Research Council for Automobile Repairs
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RCAR Standards

A Procedure for Evaluating Motor Vehicle Head Restraints

Static Geometric Criteria

Issue 3 March 2008

1.0 INTRODUCTION

This procedure enables the user to evaluate the geometry of head restraints with respect to their ability to reduce neck injuries in vehicle rear impacts. Various statistical and biomechanical research studies have illustrated the importance of head restraints in limiting neck injuries in vehicle rear impacts. Head restraint geometry, the horizontal and vertical measurement between the head and the restraint, has been shown to be important in reducing the so-called "whiplash" injury. Research has also indicated that optimising these measurements can reduce the likelihood of injury in rear crashes. With this in mind, the Research Council for Automobile Repairs (RCAR) has issued this procedure to evaluate head restraints, based on geometric criteria, as good, acceptable, marginal, or poor.

2.0 SCOPE

2.1 All vehicles fitted with active or passive head restraints conforming to one of the types defined in paragraph 3 below.

2.2 It does not apply to head restraint devices that may be fitted to seats facing toward the side or the rear of the vehicle.

2.3 It also applies to seat backs that are designed to serve also as integrated head restraints, as defined in paragraph 3.2 below.

3.0 DEFINITIONS

For the purpose of this procedure, the following definitions shall apply.

3.1 "Head restraint" means 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 cervical vertebrae in the event of a rear impact.

3.2 "Integrated head restraint" or **"fixed head restraint"** means a head restraint formed by the upper part of the seat back, or a head restraint that is not height adjustable and 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.

3.3 "Adjustable head restraint" means a head restraint that is capable of being positioned to fit the morphology of the seated occupant. The device may permit horizontal displacement, known as "tilt" adjustment, and/or vertical displacement, known as "height" adjustment.

3.4 "Active head restraint" means a device designed to automatically improve head restraint geometry during an impact.

3.5 "Automatically adjusting head restraint" means a head restraint that automatically adjusts the position of the head restraint when the seat position is adjusted.

3.6 "Locking" refers to an adjustable head restraint fitted with a device to prevent inadvertent movement from its adjusted position. For example, when a rear seat occupant uses a front seat head restraint as 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 head restraint adjustment, after which the mechanism shall reset automatically.

3.7 "H-point machine" means the device used for the determination of "H" points and actual torso angles. (SAE Standard J826, SAE Handbook, Vol. 3, 1999).

3.8 "HRMD" (Head Restraint Measuring Device) means 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. *(Appendix 2 and 3).*

3.9 Head Restraint "**Height"** is defined as the measurement between the height probe of the HRMD and the top of the head restraint.

3.10 Head Restraint **"Backset"** is defined as the 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.

3.11 Head Restraint Measurement Positions

3.11.1 "Down" is defined as the lowest adjusted position of an adjustable head restraint.

3.11.2 "Up" is defined as the highest adjusted position of an adjustable head restraint.

3.11.3 "Back" is defined as the most rearward adjusted position of an adjustable head restraint.

3.11.4 "Forward" is defined as the most forward adjusted position of an adjustable head restraint.

4.0 MEASUREMENT METHODS

Head restraint height and backset measurements shall be made with a standard H-point machine fitted with an HRMD representing the head of an average-size male (*Appendix 1)*.

4.1 The head room probe from the H-point machine shall be removed and the two washers (supplied with the HRMD) shall be installed in the spaces remaining on the H-point pivot.

4.2 The HRMD includes probes to aid the measurement of height (*Appendix 2*) and backset (*Appendix 3*) relative to the head. Measurements shall be made according to the procedures outlined in the "Instruction Manual of the Head Restraint Measuring Device" (ICBC, 1995), with three modifications, as follows.

4.3 The legs of the H-point machine shall be configured in accordance with requirements of U.S. Federal Motor Vehicle Safety Standard (FMVSS) 208 to approximate the dimensions of the 50th percentile male Hybrid III dummy (49 CRF§571.208.11.4.3.1).

4.4 The height and backset measurements shall be made with the adjustable seat back positioned to achieve a torso angle of 25 ± 1 degree from vertical on the H-point machine with the HRMD installed.

4.5 The seat shall be adjusted to the fully rearward position along the seat track to allow sufficient room for the feet of the H-point machine to be raised unencumbered.

