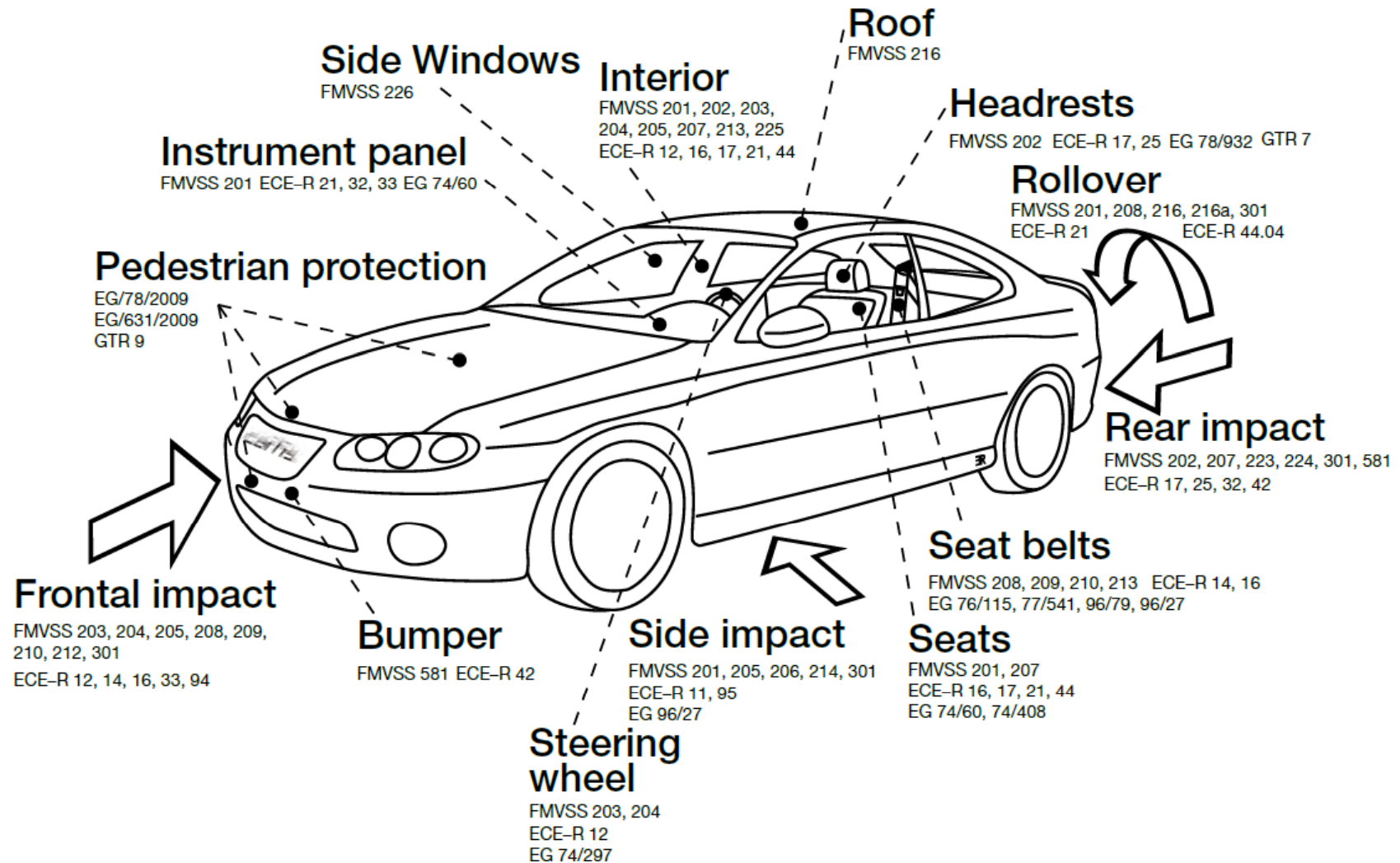


Crash and Safety overview

Contents

1. Crash Rules and regulation in Europe and USA
2. Crashworthiness Restraint Technologies
3. Crash Legal Requirements
4. New Car Assessment Program (NCAP)
5. Front Impact Overview
6. Side Impact Overview
7. Roof Crash Overview

Crash-Regulations in Europe and USA



FMVSS :- US Crash Regulations

ECE :- Europe Crash Regulations

Crashworthiness Restraint Technologies

Lap / Shoulder
Safety Belts

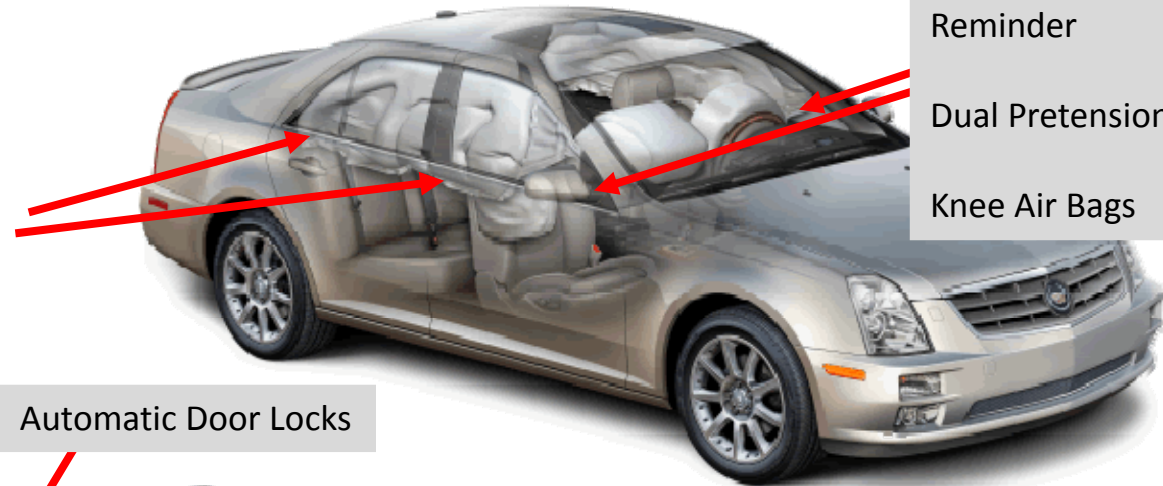
Belt Comfort Guide

Energy Management
System

Seat Belt Use
Reminder

Dual Pretensioners

Knee Air Bags



Driver and Passenger
Front Air Bags -- Dual Level

Automatic Door Locks

Passenger
Sensing
System



Rollover-capable
Head Curtain Air Bag

Side Impact Air Bags

Crash Legal Requirements and Consumer Rating



Legal requirements

FMVSS 208
ECE-R94
...

Consumer ratings

US NCAP
EURO NCAP
...

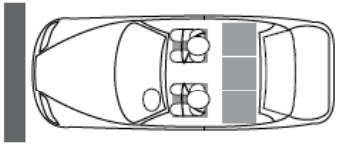
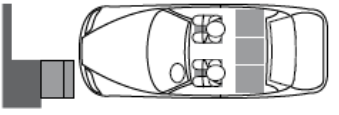
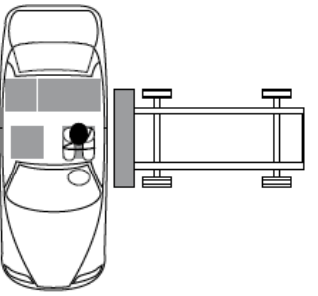
- Test setups (rigid barrier, ODB, ...)
- Dummies (5%ile female, 50%ile male, ...)
- Crash velocities (40km/h, 56km/h, ...)

➡ Basis of ratings: Dummy criteria

Design of Restraint System

Adjustment of belt + airbag systems for best overall performance

Rules and Regulations on occupant protection

			
 USA	FMVSS 208 4 Tests at 32 to 56 km/h belted and unbelted 2 H-III / 2 H-III 5 % female see page 38	FMVSS 208 40 km/h 40 % Offset 2 H-III 5 % female belted	 FMVSS 214 (new) 54 km/h 27° crab angle 1068 kg ES-2re front SID-IIs rear FMVSS 201p 29 km/h 90° on pole 254mm SID-H3 FMVSS 214 (new) 32 km/h 75° on Pole 254mm ES-2re or SID-IIs
 Europe		ECE-R94; 96/79/EC 56 km/h 40 % Offset 2 H-III	ECE-R95; 96/27/EC 50 km/h 950 kg ES-2
 Japan	TRIAS 47 50 km/h 2 H-III	TRIAS 47-4 56 km/h 40 % Offset 2 H-III	TRIAS 47-3-2000 50 km/h 950 kg ES-2

Pedestrian

78/2009

631/2009

TRIAS 63

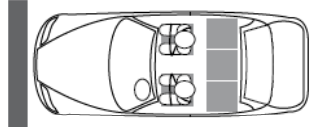
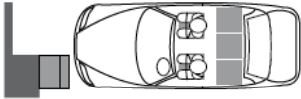
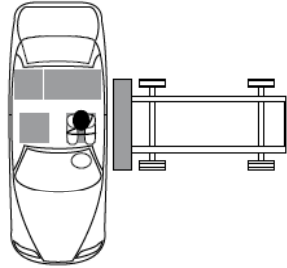


Rollover



FMVSS 216 upgrade
 FMVSS 208 (tilted ramp)

