] of the test reference mass defined in paragraph 3.16 of this Regulation.

3.5 [The vehicle "as tested" front left and right side door sill pitch angles shall be between the corresponding unladen attitude door sill pitch angle and test reference attitude door sill pitch angle, inclusive.

3.6 Each corresponding "as tested", unladen and test reference pitch angle in paragraph 3.5 above shall be measured between the same linear reference and the same level surface or horizontal reference plane when the vehicle is in the "as tested" attitude, the unladen attitude and the test reference attitude respectively.

3.7 Each linear reference used to measure pitch angle in paragraph 3.6 above shall connect the same fixed reference points on the front left or right side door sill (as applicable).

3.8 The vehicle "as tested" front and rear bumper roll angles shall be between the corresponding unladen attitude bumper roll angle and test reference attitude bumper roll angle, inclusive.

3.9 Each corresponding "as tested", unladen and test reference roll angle in paragraph 3.8 above shall be measured between the same linear reference and the same level surface or horizontal reference plane when the vehicle is in the "as tested" attitude, the unladen attitude and the test reference attitude respectively.

3.10 Each linear reference used to measure roll angle in paragraph 3.9 above shall connect the same fixed reference points on the front or rear bumper (as applicable)].

Comment [tb219]: Test attitude clauses drafted by Australia based on FMVSS 214 S10.2 vehicle test attitude requirements.

4. VEHICLE PASSENGER COMPARTMENT ADJUSTMENTS

4.1 Adjustable Front Row Seats

4.1.1 Any seat adjustment, including any seat cushion, seatback, armrest, lumbar support, and head restraint shall be placed in the position of adjustment specified in Annex 2.

4.2 Adjustable Seat Belt Anchorages

4.2.1 Adjustable seat belt anchorages shall be placed in the position of adjustment specified in Annex 2.

4.3 Adjustable Steering Wheels

4.3.1 Adjustable steering wheels shall be placed in the position of adjustment specified in Annex 2.

4.4 Convertible Tops

4.4.1 Convertibles and open-body type vehicles shall have the top, if any, in place in the closed passenger compartment configuration.

4.5 Doors

4.5.1 Doors, including any rear hatchback or tailgate, shall be fully closed and fully latched, but not locked.

4.6 Parking Brake

4.6.1 The parking brake shall be engaged.

4.7 [Electrical System

4.7.1 The vehicle master control switch shall be in the "on" position].

4.8 Pedals

4.8.1 Any adjustable pedals shall be placed as specified in Annex 2.

4.9 Transmission

4.9.1 For a vehicle equipped with a manual transmission, the transmission shall be placed in second gear.

4.9.2 For a vehicle equipped with an automatic transmission, the transmission shall be placed in neutral.

4.10 Windows, Vents and Sunroofs

4.10.1 Moveable vehicle windows and vents located on the impact side of the vehicle shall be placed in the fully closed position.

4.10.2 Any sunroof(s) shall be placed in the fully closed position.

5. DUMMY PREPARATION AND POSITIONING

5.1 A WorldSID 50th percentile adult male dummy in accordance with paragraph 2.3.1 of this Annex shall be positioned in accordance with Annex 2, in the front outboard seat located on the impact side of the vehicle.

5.2 The test dummy shall be configured and instrumented to be struck on the side closest to the side of the vehicle impacting the pole.

5.3 The stabilised temperature of the test dummy at the time of the test shall be between 20.6 °C and 22.2 °C.

5.4 A stabilised dummy temperature shall be obtained by soaking the dummy at controlled test laboratory environment temperatures within the range specified in paragraph 5.3 above prior to the test.

5.5 The stabilised temperature of the test dummy shall be recorded by an internal dummy chest cavity temperature sensor.

6. VEHICLE-TO-POLE SIDE IMPACT TEST

6.1 A test vehicle prepared in accordance with paragraph 3, paragraph 4 and paragraph 5 of this Annex, shall be impacted at any velocity up to and including 32 km/h, with a stationary pole[1].

6.2 [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.

6.3 The angle in paragraph 6.2 above shall be measured between the vehicle longitudinal centreline and a vertical plane parallel to the vehicle impact velocity

Comment [tb220]: UK suggested wording.

Comment [tb221]: Concept under discussion: Allow for testing of Kei-car or Kei-car type vehicles at either 32km/h or 26km/h – with 26 km/h subject to sunset or review (see Article 4, paragraph 4.2 of the 1998 Agreement). NHTSA to suggest appropriate wording.