5.0 VEHICLE PREPARATION AND INSTALLATION OF H-POINT MACHINE AND HRMD

5.1 Vehicle Setup

5.1.1 The vehicle shall be positioned on level ground.

5.1.2 To confirm the vehicle attitude, the door sill (front to rear level) and centre luggage compartment (side to side level) shall be used as level reference points.

5.1.3 Loose floor mats shall be removed.

5.1.4 If the seat is equipped with a movable armrest, it shall be raised or placed in its stored position; adjustable lumbar supports shall be fully retracted, adjustable cushion extension shall be fully retracted, and adjustable lateral thigh supports and seat back supports (bolsters) shall be set open or as wide as possible.

5.1.5 The seat will be adjusted to its lowest position.

5.1.6 The seat shall be adjusted to its fully rearward position along the seat track.

5.1.7 If there are other adjustable seat components, they shall be set in the middle position and the position recorded on the data sheet. For example if the upper portion of the seat back moves independently of the lower portion, place the upper portion in the middle of its adjustment range.

5.2 H-Point Machine Setup

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

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

5.2.3 The H-point back pan shall be installed in the seat.

5.2.4 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 H-point machine settings closest to the FMVSS 208 requirement.

5.2.5 The legs shall be attached to the H-point machine and set to the 5th position (no.5) on the knee joint T-bar, which places the knees 25 cm apart.

5.2.6 With the legs attached and the back pan tilted forward, the H-point machine shall be positioned in the driver seat such that its central sagittal plane coincides with the longitudinal centreline of the seat.

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

5.2.8 The feet shall be place as far forward as possible, with the heels on the floor and the soles of the feet resting on the floor, toe board, or firewall. If necessary, the leg spacing as in 5.2.5 may be changed to clear obstructions (e.g., instrument panel fixtures, tunnel width, seat tracks). Any changes in leg spacing for proper feet positioning shall be recorded on the data sheet.

5.2.9 The lower leg and thigh weights shall be attached to the H-point machine and the machine shall be levelled.

5.2.10 The back pan shall be tilted forward and the H-point machine assembly pushed rearward until the seat pan contacts the vehicle seat back. While tilting the back pan forward, a horizontal rearward load of 10kg shall be applied using the plunger if present or using a force gauge pressed against the hip angle quadrant structure.

5.2.11 The load application shall be repeated and, while keeping the pressure applied, the back pan shall be returned to the vehicle seat back and the pressure then released.

5.2.12 A check shall be made to determine that the H-point machine is level, facing directly forward, and located in the centreline of the seat.

5.2.13 As an approximation of the vehicle seat back position, it shall be placed such that the torso angle is about 21 degrees before the buttocks and chest weights are added. This angle may be varied according to the subjective estimate of the seat cushion stiffness.

5.2.14 The H-point machine torso angle shall be measured by placing an inclinometer on the lower brace of the torso weight hanger.

5.2.15 After estimating the vehicle seat back position, the right and left buttock weights shall be installed. The six chest weights shall be installed by alternating left to right. The two larger HRMD chest weights shall be attached last, flat side down.

5.2.16 Tilting the back pan forward to a vertical position, the assembly shall be rocked from side to side over a 10-degree arc – 5 degrees in each direction. This rocking shall be repeated for a total of three complete cycles while preventing any horizontal translation of the 'H' point machine seat pan.

5.2.17 The back pan shall be returned to the vehicle seat back, and the H-point machine shall be levelled again as in 5.2.9.

5.2.18 The feet shall be positioned as follows: each foot shall be alternately lifted off the floor via the instep, until no additional forward foot movement is available.

5.2.19 When each foot is placed back in the down position, the heel shall be in contact with the floor, and the sole of the foot shall be in contact with the floor, toe board, or firewall.

5.2.20 If the H-point seat pan 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.

5.3. Installation of the HRMD

5.3.1 The backset probe shall be installed and pushed flush against the HRMD.

5.3.2 The height probe shall be removed from the HRMD.

5.3.3 The leveling knob shall be confirmed as finger tight.

5.3.4 The HRMD shall then be lowered into position on the H-point machine torso weight hangers and on the top edge of the channel between the hangers.