Rules and Regulations on occupant protection

			
 China	GB 11551-2003 50 km/h 2 H-III	GB 20913-2007 56 km/h 40 % Offset 2 H-III (optional test)	GB 20071-2006 50 km/h 950 kg EuroSID
 India		AIS-098/F 56 km/h 40 % Offset 2 H-III (as of 2012)	AIS-099/F 50 km/h 950 kg EuroSID (as of 2012)
 South Korea	KMVSS 102 48,3 km/h 2 H-III		KMVSS 102 50 km/h 950 kg EuroSID
 Australia	ADR 69/00 48 km/h 2 H-III	ADR 73/00 56 km/h 40 % Offset 2 H-III	ADR 72/00 50 km/h 950 kg EuroSID SafetyWissen by carhs

Head Impact

FMVSS 201u



ECE-R21



Ejection Mitigation

FMVSS 226



NEW

Rear Impact

FMVSS 301 (new)



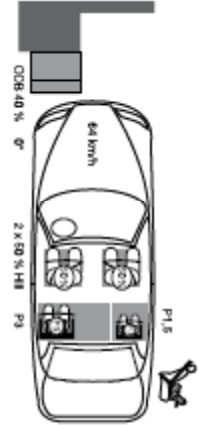
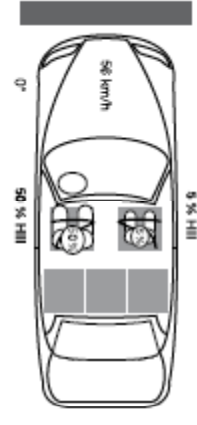
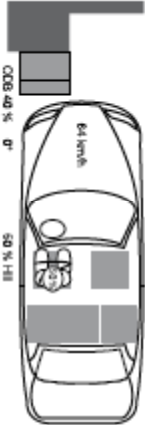
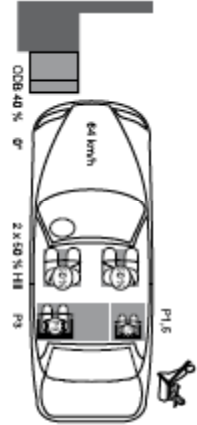
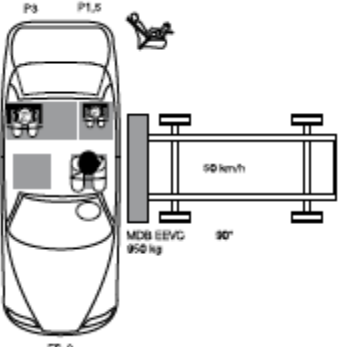
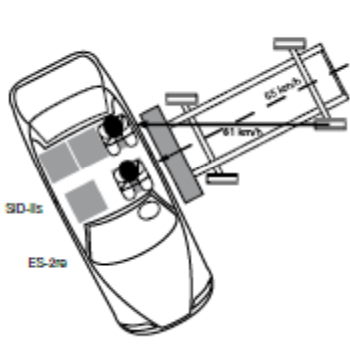
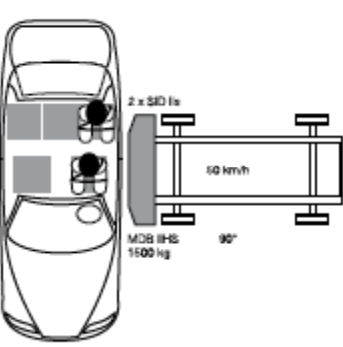
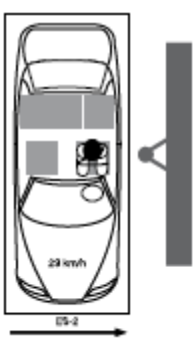
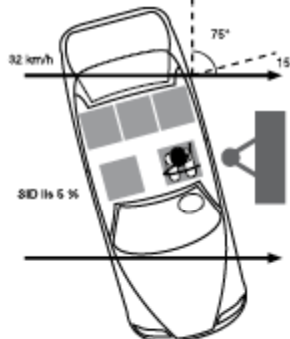
FMVSS 202a (new)

ECE-R32

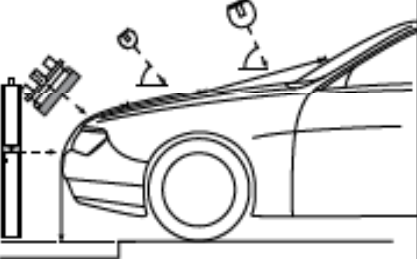


Ref:- Safety Companion 2011 (Carhs)

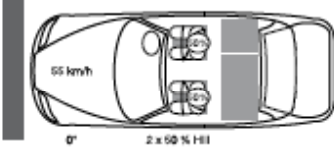
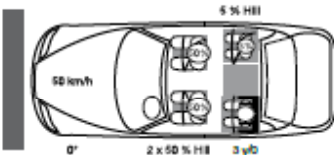
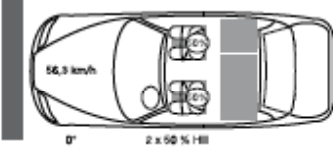
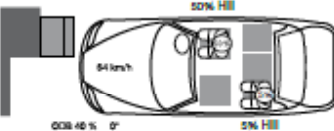
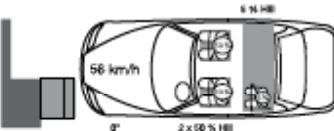
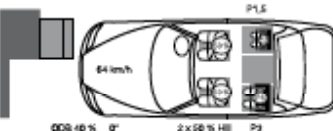
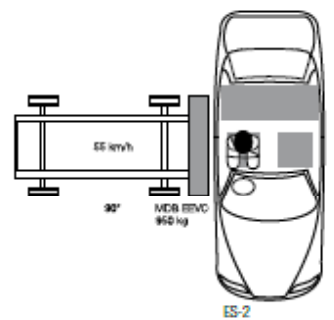
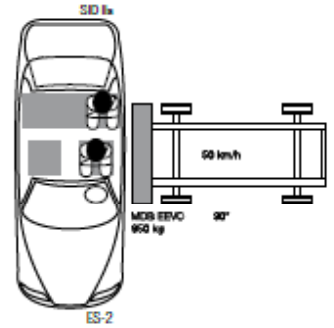
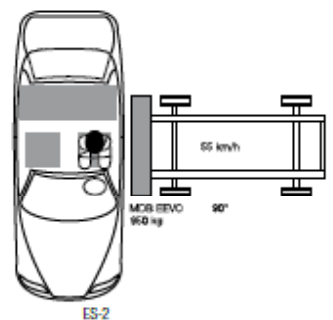
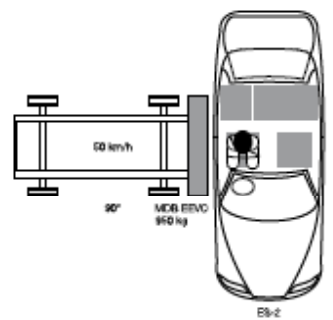
NCAP-Tests in Europe & America

Euro NCAP	US NCAP	USA IIHS	Latin NCAP
 Diagram showing a frontal impact test. The car is moving at 64 km/h. The impactor is a 1500 kg vehicle moving at 40 km/h. The test is conducted at 0°.	 Diagram showing a frontal impact test. The car is moving at 56 km/h. The impactor is a 9% HII moving at 50 km/h. The test is conducted at 0°.	 Diagram showing a frontal impact test. The car is moving at 64 km/h. The impactor is a 1500 kg vehicle moving at 40 km/h. The test is conducted at 0°.	 Diagram showing a frontal impact test. The car is moving at 64 km/h. The impactor is a 1500 kg vehicle moving at 40 km/h. The test is conducted at 0°.
 Diagram showing a side impact test. The car is moving at 50 km/h. The impactor is a 950 kg vehicle moving at 50 km/h. The test is conducted at 90°.	 Diagram showing a side impact test. The car is moving at 65 km/h. The impactor is a 950 kg vehicle moving at 61 km/h. The test is conducted at 90°.	 Diagram showing a side impact test. The car is moving at 50 km/h. The impactor is a 1500 kg vehicle moving at 50 km/h. The test is conducted at 90°.	
 Diagram showing a pole impact test. The car is moving at 29 km/h. The impactor is a 1500 kg vehicle moving at 29 km/h. The test is conducted at 90°.	 Diagram showing a pole impact test. The car is moving at 32 km/h. The impactor is a 1500 kg vehicle moving at 32 km/h. The test is conducted at 75° and 15°.		

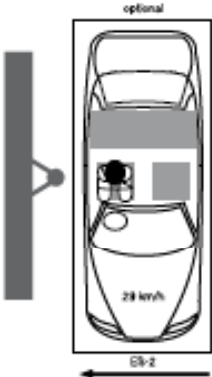
NCAP-Tests in Europe & America

Euro NCAP	US NCAP	USA IIHS	Latin NCAP
			
■ static ■ dynamic (P. 48) 		■ static ■ dynamic (P. 48) 	
	■ Static Stability Factor and Fishhook Manoeuvre (P. 74)	■ Roof crush (P. 36) 	
■ Child Protection (P. 57) ■ Assistance systems (P. 74)		■ ESC	■ Child Protection = Euro NCAP ■ Seat Belt Reminder

NCAP-Tests in Asia / Australia

JNCAP 	C-NCAP 	KNCAP 	Australia 
			
		planned	
			

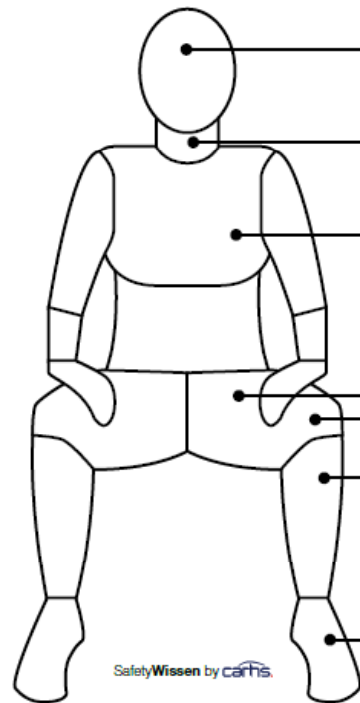
NCAP-Tests in Asia / Australia

JNCAP 	C-NCAP 	KNCAP 	Australia 
■ Pedestrian Protection ■ Whiplash Test ■ Dynamic Tests with child protection systems and ease of use rating ■ Brake test ■ Annual Grand Prix Award for best performing vehicle	■ Fuel Consumption	■ Pedestrian Protection ■ Head rest assessment ■ Static Stability Factor and Fishhook Manoeuvre (P. 74) ■ Brake test ■ Whiplash Planned: ■ Frontal Offset 64 km/h ■ Pole-Side-Impact 29 km/h ■ Overall Rating	 ■ Pedestrian Protection

Euro NCAP Protection Criteria in Frontal Impact

Each Body region gets the colour according to its assessment, i.e. points derived from the load minus modifier.