Comment [tb222]: Different speeds and type approval issues associated with this may need to be handled in the preamble.

[1] [Based on a determination by each Contracting Party or regional economic integration organisation, "any velocity up to and including 32 km/h" may be limited in domestic legislation to "31.5 ± 0.5 km/h".]

vector, as indicated in Annex 5, Figure 5-1 (or Figure 5-2) for left (or right) side impact].

6.4 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.

Comment [tb223]: NHTSA to advise on acceptability of tighter 25mm impact alignment tolerance.

6.5 During the acceleration phase of the test prior to first contact between the vehicle and the pole, the acceleration of the test vehicle shall not exceed [1.5 m/s^2].

ANNEX 2

WORLDSID 50TH PERCENTILE ADULT MALE SEATING PROCEDURE

[RESERVED]

ANNEX 3

DESCRIPTION OF THE THREE-DIMENSIONAL H-POINT MACHINE [1]/

(3-D H Machine)

1. BACK AND SEAT PANS

The back and seat pans are constructed of reinforced plastic and metal; they simulate the human torso and thigh and are mechanically hinged at the "H" point. A quadrant is fastened to the probe hinged at the H-point to measure the actual torso angle. An adjustable thigh bar, attached to the seat pan, establishes the thigh centreline and serves as a baseline for the hip angle quadrant.

2. BODY AND LEG ELEMENTS

Lower leg segments are connected to the seat pan assembly at the T bar joining the knees, which is a lateral extension of the adjustable thigh bar. Quadrants are incorporated in the lower leg segments to measure knee angles. Shoe and foot assemblies are calibrated to measure the foot angle. Two spirit levels orient the device in space. Body element weights are placed at the corresponding centres of gravity to provide seat penetration equivalent to a 76 kg male. All joints of the 3-D H machine should be checked for free movement without encountering noticeable friction.

[1]/ For details of the construction of the 3-D H machine refer to SAE International (SAE), 400 Commonwealth Drive, Warrendale, Pennsylvania 15096, United States of America (SAE J826 1995 version). The machine corresponds to that described in ISO Standard 6549: 1999.