5.3.5 The height probe shall then be reinstalled so that the bottom of the rear tip is level with the top of the HRMD.

5.3.6 The HRMD shall be levelled by loosening the rear knob and repositioning the head using the HRMD bubble level; the knob shall then be retightened by hand.

5.3.7 The H-point machine shall be levelled.

5.3.8 If the measured angle is not 25±1 degrees as measured on the flat portion of the torso weight hanger bar that is welded to the back pan, the HRMD and chest and buttocks weights shall be removed, the seat back readjusted, and the steps to position the H-point machine shall be repeated, beginning with tilting the back pan forward and pushing the H-point machine rearward as in 5.2.10.

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

6.0 HEAD RESTRAINT MEASUREMENT EVALUATION PROCEDURE

6.1 Head restraint rating overview

6.1.1 Each restraint shall be classified into one of four geometric zones, as defined by its height (as measured from the top of the head of the HRMD) and backset (as measured from the back of the head of the HRMD) measurements (*Appendix 4).*

	Backset (B)	***Height (H)***	***Rating***
zone 1	B ≤ 7 cm	H 6 ≤ cm	**good**
zone 2	7 cm <B≤ 9 cm	6 cm <H≤8cm	**acceptable**
zone 3	9 cm<B≤11cm	8 cm<H≤10 cm	**marginal**
zone 4	B > 11 cm	H > 10 cm	**poor**

6.1.2 The rating for a restraint depends on the zone into which the height and backset place it and whether it is integrated (fixed) or adjustable.

6.1.3 The rating for an integrated or fixed restraint is defined by the zone into which the height and backset place it *(Appendix 5).*

6.1.4 The rating for an adjustable head restraint depends on whether height and/or tilt adjustments lock into position. Care should be taken to ascertain whether a locking mechanism is present.

(Reference must be made to the vehicle handbook or the vehicle manufacturer).

6.1.5 If the head restraint does not have a lock for height adjustment then its rating is defined by the zone into which the height and backset place it in the down position *(Appendix 6).*

6.1.6 If the restraint does not have a lock for the tilt adjustment then its rating is defined by the zone into which the height and backset place it in the back position *(Appendix 7).*

6.1.7 If the restraint has a height lock but no tilt lock then the rating is defined as the geometric midpoint on a line drawn between the down and back position and highest locking up and back positions (*Appendix 8).*

6.1.8 If the restraint does not have a height lock but has a tilt lock when in the forward position then the rating is defined as the geometric midpoint between the down and back position and the down and forward locking position (*Appendix 9).*

6.1.9 If the restraint has both a height lock and tilt lock then the rating is defined by the geometric midpoint between the down and back position and three alternate, adjusted positions, as follows:

a. Head restraint down and in its most forward locking position.

b. Head restraint up in its highest locking position and tilted back.

c. Head restraint up in its highest locking position and its most forward locking position.

The rated position will be the most favourable mid-point among lines a, b, c. (*Appendix 10).* In all cases, if the unadjusted, down and back head restraint position gives a more favorable rating than the geometric midpoint of the locking positions the rating will be that of the unadjusted position.

6.1.10 If the rated position falls on the line between the zones of the rating diagram, then the more favourable zone shall be used.

6.1.11 A head restraint is able to offer the best protection if it is rated in **Zone 1** AND the highest locking position of the head restraint is at least the same height (or higher than) the top of the HRMD head. Manufacturers offering adjustable head restraints are encouraged to provide lockable positions that are above the top of the head of HRMD machine, so that taller occupants are able to correctly position their restraint. If a head restraint meets this requirement it shall be noted.

6.2 Advanced seat/head restraint designs

A seat fitted with an active head restraint as in 3.4 shall be rated according to their measurements in their undeployed position.

6.3 Automatically adjusting head restraint

The rating for an automatically adjusting head restraint as in 3.5 shall be defined by the zone into which its height and backset place it when the seat is adjusted for 50th percentile male occupant.

6.4 Head Restraint Measurements

6.4.1 If the restraint is integrated/fixed, it shall be noted.

6.4.2 If the head restraint has a height adjustment it shall be adjusted to its down position and the position noted.

6.4.3 If the restraint has a tilt adjustment, the restraint shall be adjusted to its back position and the position noted.