- 4,00 points
- 2,67 – 3,99 points
- 1,33 – 2,66 points
- 0,01 – 1,32 points
- 0,00 points



Head	
4 points	HIC 36 < 650; a_{3ms} < 72 g
0 points	HIC 36 > 1000; a_{3ms} > 88 g
Modifier	unstable airbag contact (-1 point), Steering column displacement (-1 point)

Neck	
4 points	$M_{\text{extension}}$ < 42 Nm
	Tension: < 2,7 kN @ 0 ms
	< 2,3 kN @ 35 ms
	< 1,1 kN @ 60 ms
0 points	Shearing: < 1,9 kN @ 0 ms
	< 1,2 kN @ 25 – 30 ms
	< 1,1 kN @ 45 ms
	$M_{\text{extension}}$ > 57 Nm
0 points	Tension: > 3,3 kN @ 0 ms
	> 2,9 kN @ 35 ms
	> 1,1 kN @ 60 ms
	Shearing: > 3,1 kN @ 0 ms
0 points	> 1,5 kN @ 25 – 35 ms
	> 1,1 kN @ 45 ms

Chest	
4 points	Deflection < 22 mm; VC < 0,5 m/s
0 points	Deflection > 50 mm; VC > 1,0 m/s
Modifier	Deformation A-Pillar (-2 points) Compartment deformed (-1 point) Contact with steering wheel (-1 point)

Femur	
4 points	Compression force < 3,8 kN
0 points	Compression force > 9,07 kN > 7,56 kN @ 10 ms

Knee	
4 points	Displacement < 6 mm
0 points	Displacement > 15 mm
Modifier	Variable contact (-1 point) Concentrated Loading (-1 point)

Tibia	
4 points	TI < 0,4; Compression force < 2 kN
0 points	TI > 1,3; Compression force > 8 kN
Modifier	z-displacement of worst pedal (-1 point)

Foot	
4 points	x-displacement braking pedal < 100 mm
0 points	x-displacement braking pedal > 200 mm
Modifier	footwell intrusion (-1 point) blocked pedal (-1 point)

Airbag	
Modifier	Airbag Deployment Modifier for incomplete unfolding of any Airbag (-1 Point)

Euro NCAP Protection Criteria in MDB Side Impact



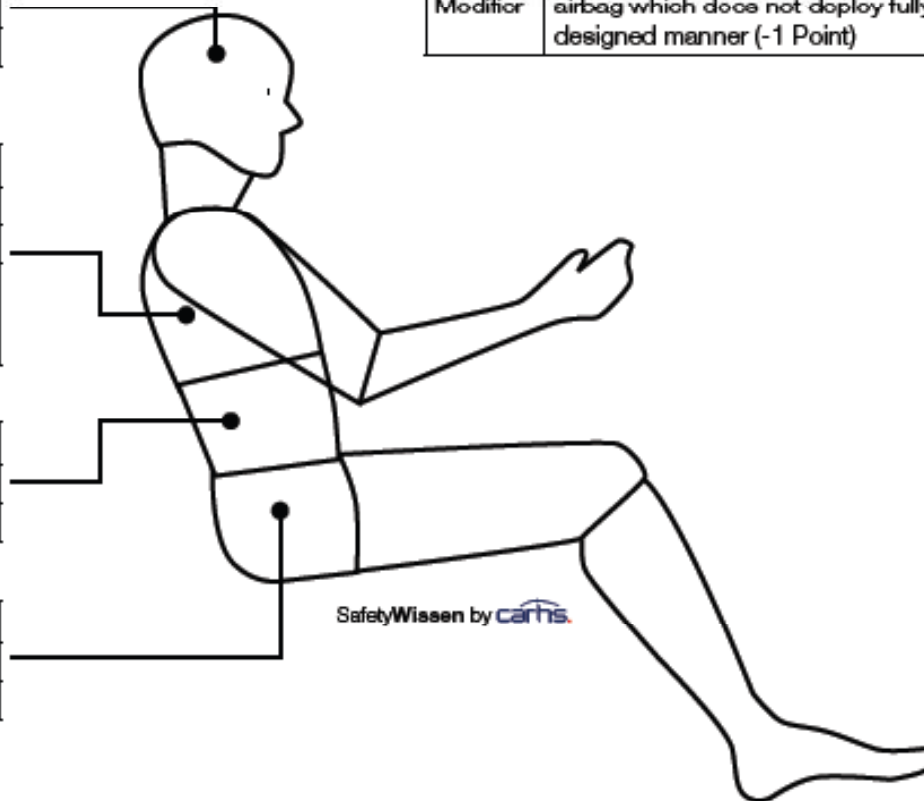
Head	
4 points	HIC 36 < 650; $a_{3ms} < 72 \text{ g}$
0 points	HIC 36 > 1000; $a_{3ms} > 88 \text{ g}$

Chest	
4 points	rib deflection < 22 mm; VC < 0,32 m/s
0 points	rib deflection > 42 mm; VC > 1,0 m/s
Modifier	T12 Load Modifier Backplate Load Modifier (total -2 points maximum)

Abdomen	
4 points	abdominal peak force < 1,0 kN
0 points	abdominal peak force > 2,5 kN

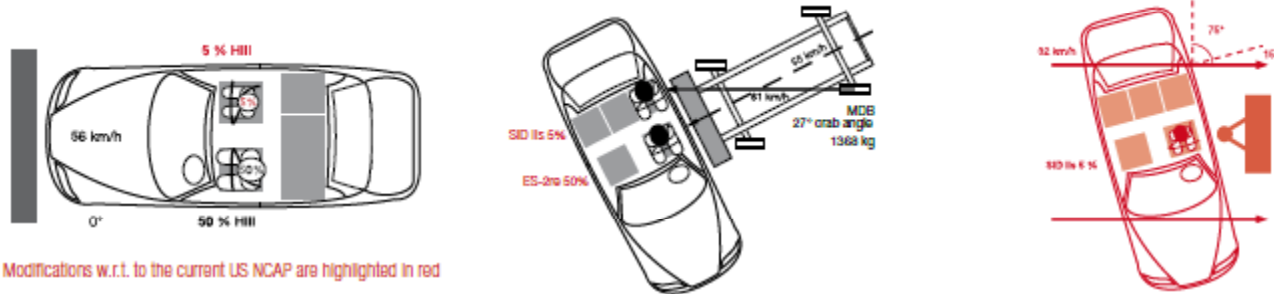
Pelvis	
4 points	pubic symphysis peak force < 3,0 kN
0 points	pubic symphysis peak force > 6,0 kN

Airbag	
Modifier	Airbag Deployment Modifier for any airbag which does not deploy fully in the designed manner (-1 Point)



US NCAP Tests and Criteria

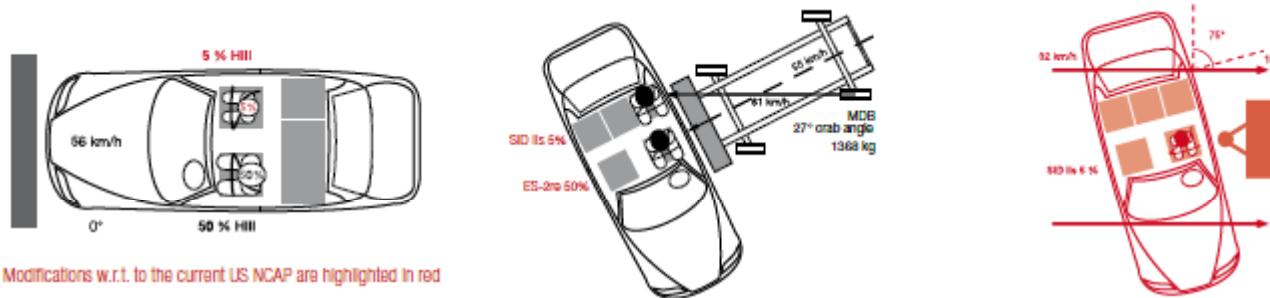
The new US NCAP Rating will be applied from model year 2011



