Performance as Test Procedures of the PDB and ODB Tests for the Light and Heavy Cars

JAPAN

May 25, 2009

5th Meeting of the Informal Group on Frontal Impact

Objective

- **To examine effects on light and heavy cars when the test conditions prescribed in ECE R94 are replaced by PDB test.**

Test Matrix

Test Vehicles	Mini-Car A		Mini-Car B				Minivan		Passenger Car	
Test Conditions	60PDB	64ODB*	60PDB	64ODB*	56ODB (ECE R94)	50CTC	60PDB	64ODB*	64ODB*	50CTC
Test Weight (kg)	1144		1120				2110		1313	
Dummies (DR&PA)	H3 50% Male		H3 50% Male				H3 50% Male		H3 50% Male	

* Conducted in JNCAP

- 60PDB: PDB barrier - 60km/h - 50% overlap - 150mm ground clearance
- 64ODB: EEVC barrier - 64km/h - 40% overlap - 200mm ground clearance
- 56ODB: EEVC barrier - 56km/h - 40% overlap - 200mm ground clearance
- 50CTC: Mini-Car B vs Passenger Car - 50km/h - 50% overlap

Test Vehicles

Mini-Car A

- Front Rail and Bumper Cross Beam

Mini-Car B

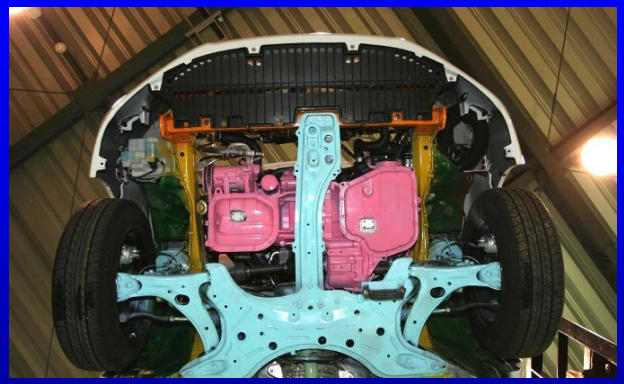
- Front Rail and Lower Cross Beam (w/o Bumper Cross Beam)