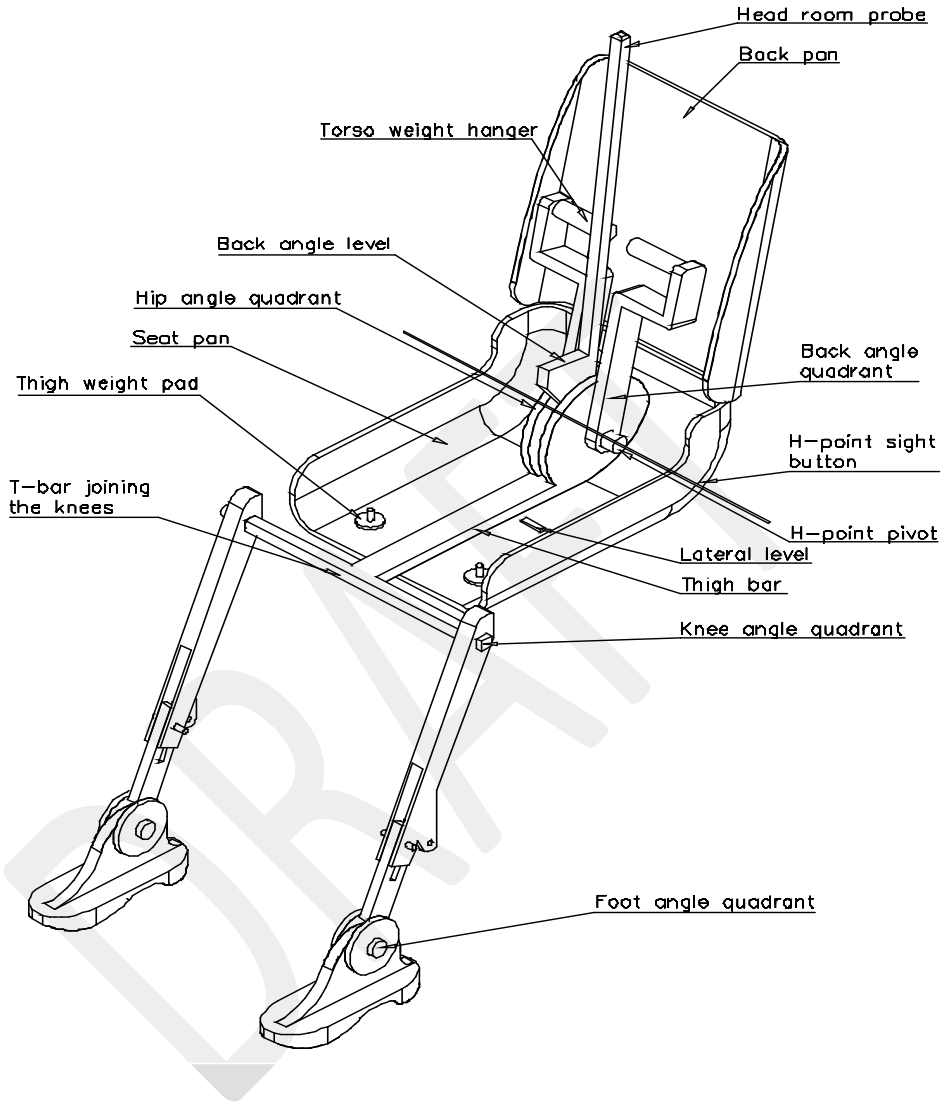

Figure 3-1 – 3-D H machine elements designation

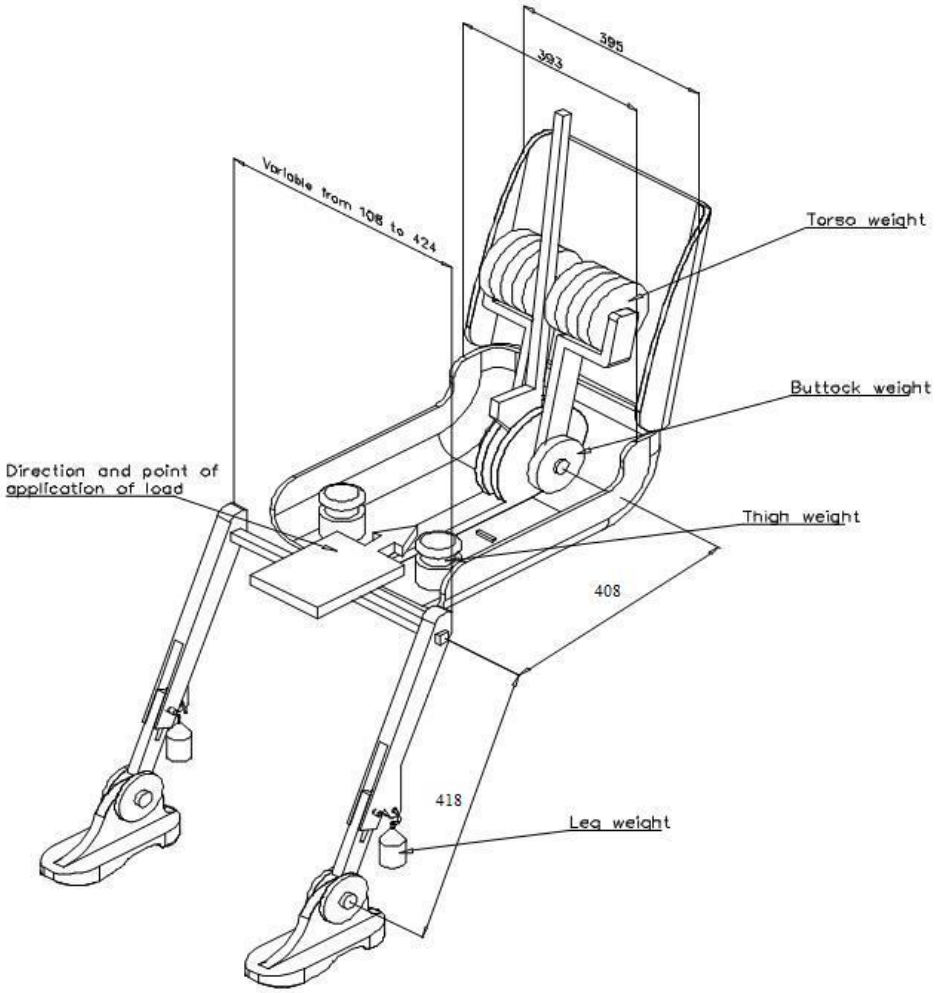

Figure 3-2 – Dimensions of the 3-D H machine elements and load distribution

(Dimensions in millimeters)

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ANNEX 4

Comment [tb224]: Inserted to enable simplification of impact reference line definition and improve clarity.