Injury Criteria	Injury Risk Curves	
FRONTAL IMPACT		
	Hybrid III 50% (Driver)	Hybrid III 5% (Passenger)
Head (HIC ₁₅)	$P_{head} (AIS\ 3+) = \Phi\left(\frac{\ln(HIC15) - 7.45231}{0.73998}\right)$ <i>where</i> Φ = cumulative normal distribution	$P_{head} (AIS\ 3+) = \Phi\left(\frac{\ln(HIC15) - 7.45231}{0.73998}\right)$ <i>where</i> Φ = cumulative normal distribution
Chest (deflection in mm)	$P_{chest_defl} (AIS\ 3+) = \frac{1}{1 + e^{10.5456 - 1.568 * (ChestDefl)^{0.4612}}}$	$P_{chest_defl} (AIS\ 3+) = \frac{1}{1 + e^{10.5456 - 1.7212 * (ChestDefl)^{0.4612}}}$
Femur (force in kN)	$P (AIS\ 2+) = \frac{1}{1 + e^{5.795 - 0.5196 \cdot Femur_Force}}$	$P (AIS\ 2+) = \frac{1}{1 + e^{5.7948 - 0.7619 \cdot Femur_Force}}$
Neck (Nij and tension/ compression in kN)	$P_{neck_Nij} (AIS\ 3+) = \frac{1}{1 + e^{3.2269 - 1.9688 \cdot Nij}}$ $P_{neck_Tens} (AIS\ 3+) = \frac{1}{1 + e^{10.9745 - 2.375 \cdot Neck_Tension}}$ $P_{neck_Comp} (AIS\ 3+) = \frac{1}{1 + e^{10.9745 - 2.375 \cdot Neck_Compression}}$ $P_{neck} = \max imum(P_{neck_Nij}, P_{neck_Tens}, P_{neck_Comp})$	$P_{neck_Nij} (AIS\ 3+) = \frac{1}{1 + e^{3.2269 - 1.9688 \cdot Nij}}$ $P_{neck_Tens} (AIS\ 3+) = \frac{1}{1 + e^{10.958 - 3.770 \cdot Neck_Tension}}$ $P_{neck_Comp} (AIS\ 3+) = \frac{1}{1 + e^{10.958 - 3.770 \cdot Neck_Compression}}$ $P_{neck} = \max imum(P_{neck_Nij}, P_{neck_Tens}, P_{neck_Comp})$
	$P_{joint} = 1 - (1 - P_{head}) \times (1 - P_{neck}) \times (1 - P_{chest}) \times (1 - P_{femur})$	

US NCAP Tests and Criteria

The new US NCAP Rating will be applied from model year 2011



Injury Criteria	Injury Risk Curves	
SIDE IMPACT (MDB & Pole Test)		
	ES-2re 50%	SID-11s 5%
Head (HIC ₃₆)	$P_{\text{head}}(\text{AIS}3+) = \Phi\left(\frac{\ln(\text{HIC}36) - 7.45231}{0.73998}\right)$ <i>where</i> Φ = cumulative normal distribution	$P_{\text{head}}(\text{AIS}3+) = \Phi\left(\frac{\ln(\text{HIC}36) - 7.45231}{0.73998}\right)$ <i>where</i> Φ = cumulative normal distribution
Chest (rib deflection in mm)	$P_{\text{chest}}(\text{AIS}3+) = \frac{1}{1 + e^{5.3895 - 0.0919 * \text{max. rib deflection}}}$	
Abdomen (total abdominal force in N)	$P_{\text{abdomen}}(\text{AIS}3+) = \frac{1}{1 + e^{6.04044 - 0.002133 * F}}$ <i>where F = total abdominal force (N) in ES-2re</i>	
Pelvis (Force)	$P_{\text{pelvis}}(\text{AIS}3+) = \frac{1}{1 + e^{7.5969 - 0.0011 * F}}$ <i>where F is the pubic force in the ES-2re in Newtons</i>	$P_{\text{pelvis}}(\text{AIS}2+) = \frac{1}{1 + e^{6.3055 - 0.00094 * F}}$ <i>where F is the sum of acetabular and iliac force in the SID-11s dummy in Newtons</i>
	$P_{\text{joint}} = 1 - (1 - P_{\text{head}}) \times (1 - P_{\text{chest}}) \times (1 - P_{\text{abdomen}}) \times (1 - P_{\text{pelvis}})$	$P_{\text{joint}} = 1 - (1 - P_{\text{head}}) \times (1 - P_{\text{pelvis}})$

IIHS Rating Frontal Impact

SafetyWissen by carhs.	Good	Acceptable	Marginal	Poor
Head/Neck				
HIC-15	≤ 560	559 - 700	701 - 840	> 840
N _i	≤ 0,80	0,79 - 1,00	1,01 - 1,20	> 1,20
Neck axial tension (kN)	≤ 2,6	2,7 - 3,3	3,4 - 4,0	> 4,0
Neck compression (kN)	≤ 3,2	3,3 - 4,0	4,1 - 4,8	> 4,8
a _{res peak}	Werte > 70 g führen zu Abwertung			
Chest				
a3ms	≤ 60	61 - 75	76 - 90	> 90
Sternum deflection (mm)	≤ 50	51 - 60	61 - 75	> 75
Sternum deflection rate (m/s)	≤ 6,6	6,7 - 8,2	8,3-9,8	> 9,8
Viscous criterion (m/s)	≤ 0,8	0,9 - 1,0	1,1 - 1,2	> 1,2
Legs & Feet				
Femur axial force (kN) (Force duration corridors)	≤ 7,3 @ 0ms ≤ 6,1 @ 10ms	7,4 - 9,1 @ 0ms 6,2 - 7,6 @ 10ms	9,2 - 10,9 @ 0ms 7,7 - 9,1 @ 10ms	>10,9 @ 0ms > 9,1 @ 10ms
Tibla-femur displacement (mm)	≤ 12	13-15	16-18	> 18
Tibia index (upper, lower)	≤ 0,80	0,81 - 1,00	1,01 - 1,20	> 1,20
Tibia axial force (kN)	≤ 4,0	4,1 - 6,0	6,1 - 8,0	> 8,0
Foot acceleration (g)	≤ 150	151 - 200	201 - 260	> 260

IIHS Rating Frontal Impact

Seat / Head restraints

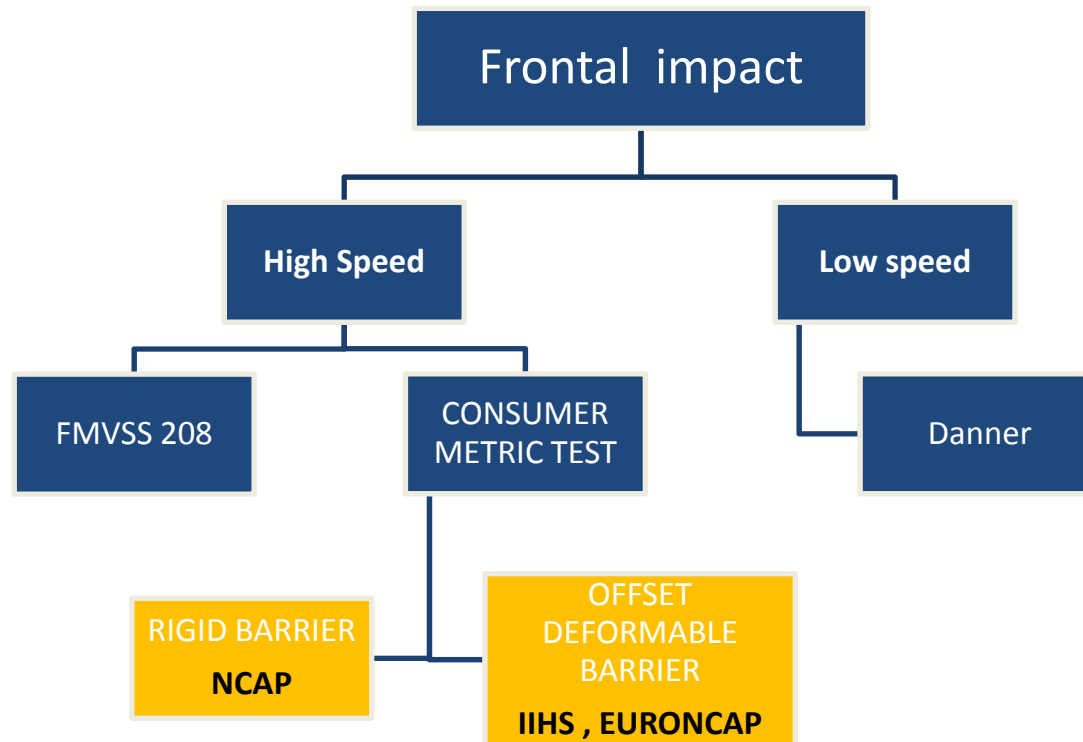
SafetyWissen by Carhs.	Good	Acceptable	Marginal	Poor
Static Assessment				
Backset (mm)	≤ 70	71 - 90	91 - 110	> 110
Distance from top of head (mm)	≤ 60	61- 80	81 - 100	> 100
Dynamic Assessment (see also page 48)				
Vector sum of the standardized shear (F_x) and tension (F_z) values $\{F_x / 315\}^2 + \{(F_z - 234) / 1131\}^2$	$< \{0.450\}^2$	$\{0.450\}^2 - \{0.825\}^2$	$> \{0.825\}^2$	
Time to head restraint contact (ms)	for values > 70 ms the rating is reduced by one level*			
T1 acceleration (g)	for values $> 9,5$ the rating is reduced by one level*			
	* only if both exceed the given level			
The overall rating equals the static or dynamic rating, whichever is worse. Exceptions: If the static rating is „acceptable“ but the backset is sufficient for a „good“ rating and the dynamic rating is „good“ then the overall rating is also „good“. If the static rating is „marginal“ or „poor“ no dynamic test is made and the overall rating is „poor“.				