6.4.4 The height probe shall be pushed rearward until it is positioned directly over the top of the restraint.

6.4.5 A steel rule shall be used to measure the vertical distance to the nearest half-centimetre between the top of the restraint and the lower surface of the probe tip. The measurement shall be recorded.

6.4.6 The backset probe shall be pushed rearward until the head/neck profile touches the restraint. The horizontal distance shall be measured to the nearest half centimetre as displayed by the backset probe. The measurement shall be recorded.

6.4.7 If the head restraint is too low to be contacted by the backset probe in any position, the distance shall be recorded as 16 cm, the maximum scaled measurement on the probe.

6.4.8 If the head restraint is higher than the height probe, measure from the bottom of the height probe to the top of the restraint and record, to the nearest half centimetre, as a negative value.

6.4.9 If the head restraint has height adjustment, the measuring process shall be repeated for the up position and the measurement recorded.

6.4.10 If the head restraint has a tilt adjustment, the measuring process shall be repeated for the forward position and the measurement recorded.

6.4.11 If the head restraint is both height adjustable and tilt-adjustable, the measuring process shall be repeated for the up and back position, the up and forward position, and the down and forward position. These three sets of measurements shall be recorded.

7.0 PRESENTATION OF RESULTS

The measurements shall correspond to one of four zones depending on restraint design and geometry. Each zone translates into a rating using the terminology as in 6.1.1.

7.1 Where results are presented in colour the following colours shall be used as backgrounds to black text:

Good	**Green**
Acceptable	**Yellow**
Marginal	**Orange**
Poor	**Red**

7.2 The results shall be presented in table form in a landscape format. An example sheet is shown in *Appendix 11.*

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Revision History

Section 4.1 (added) to clarify removal of the head room probe for use of the HPM with the HRMD.

Section 5.1.4 (edited) to add additional seat adjustment settings.

Section 5.1.7 (edited) to add additional seat adjustment settings.

Section 5.2.16 (edited) to clarify procedure for rocking HPM.

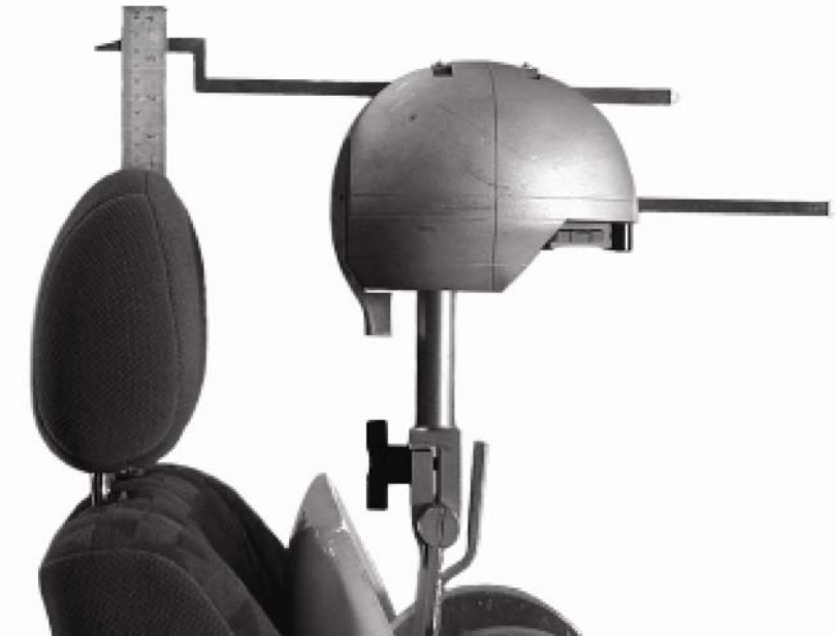
Section 5.3.8 (edited) to clarify where to measure the torso angle.

Section 6.2 (edited) to amend the rating procedure for seats equipped with active head restraints.