Test Vehicles

Minivan

- Front Rail, Bumper Cross Beam, and Sub-Frame

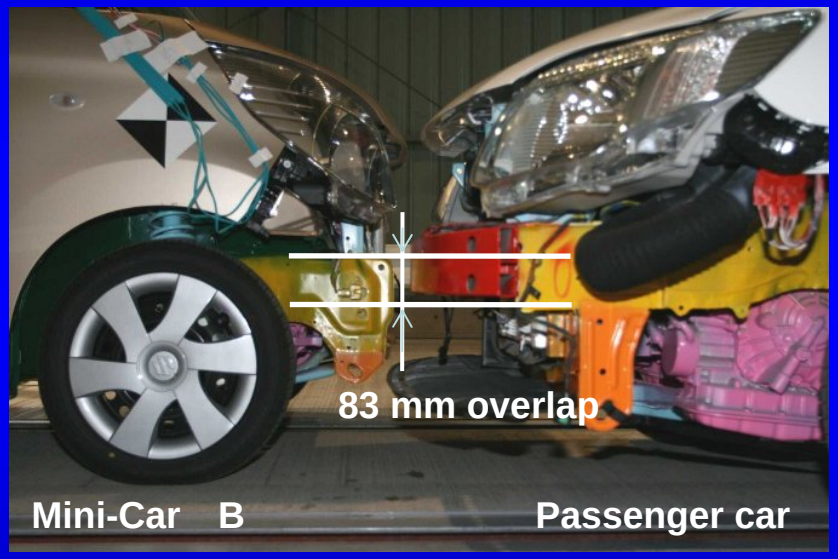
Passenger Car



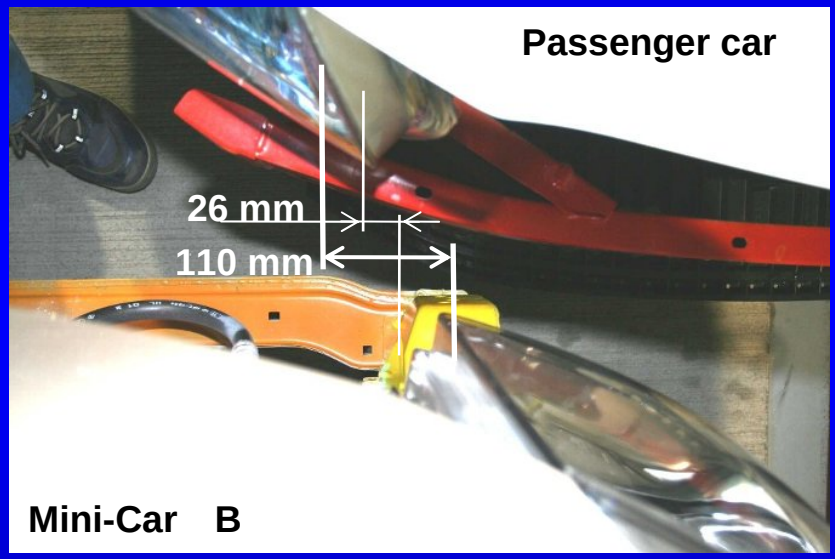
- Front Rail and Bumper Cross Beam

Geometory Conditions

Mini-Car B vs Passenger Car



Mini-Car B's Front Rail
Upper: 495 mm, Lower: 311 mm
Passenger Car's Front Rail
Upper: 523 mm, Lower: 412 mm



Rail (CTR) to Rail (CTR): 110mm
Rail (Inside) to Rail (Inside): 26mm

Barrier Deformation

Mini-Car A

60PDB

- The front plate broke wide open.

64ODB (EEVC Barrier)

- The lower part of the honeycomb bottomed out completely.

Vehicle Deformation

Mini-Car A

60PDB

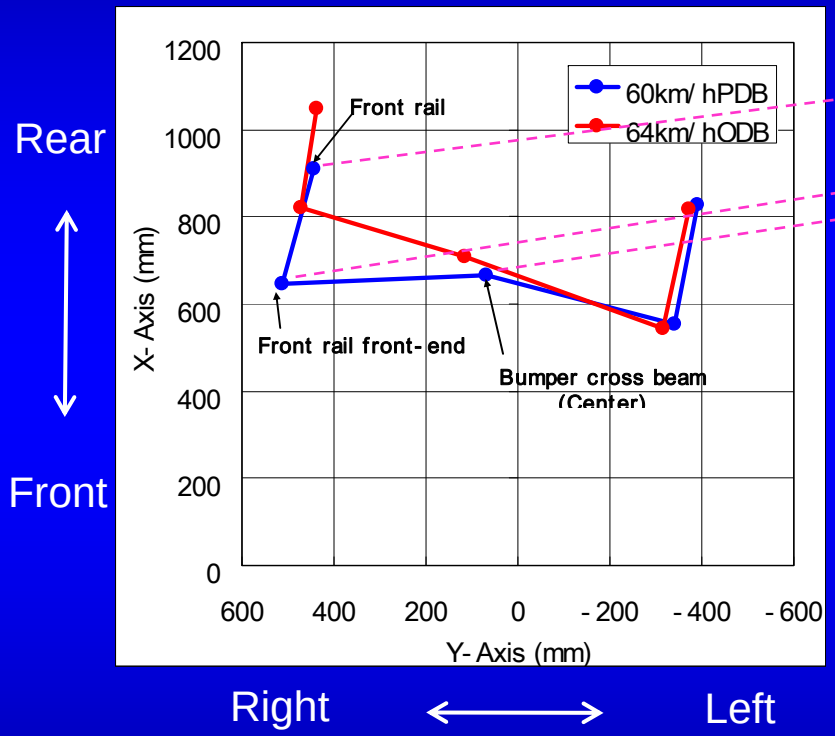
➢The front rail was rarely deformed.
➢The bumper cross beam was bent significantly.

64ODB (EEVC Barrier)

➢ The front rail was deformed.