IMPACT REFERENCE LINE

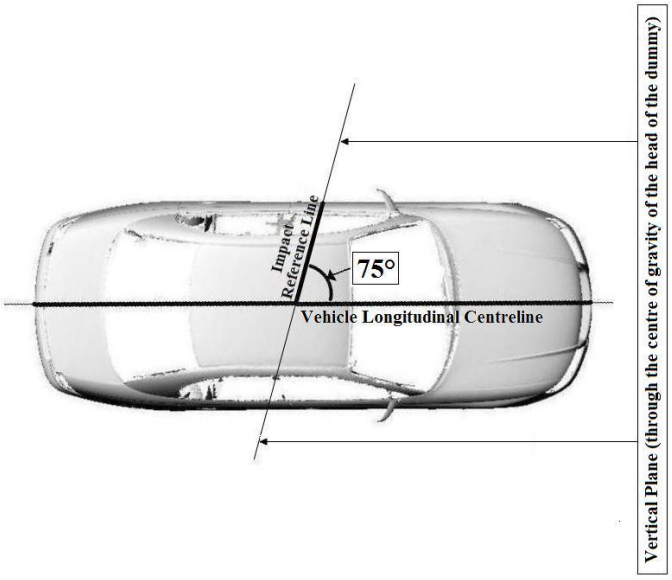

Figure 4-1 – vehicle to be impacted on left side (overhead plan view)

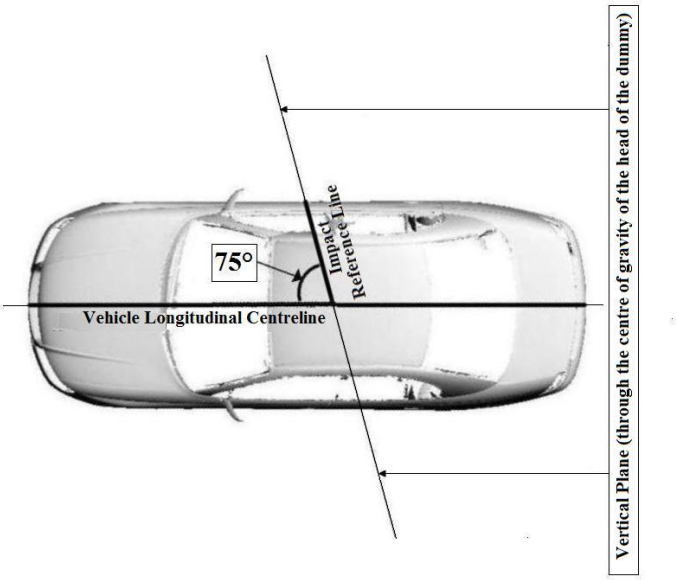

Figure 4-2 – vehicle to be impacted on right side (overhead plan view)

ANNEX 5

Comment [tb225]: Inserted to allow simplification of angle of impact related clauses and improve clarity.

IMPACT ANGLE

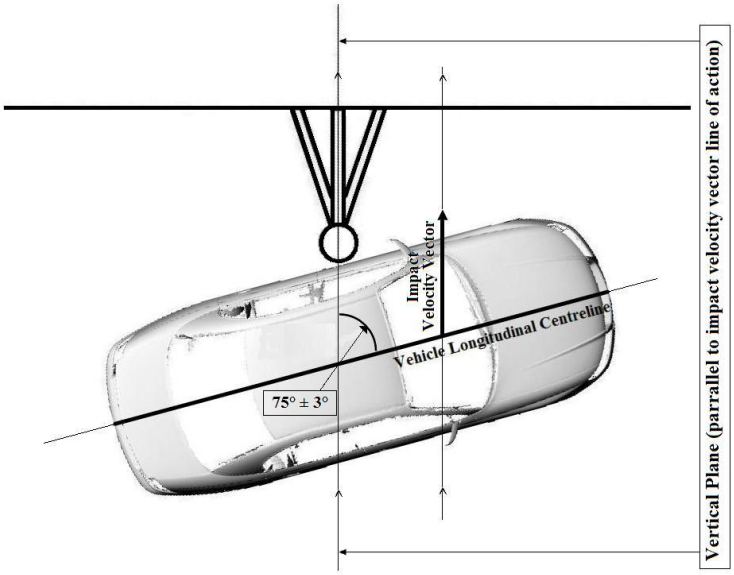

Figure 5-1 – left side impact (overhead plan view)