H-Point Machine with Head Restraint Measurement Device

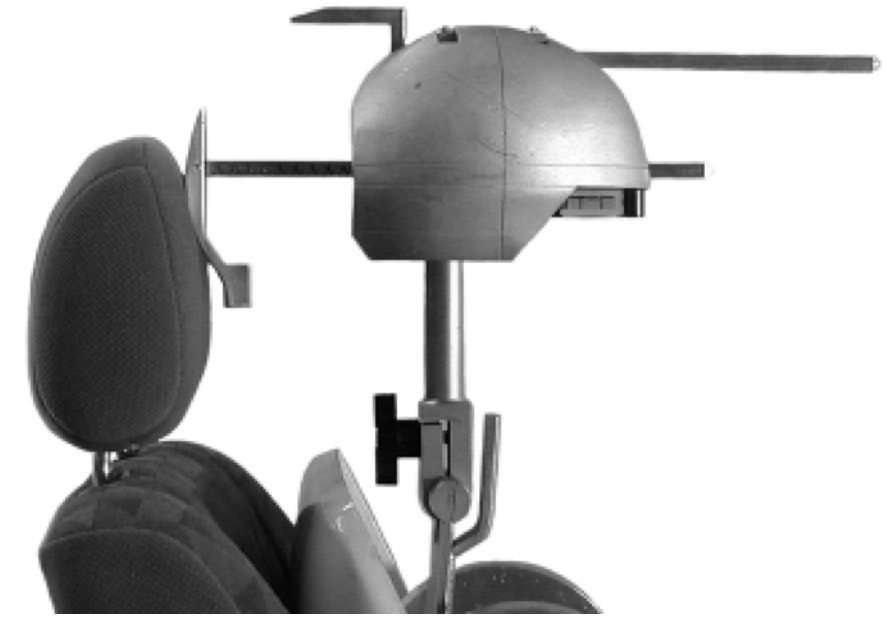
Appendix 2

Head Restraint Height Measurement



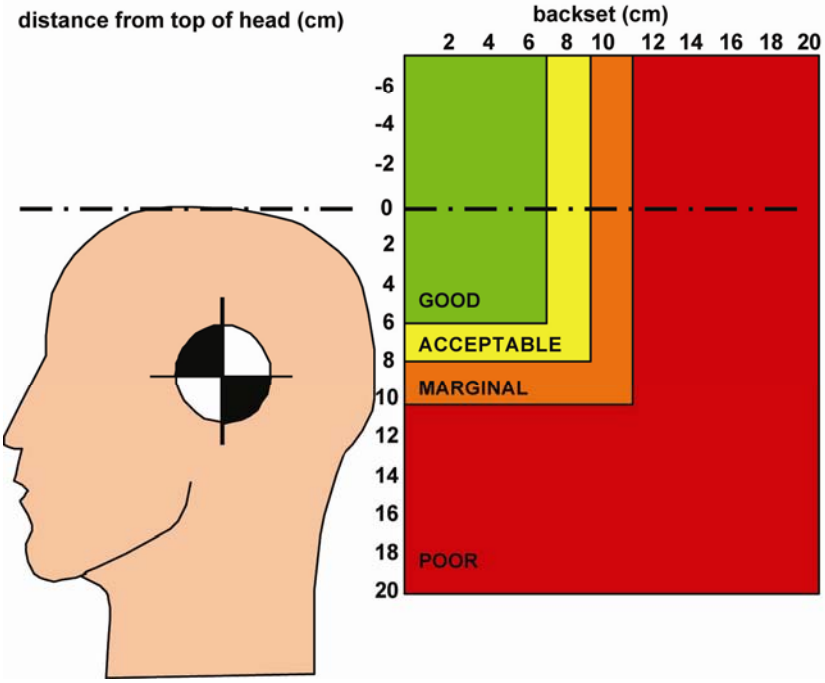
Appendix 3

Head Restraint Backset Measurement



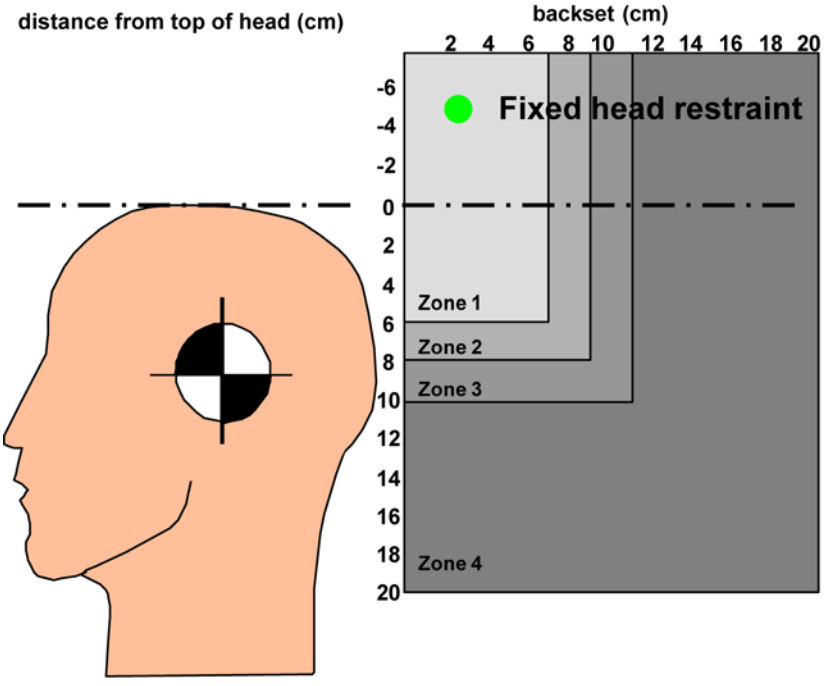