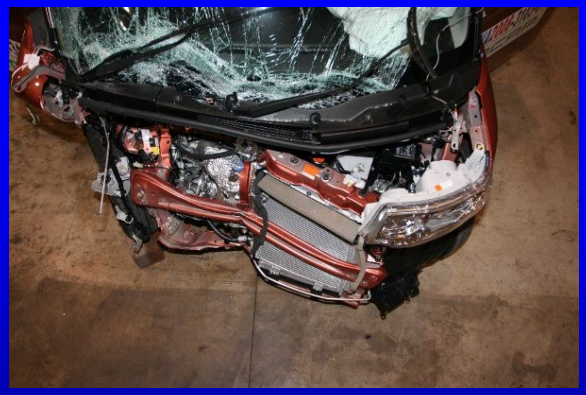
Vehicle Deformation

Mini-Car A



60PDB

64ODB (EEVC Barrier)



- In both 60PDB and 64ODB, the front rail front-end was deformed to the right of the vehicle.
- In 60PDB, due to the part of the front rail left undeformed, the deformation of the bumper cross beam was larger around its center.
- In 64ODB, the front rail was deformed in the axial direction, and the deformation of the bumper cross beam was larger at its right outer edge.

Barrier Deformation

Mini-Car B

60PDB

- The front plate broke wide open.

64ODB (EEVC Barrier)

- The lower part of the honeycomb bottomed out completely.

56ODB (EEVC Barrier)

- The lower part of the honeycomb bottomed out.

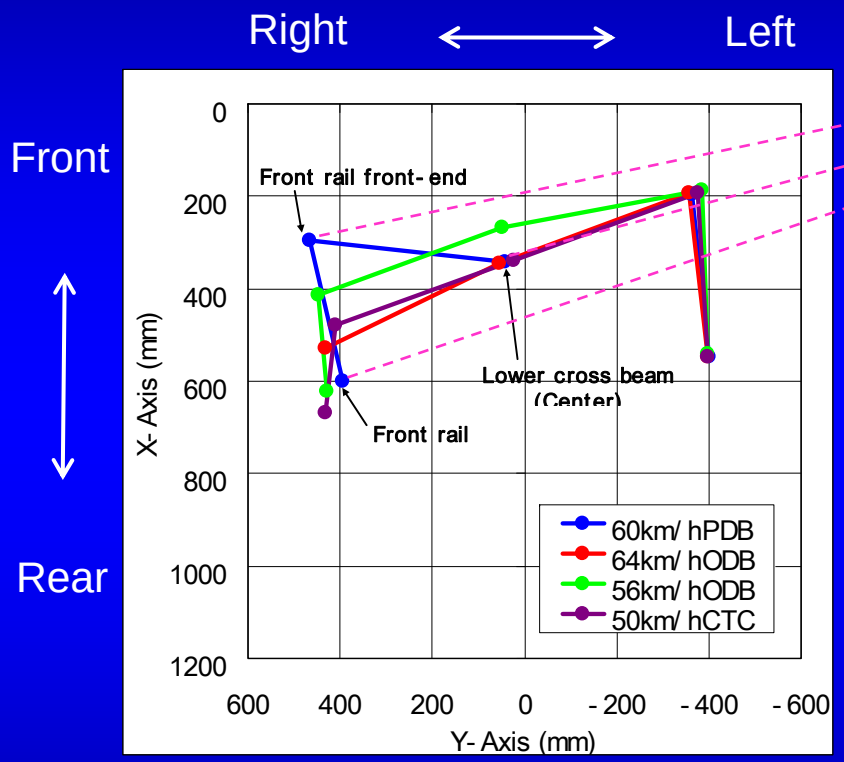
Vehicle Deformation

Mini-Car B

60PDB	64ODB (EEVC Barrier)	56ODB (EEVC Barrier)	50CTC
			
			
➢ The front rail was rarely deformed. ➢ The lower cross beam was bent significantly.	➢ The front rail was deformed.	➢ The front rail was deformed.	➢ The front rail was deformed.

Vehicle Deformation

Mini-Car B



60PDB

64ODB

56ODB

50CTC

- 64ODB and 50CTC showed similar deformation modes.
- While the deformation in 56ODB was smaller than 64ODB and 50CTC, its deformation mode was similar to theirs.
- Only 60PDB showed the deformation mode that differed from the other three tests: The front rail was not deformed in the axial direction, and its front-end was deformed to the outside of the vehicle.

Barrier Deformation

Minivan

60PDB

- The front plate broke wide open.
- Deformation reached the right edge of the barrier.

64ODB (EEVC Barrier)

- The honeycomb bottomed out completely.