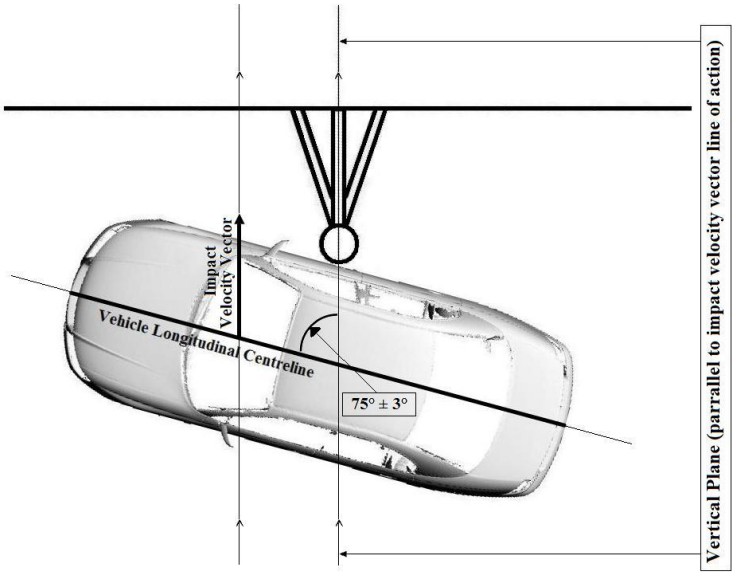

Figure 5-2 – right side impact (overhead plan view)

ANNEX 6

DETERMINATION OF WORLDSID 50TH PERCENTILE ADULT MALE PERFORMANCE CRITERIA

1. HEAD INJURY CRITERION (HIC36)

1.1 The Head Injury Criterion is the maximum value calculated from the expression:

$$\mathrm{HIC36} = \left[\frac{1}{(t_2 - t_1)} \int_{t_1}^{t_2} a_R \, dt\right]^{2.5} (t_2 - t_1)$$

Where:

a_R = the resultant translational acceleration at the centre of gravity of the dummy head recorded versus time in units of gravity, g (1 g = 9.81 m/s^2); and

t_1 and t_2 are any two points in time during the impact which are separated by not more than a 36 millisecond time interval and where t_1 is less than t_2.

1.2 The resultant acceleration at the centre of gravity of the dummy head is calculated from the expression:

$$a_R = \sqrt{a_X^2 + a_Y^2 + a_Z^2}$$

Where:

a_X = the longitudinal (x-axis) acceleration at the centre of gravity of the dummy head recorded versus time and filtered at a channel frequency class (CFC)[1] of 1000 Hz;
a_Y = the lateral (y-axis) acceleration at the centre of gravity of the dummy head recorded versus time and filtered at a CFC of 1000 Hz; and
a_Z = the vertical (z-axis) acceleration at the centre of gravity of the dummy head recorded versus time and filtered at a CFC of 1000 Hz.

[1] For details of each Channel Frequency Class (CFC) refer to SAE Recommended Practice J211/1 (revision December 2003).

2 [BRAIN INJURY CRITERION

2.1 The Brain Injury Criterion (BRIC) is the value calculated from the expression:

$$BRIC = \frac{\omega_{max}}{\omega_{critical}} + \frac{\alpha_{max}}{\alpha_{critical}}$$

Where:

ω_{max} = the maximum resultant rotational velocity recorded at the centre of gravity of the dummy head in units of rad/s and filtered at a CFC of 1000 Hz;
α_{max} = the maximum resultant rotational acceleration recorded at the centre of gravity of the dummy head in units of rad/s^2 and filtered at a CFC of 1000 Hz;
$\omega_{critical}$ = 153.18 rad/s; and
$\alpha_{critical}$ = 11,527.92 rad/s^2;]

Comment [tb226]: BRIC calculation paragraph inserted by Australia based on ESV paper 11-0263.

3 [SHOULDER PERFORMANCE CRITERIA

3.1 The shoulder rib deflection is determined in accordance with [insert reference standard / GTR here] from the voltage output measurements recorded by the deflection sensor mounted between the struck side shoulder rib mounting bracket and central spine box ball joint assembly, and filtered at a CFC of 600 Hz.