Appendix 4

HEAD RESTRAINT RATING DIAGRAM



Appendix 5

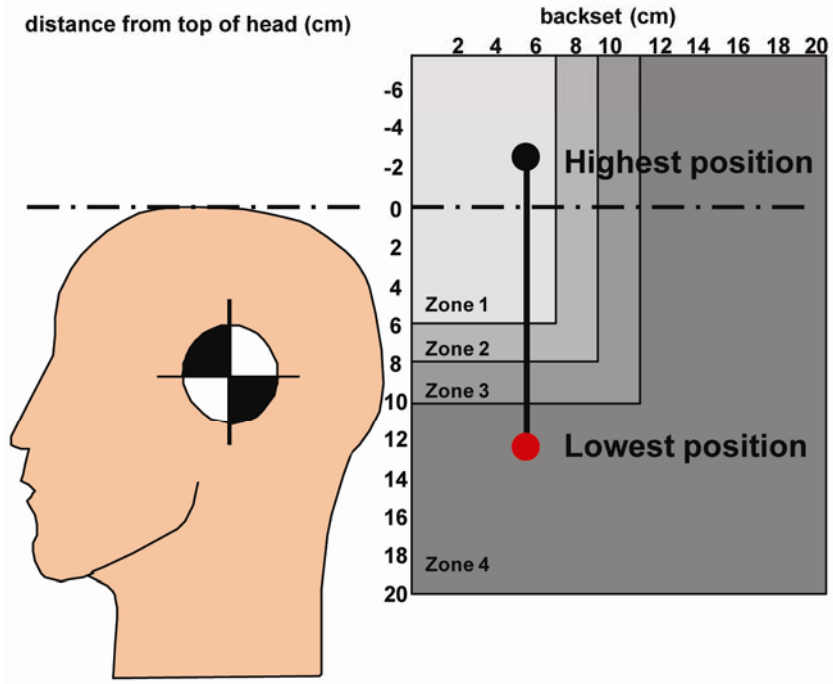
HEAD RESTRAINT RATING FIXED



● -Rated Position

Appendix 6

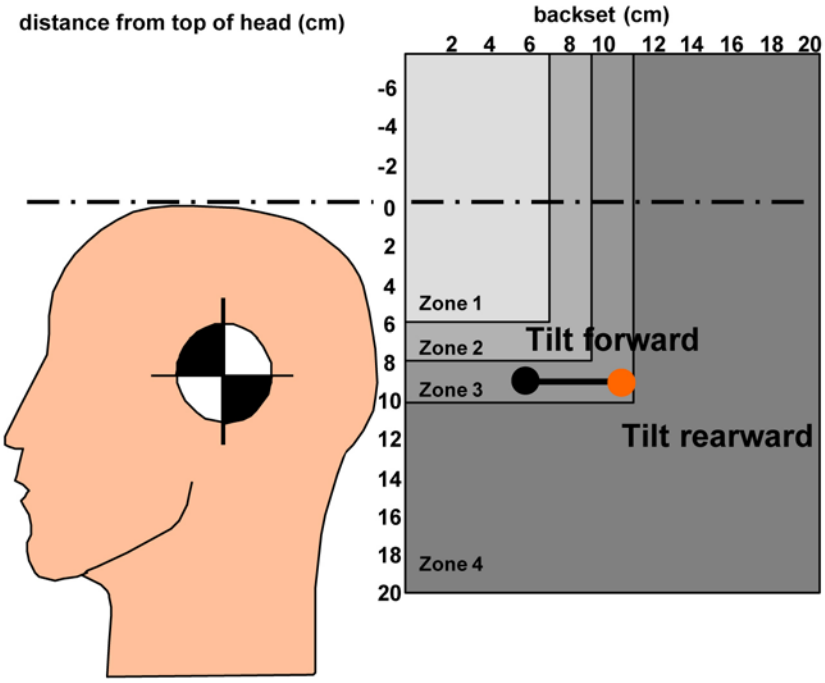
HEAD RESTRAINT RATING (HEIGHT ADJUSTMENT) NON LOCKING