IIHS Rating Side Impact

SafetyWissen by carhs.	Good	Acceptable	Marginal	Poor
Head/Neck				
HIC-15	≤ 623	624 - 779	780 - 935	> 935
Neck axial tension (kN)*	≤ 2,1	2,2 - 2,5	2,6 - 2,9	> 2,9
Neck compression (kN)*	≤ 2,5	2,6 - 3,0	3,1 - 3,5	> 3,5
Brust/Torso				
Shoulder deflection (mm)	Werte > 60 führen zu Abwertung			
Ø Rib deflection (mm)	≤ 34	35 - 42	43 - 50	> 50
worst rib deflection (mm)			51 - 55	> 55
Deflection rate (m/s)	≤ 8,20	8,21 - 9,84	9,85 - 11,48	> 11,48
Viscous criterion (m/s)	≤ 1,00	1,01 - 1,20	1,21 - 1,40	> 1,40
Pelvis & Left Femur				
Acetabulum force (kN)	≤ 4,0	4,1 - 4,8	4,9 - 5,6	> 5,6
Ilium force (kN)	≤ 4,0	4,1 - 4,8	4,9 - 5,6	> 5,6
Combined acetabulum and ilium force (kN)	≤ 5,1	5,2 - 6,1	6,2 - 7,1	> 7,1
Femur A-P force (3 ms clip, kN)	≤ 2,8	2,9 - 3,4	3,5 - 3,9	> 3,9
Femur L-M force (3 ms clip, kN)	≤ 2,8	2,9 - 3,4	3,5 - 3,9	> 3,9
Femur A-P bending moment (3 ms clip, Nm)	≤ 254	255 - 305	306 - 356	> 356
Femur L-M bending moment (3 ms clip, Nm)	≤ 254	255 - 305	306 - 356	> 356

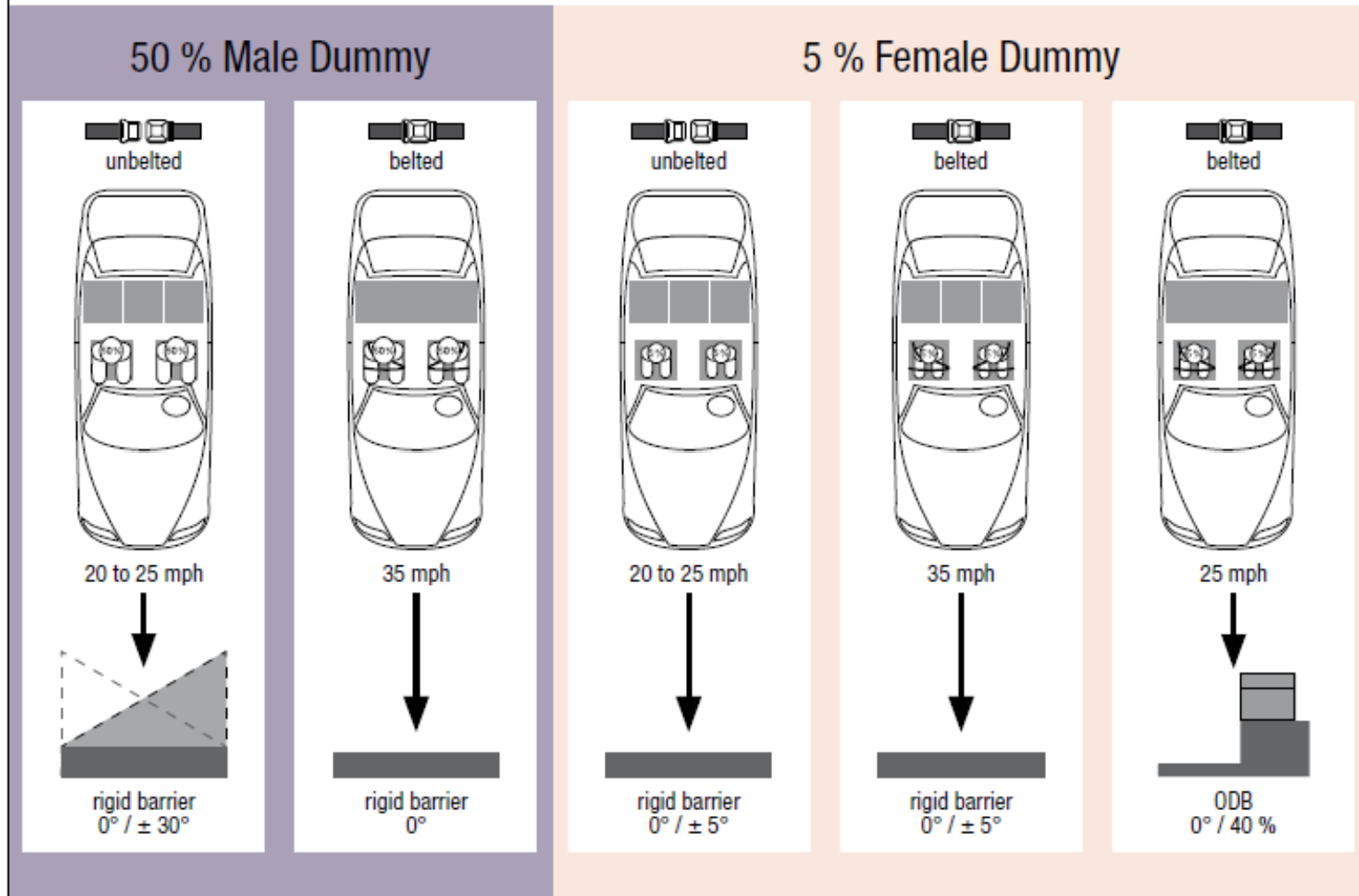
Front Impact

Types of Frontal Load cases



FMVSS 208: Frontal Impact Requirements: In-Position

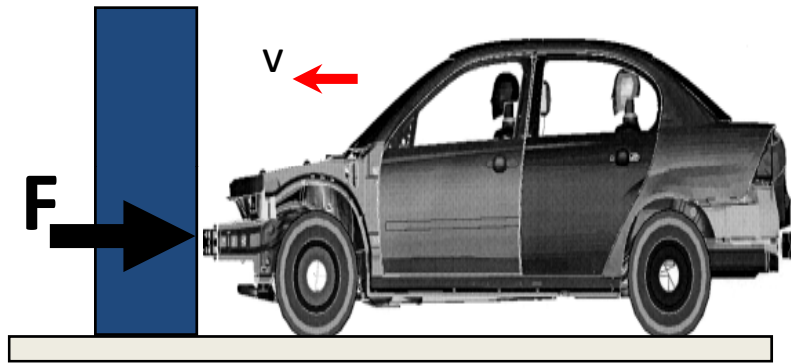
Test Configurations In-Position



FMVSS 208: Frontal Impact Requirements: Out of Position

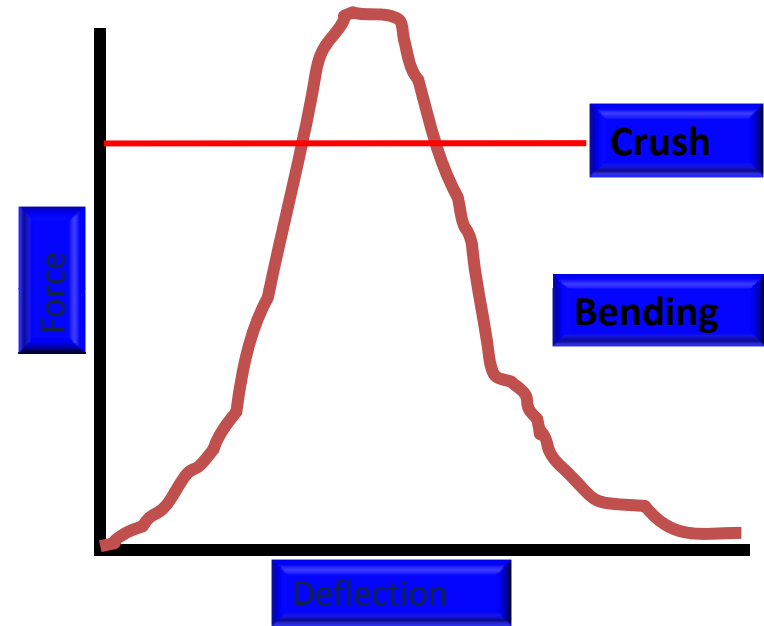
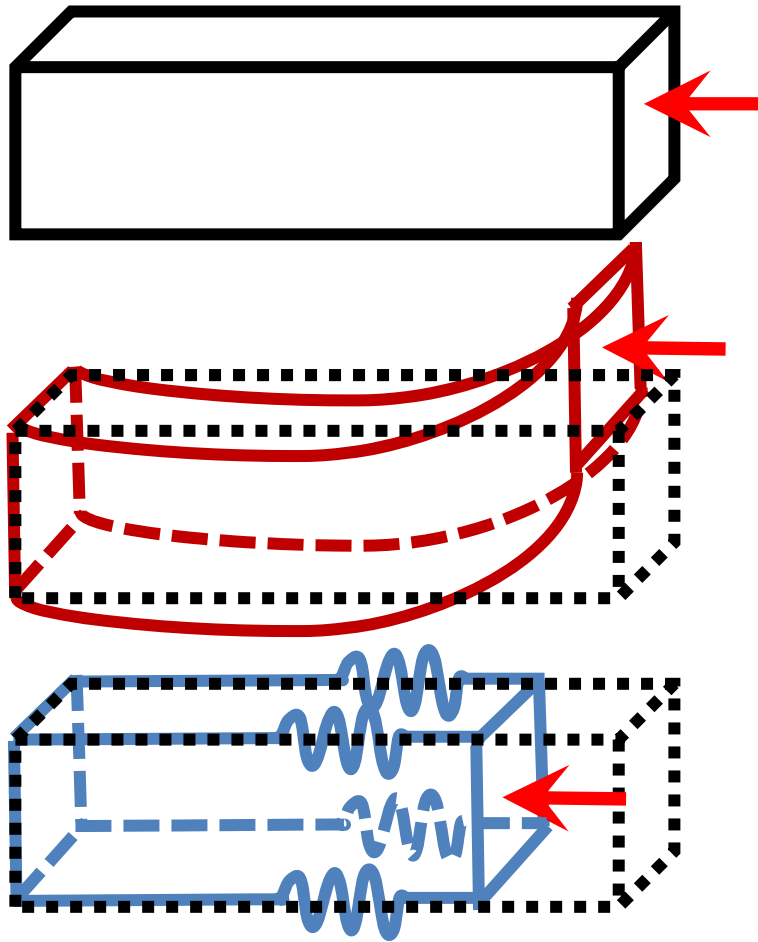
Front seat	Dummy	Test configuration
Driver side	HIII 5% female dummy	chin on airbag module in steering wheel chin on top of steering wheel
Passenger side	1 year old child dummy	in 23 defined CRS / positions
	3 year old CRABI - dummy	chest on instrument panel head on instrument panel
	6 year old CRABI - dummy	chest on instrument panel head on instrument panel