3.2 The longitudinal (x-axis), lateral (y-axis) and vertical (z-axis) shoulder forces are measured by the load cell mounted between the shoulder clevis assembly and the shoulder rib doubler. The peak resultant shoulder force is calculated from the expression:

$$F_R = \sqrt{F_X^2 + F_Y^2 + F_Z^2}$$

Where:

F_X = the longitudinal (x-axis) shoulder force recorded versus time and filtered at a CFC of 600 Hz;
F_Y = the lateral (y-axis) shoulder force recorded versus time and filtered at a CFC of 600 Hz; and
F_Z = the vertical (z-axis) shoulder force recorded versus time and filtered at a CFC of 600 Hz.]

4 THORAX PERFORMANCE CRITERIA

4.1 The maximum thorax rib deflection is the maximum deflection of any (upper, middle or lower) thorax rib, as determined in accordance with Special Resolution 2, Annex [X] from the voltage output measurements recorded by the deflection sensor mounted between the accelerometer mounting bracket and central spine box ball joint assembly inside each struck side thorax rib, and filtered at a CFC of 600 Hz.

4.2 [The peak thorax viscous criterion response is the maximum value of VC on any (upper, middle or lower) thorax rib which is calculated from the instantaneous product of the thorax rib deflection as a proportion of the half thorax width, and the velocity of thorax rib deflection derived by differentiation of the deflection with respect to time:

$$VC = Max\left[\frac{D}{0.17} \cdot \frac{dD}{dt}\right]$$

Where:

D = thorax rib deflection (metres) filtered at a CFC of 600 Hz

$$\frac{dD}{dt} = \frac{8[D_{(t+1)} - D_{(t-1)}] - [D_{(t+2)} - D_{(t-2)}]}{12dt}$$

t = time (s)

For the purposes of this calculation the standard width of the half thorax rib cage is 170 mm (0.17 m).]

5 ABDOMEN PERFORMANCE CRITERIA

5.1 The maximum abdomen rib deflection is the maximum deflection of any (upper or lower) abdomen rib, as determined in accordance with Special Resolution 2, Annex [X] from the voltage output measurements recorded by the deflection sensor mounted between the accelerometer mounting bracket and central spine box ball joint assembly inside each struck side abdomen rib, and filtered at a CFC of 600 Hz.

5.2 [The peak abdomen viscous criterion response is the maximum value of VC on any (upper or lower) abdomen rib which is calculated from the instantaneous product of the abdomen rib deflection as a proportion of the half thorax width, and the velocity of abdomen rib deflection derived by differentiation of the deflection with respect to time:

$$VC = Max\left[\frac{D}{0.17} \cdot \frac{dD}{dt}\right]$$

Where:

D = abdomen rib deflection (metres) filtered at a CFC of 600 Hz

$$\frac{dD}{dt} = \frac{8[D_{(t+1)} - D_{(t-1)}] - [D_{(t+2)} - D_{(t-2)}]}{12dt}$$

t = time (s)

For the purposes of this calculation the standard width of the half thorax rib cage is 170 mm (0.17 m).

5.3 The value of the resultant lower spine (T12) acceleration (a_R) which is exceeded for 3 milliseconds cumulatively (i.e. across one or more peaks) is calculated from the expression:

$$a_R = \sqrt{a_X^2 + a_Y^2 + a_Z^2}$$

Where:

a_X = the longitudinal (x-axis) acceleration of the dummy lower spine recorded versus time and filtered at a CFC of 180 Hz;
a_Y = the lateral (y-axis) acceleration of the dummy lower spine recorded versus time and filtered at a CFC of 180 Hz; and
a_Z = the vertical (z-axis) acceleration of the dummy lower spine recorded versus time and filtered at a CFC of 180 Hz.]

6 PELVIS PERFORMANCE CRITERIA

6.1 The pubic symphysis peak force (PSPF) is the maximum force measured by the load cell at the pubic symphysis of the pelvis and filtered at a CFC of 600 Hz.

6.2 [The value of the resultant pelvis acceleration (a_R) which is exceeded for 3 milliseconds cumulatively (i.e. across one or more peaks) is calculated from the expression:

$$a_R = \sqrt{a_X^2 + a_Y^2 + a_Z^2}$$

Where:

a_X = the longitudinal (x-axis) acceleration of the dummy pelvis recorded versus time and filtered at a CFC of 1000 Hz;
a_Y = the lateral (y-axis) acceleration of the dummy pelvis recorded versus time and filtered at a CFC of 1000 Hz; and
a_Z = the vertical (z-axis) acceleration of the dummy pelvis recorded versus time and filtered at a CFC of 1000 Hz.]