● - Rated Position

Appendix 7

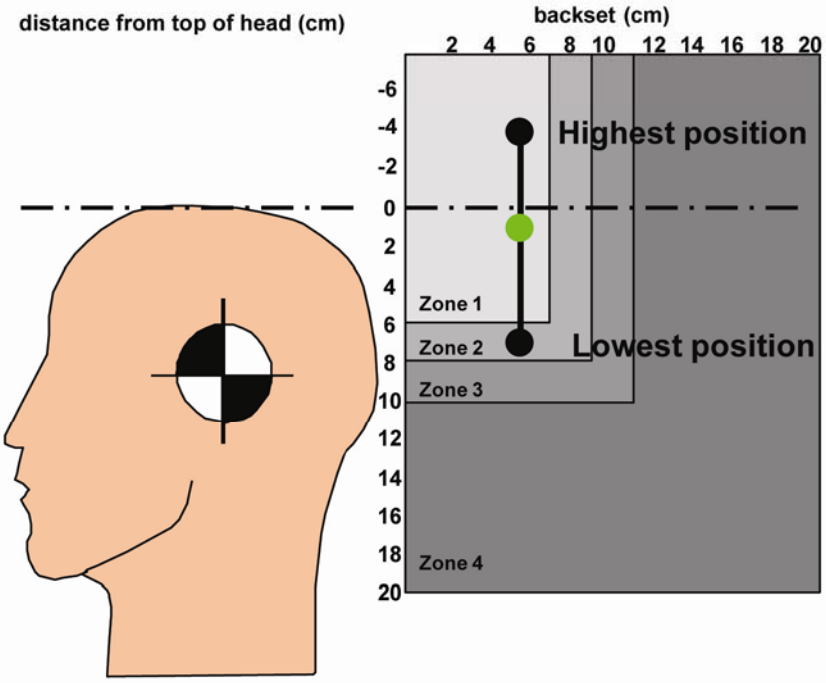
HEAD RESTRAINT RATING (TILT ADJUSTMENT) NON LOCKING



● - Rated Position

Appendix 8

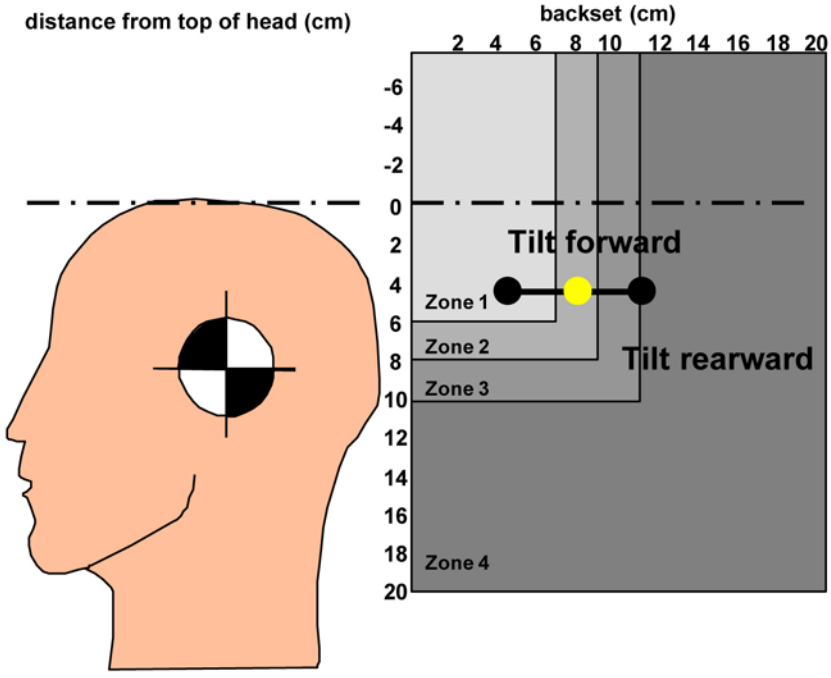
HEAD RESTRAINT RATING WITH HEIGHT LOCK (NO TILT LOCK)