Physics of a Crash



- Kinetic Energy = $\frac{1}{2} mv^2$
- Work = $F \cdot D$; where
- $F \rightarrow$ Average Force on Vehicle by Wall
- $D \rightarrow$ Crush + Rebound of Vehicle
- Dissipate KE into Vehicle Deformation (or Work) but away from occupant
- Energy Dissipation Rate $\propto$ Injury
- Constant Force as “ideal”
- Axial Crush as preferred mode
- Maximize Crush Space
- Minimize Intrusion

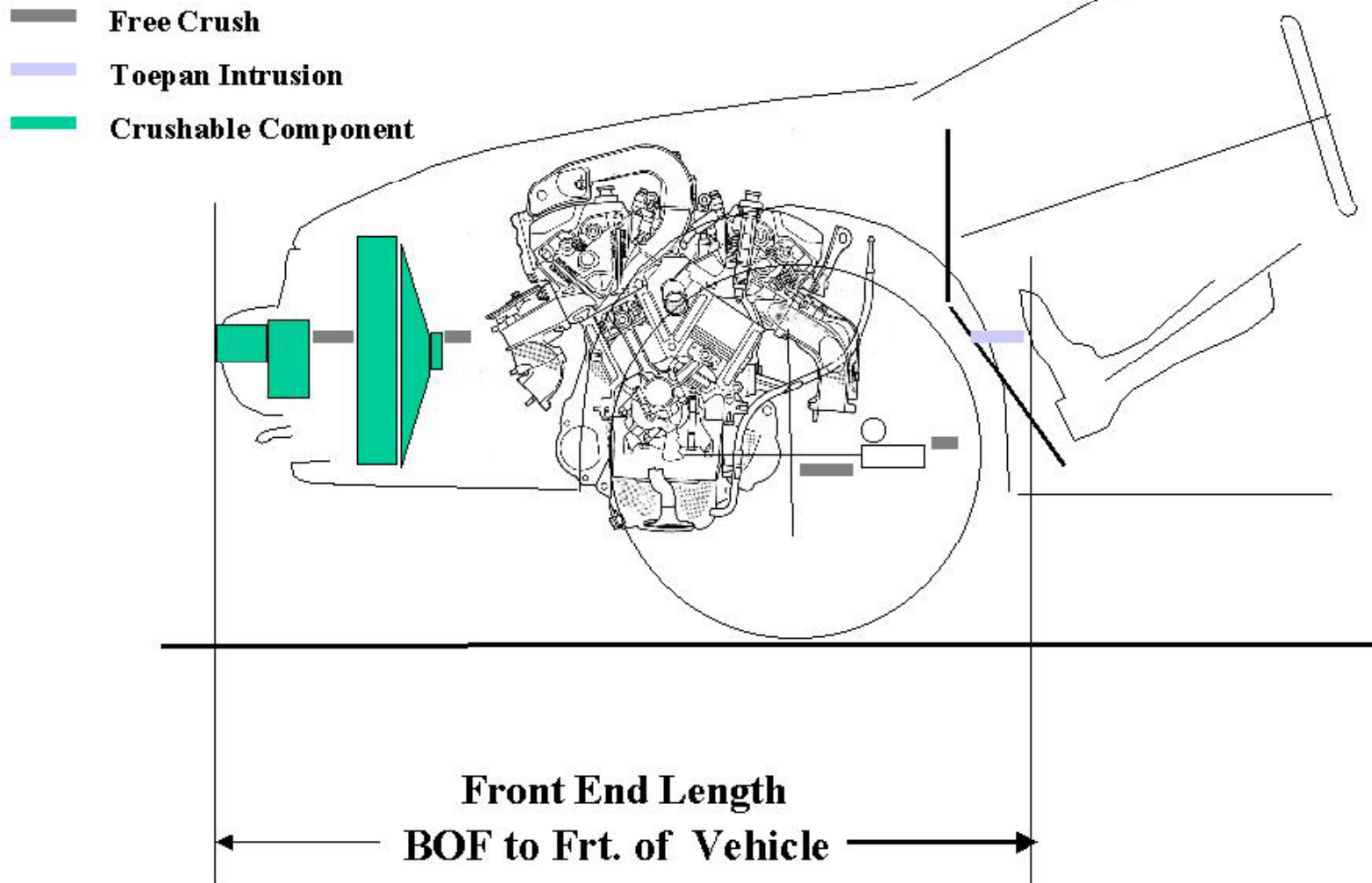
Structural Deformation in a Crash



Crush Space Measurement

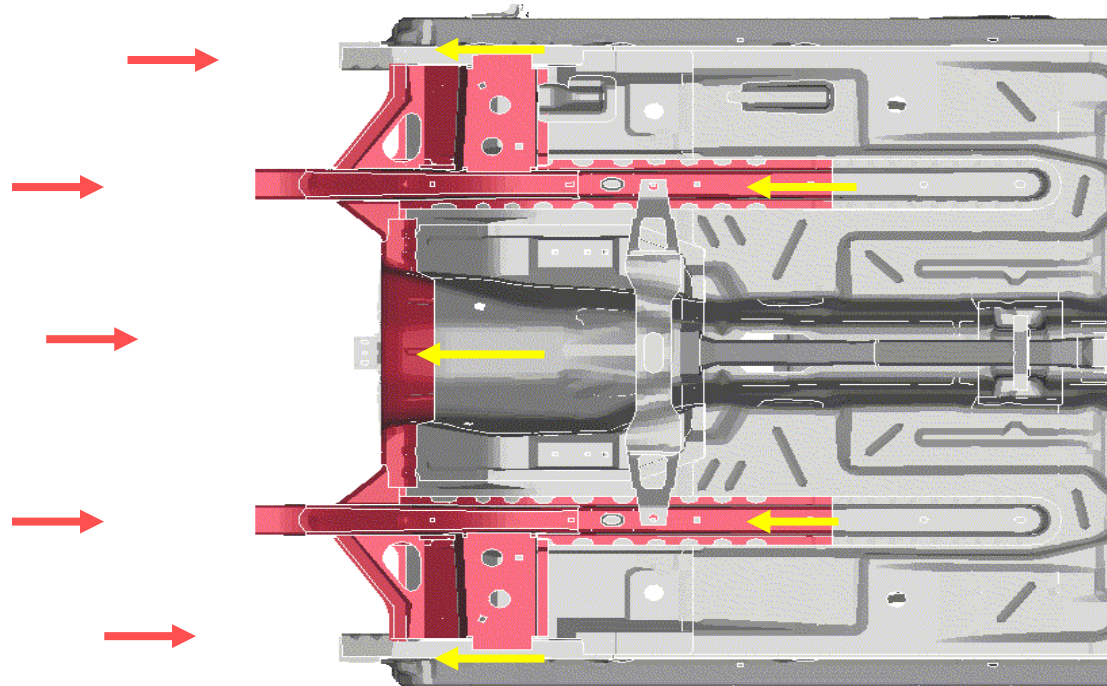
Static Crush Space = Free Crush + Crushed Components

Dynamic Crush = Static Crush Space + Dynamic Dash Intrusion



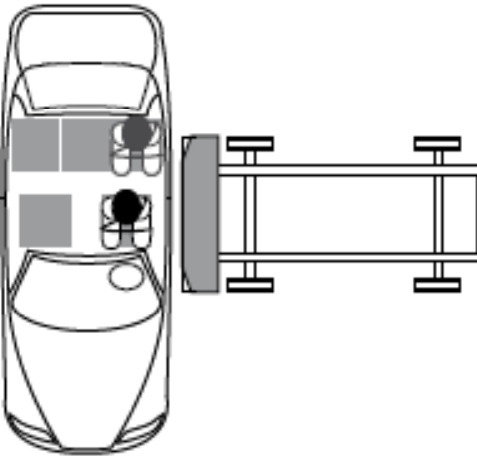
Load Distribution Philosophy

Transition Zone bridges offset between loadpaths in crush zone & safety cage;
enables effective load transfer & provides stability control