● - Rated Position

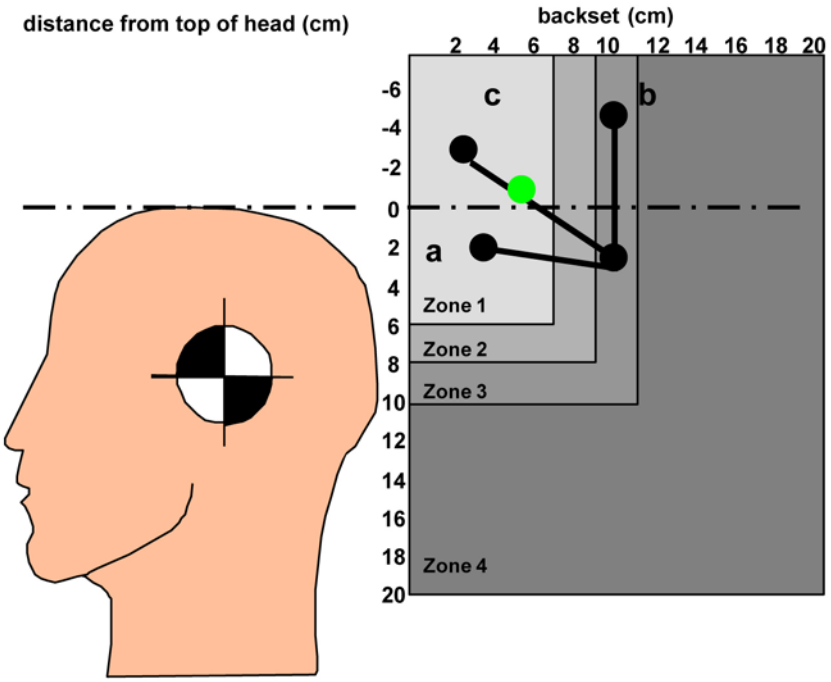
Appendix 9

HEAD RESTRAINT RATING TILT LOCK (NO HEIGHT LOCK)



● - Rated Position

HEAD RESTRAINT RATING HEIGHT AND TILT LOCKING



● - Rated Position (the most favourable rating mid-point between a, b, c)

APPENDIX 11

HEAD RESTRAINT EVALUATIONS TABLE

HEAD RESTRAINT EVALUATIONS																										
MAKE	MODEL	TRIM LEVEL	YEAR	Seat Type			Seat Trim			Seat Adjustments					Height Lock		Tilt Lock		Head Restraint down				Head Restraint up				Overall Rating
																			Tilted Back		Tilited Forward		Tilted Back		Tilited Forward		
				Standard	Sports	Active H/R	Vinyl	Cloth	Leather	Height	Back	Lumbar	Base Tilt	Other	Down	Up	Back	Forward	Horizontal Distance from Head (cm)		Vertical Distance from Head (cm)		Horizontal Distance from Head (cm)		Vertical Distance from Head (cm)		
Example 1		L	1999	X			X				X				N	N	NA	NA	4	11	NA	NA	6	1.5	NA	NA	POOR
Example 2		GL	1993	X		X		X		X	X				N	N	N	N	5.5	9	0	10	4.5	0	0	-1	MARGINAL
Example 3		GTi	2000		X					X		X			N	Y	NA	NA	7	10	NA	NA	5	6	NA	NA	ACCEPTABLE
Example 4		LUXURY	1991			X			X	E	X	X			E	E	E	E	2	6	0	6	3	1.5	0	1.5	GOOD
KEY: E= ELECTRICAL ADJUSTMENT F= FIXED HEAD RESTRAINT																										