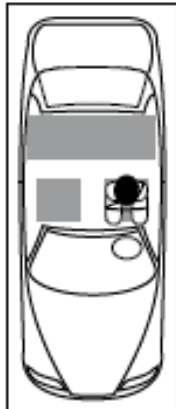
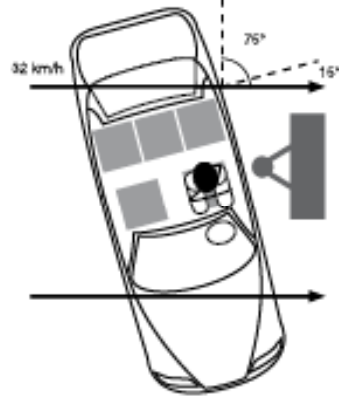
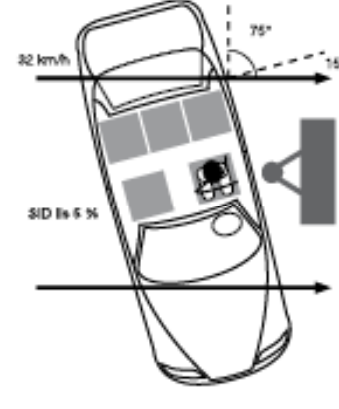


Side Impact

Side Impact Test Procedures

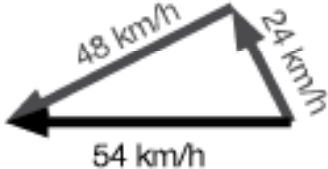
Requirement	ECE-R95, 96/27/EG, Euro NCAP	IIHS	
Impact angle	side 90°	side 90°	
MDB velocity	50 km/h	50 km/h	
Mobile Deformable Barrier (MDB)	EEVC (2000 Advanced Barrier), Mass 950 kg, 300 mm above ground, 800 mm height, 1500 mm width	IIHS, Mass 1500 kg, 379 mm above ground, 759 mm height, 1676 mm width	
Dummy	1 ES-2 frontal seat on impact side, additional for Euro NCAP on rear seat P1,5 on impact side and P3 other side	2 SID IIs on impact side	
Protection Criteria	Head HPC < 1000 Chest VC < 1,0 m/s Rib deflection D < 42 mm Abdomen sum of APF < 2,5 kN Pelvis PSPF < 6,0 kN	Different weight in assessment driver and passenger values for HIC 15, Neck-Tens./Compr., Head kinematics, Shoulder, Chest deflection, VC, Pelvis and Femur; Car body evaluation, B-pillar	

Pole (Side) Impact Tests according to Euro NCAP, FMVSS 201 and FMVSS 214 new

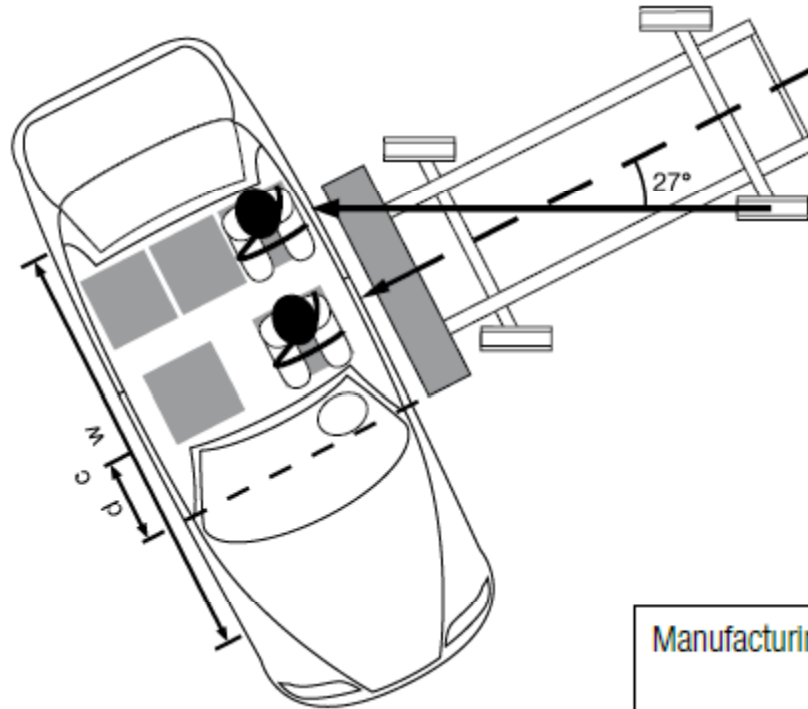
Requirement	Euro NCAP	FMVSS 201	FMVSS 214 neu („Oblique Pole Test“)	US NCAP
Vehicle Velocity (on Flying Floor)	29 km/h	29 km/h	upto 32 km/h	32 km/h
Impact angle	lateral @ 90° on fixed pole	lateral @ 90° on fixed pole	lateral @ 75° on fixed pole	lateral @ 75° on fixed pole
Pole diameter	254 mm	254 mm	254 mm	254 mm
Dummy	1 ES-2 on impact side	1 SID-H3 on impact side	ES-2 re oR SID IIs (Build Level D) j on impact side	SID IIs 5 % on impact side
Protection Criteria	HIC ₃₆ < 1000 a _{rear peak} < 80g Chest deflection < 42 mm VC < 1,0 m/s Abdominal force < 2,5 kN PSPF < 6 kN see page 22	Head HIC < 1000	SID IIs: HIC 36 < 1000 Lower Spine Acc. < 82 g Pelvis Force < 5,525 kN ES-2 re: HIC 36 < 1000 Chest deflection < 44 mm Abdominal Force < 2,5 kN PSPF < 6 kN	see page 28
Test Configuration	 Pole impact according to FMVSS 201 shall be replaced by „Oblique Pole“ Test according to new FMVSS 214.			

Side Impact Test Procedures

MDB - Side Impact Tests according to FMVSS 214 / US NCAP

Requirement	FMVSS 214 old rule	FMVSS 214 new rule	US NCAP
Impact angle	side 90°, 27° crab angle	side 90°, 27° crab angle	side 90°, 27° crab angle
Impact velocity	54 km/h (48 km/h in 90° direction)	54 km/h (48 km/h in 90° direction)	61 km/h (55 km/h in 90° direction)
Barrier	MDB, 1368 kg Mass, 279 mm above ground, 1676 mm width	MDB, 1368 kg Mass, 279 mm above ground, 1676 mm width	MDB, 1368 kg Mass, 279 mm above ground, 1676 mm width
Dummy	2 DOT-SID	Front seat: ES-2 re / Back seat: SID IIs (Build Level D) (impact side)	Front seat: ES-2 re / Back seat: SID IIs (Build Level D) (impact side)
Protection Criteria	Chest TTI < 85 g (4-doors) Chest TTI < 90 g (2-doors) Pelvis acceleration < 130 g	SID IIs: HIC 36 < 1000 Chest acceleration < 82 g Pelvis force < 5,525 kN ES-2 re: HIC 36 < 1000 Chest deflection < 44 mm Abdominal force < 2,5 kN Pelvis force < 6 kN	see page 28
Velocity Vectors for Moving Deformable Barrier			

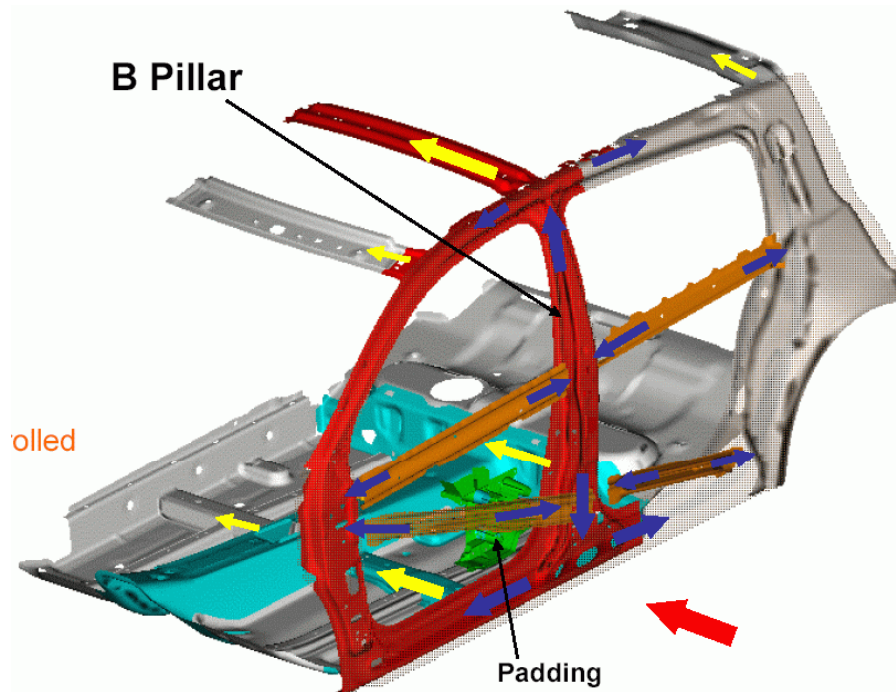
MDB - Side Impact Tests according to FMVSS 214 / US NCAP



Phase-In Schedule FMVSS 214 new rule

Manufacturing Period	Percentage of each manufacturer's vehicles required to meet the new requirements
1.9.2009-31.8.2010	20% (for GVWR $\leq$ 3855 kg)
1.9.2010-31.8.2011	50% (for GVWR $\leq$ 3855 kg)
1.9.2011-31.8.2012	75% (for GVWR $\leq$ 3855 kg)
after 1.9.2012	100% (for GVWR $\leq$ 3855 kg)
after 1.9.2013	100% (for 3855 kg < GVWR $\leq$ 4536 kg)

Primary Load Path in Side Impact

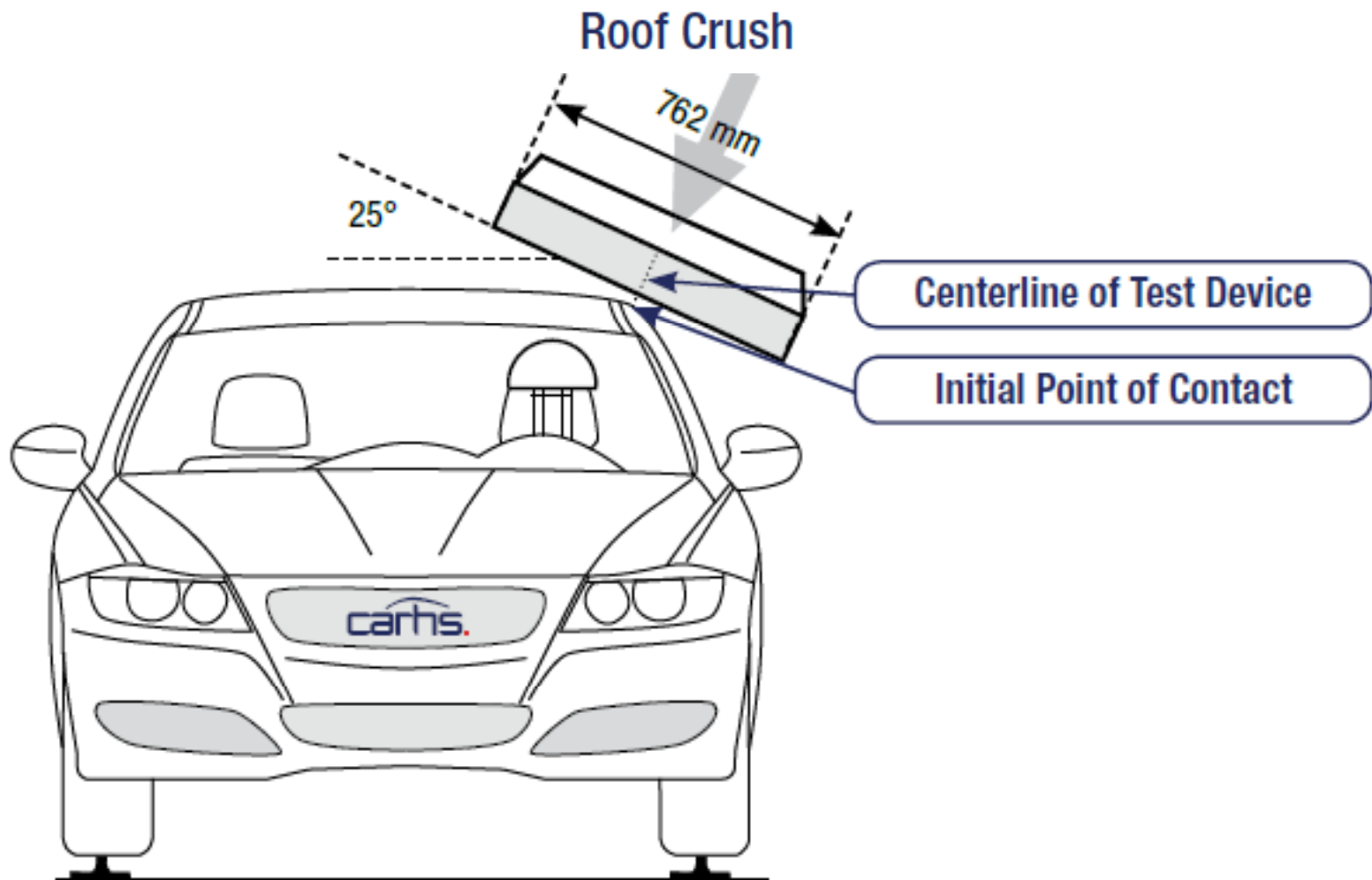


Structural criteria:

- Load transfer continuity to doors.
- Small relative displacements
- Small absolute displacements up to $t=40\text{ms}$ for enabling air bag inflation

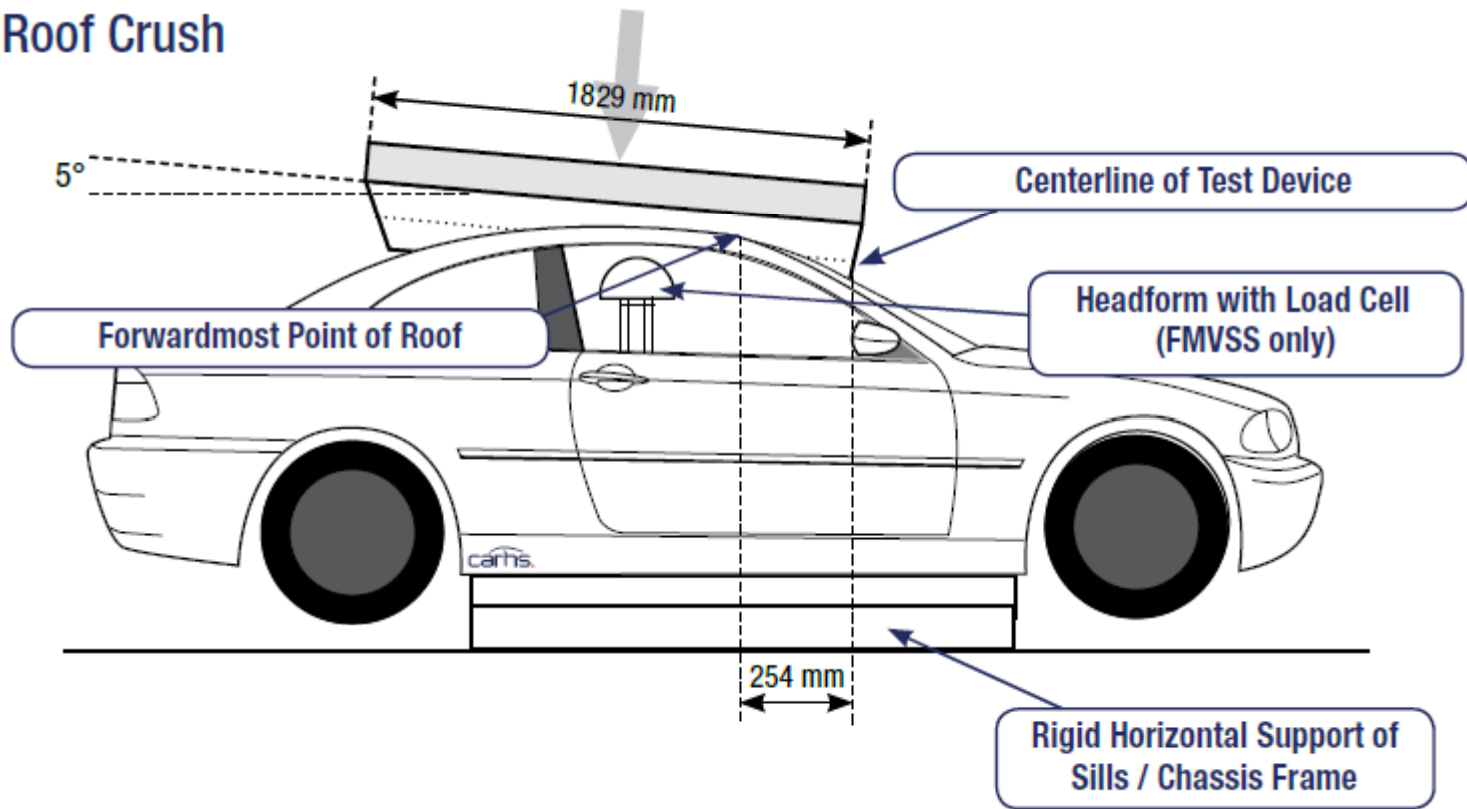


Roof Crush



SafetyWissen by carhs.	Good	Acceptable	Marginal	Poor
$SWR = F_{max} / m \times g$	$\geq 4,00$	3,99 - 3,25	3,24 - 2,50	$< 2,5$

Roof Crush



Roof Crush

IIHS (Roof Strength Test Protocol (Version 1) Nov. 2009)

Platen Displacement: 127 mm

Feed Rate: 5 mm/s

Single Side Test: Lab selects worst case

Assessment:

based on Strength-to-weight ratio (SWR) = $F_{max} / m \times g$

SWR	Rating
$\geq 4,00$	Good
$\geq 3,25$ bis $<4,00$	Acceptable
$\geq 2,50$ bis $<3,25$	Marginal
$< 2,50$	Poor

From 2010 a „Good“ rating in the roof crush test is a requirement for the Top-SafetyPick award.

FMVSS 216a

Application:

Vehicles with a GVWR ≤ 4536 kg

Applied Force:

for vehicles with a GVWR ≤ 2722 kg:

$$F = 3,0 \times \text{GVWR} \times 9,8 \text{ m/s}^2$$

for vehicles with a GVWR > 2722 kg:

$$F = 1,5 \times \text{GVWR} \times 9,8 \text{ m/s}^2$$

Feed Rate: ≤ 13 mm/s

Double Sided Test

Requirements:

Platen displacement ≤ 127 mm

Load on headform located at head position of 50% male ≤ 222 N

Phase-In for GVWR ≤ 2722 kg:

Manufacturing Period	%*
01.09.2012-30.08.2013	25%
01.09.2013-30.08.2014	50%
01.09.2014-30.08.2015	75%
on or after 01.09.2015	100%

* in % of the production of the respective period or in % of the average production of the 3 previous years

Introduction for GVWR > 2722 kg: 01.09.2016