Vehicle Deformation

Minivan

60PDB

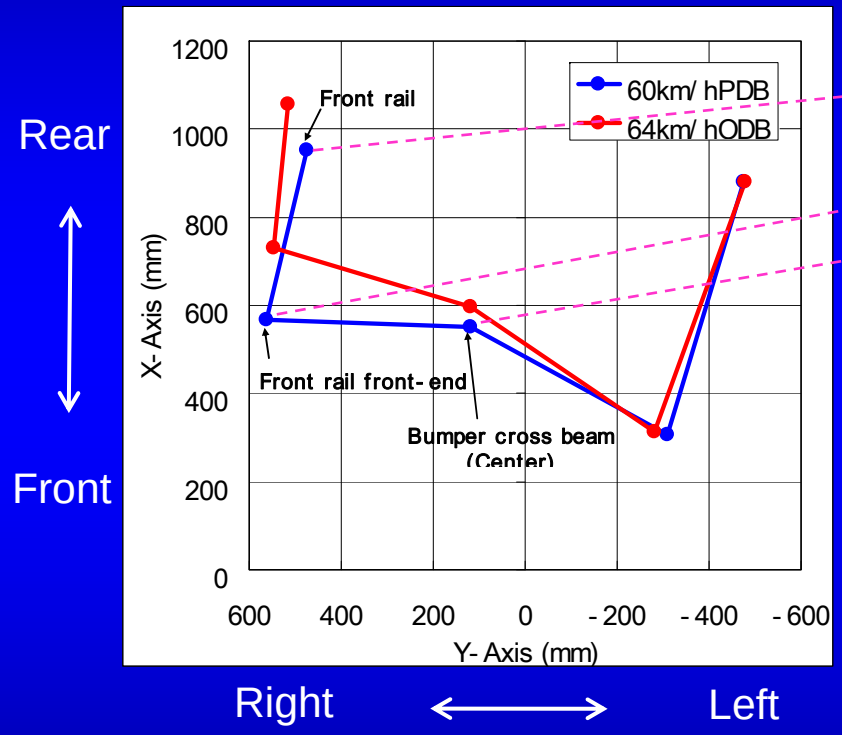
- The front rail was slightly deformed; only its end was deformed downward.
- The sub-frame was bent significantly.

64ODB (EEVC Barrier)

- The front rail was deformed.

Vehicle Deformation

Minivan



60PDB

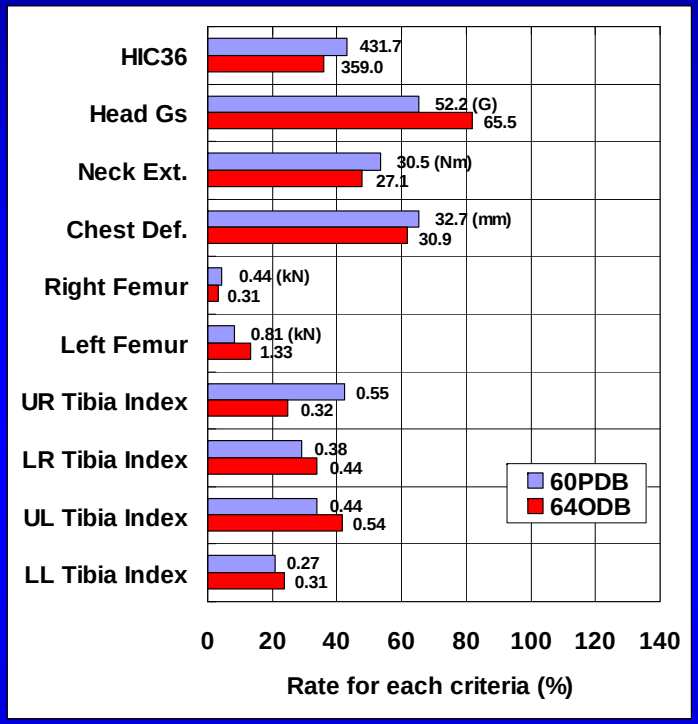
64ODB (EEVC Barrier)

- In both 60PDB and 64ODB, the front rail front-end was deformed to the right of the vehicle.
- In 60PDB, due to the part of the front rail left undeformed, the deformation of the bumper cross beam was larger around its center.
- In 64ODB, the front rail was deformed in the axial direction, and the deformation of the bumper cross beam was larger at its right outer edge.

Dummy Injury Criteria

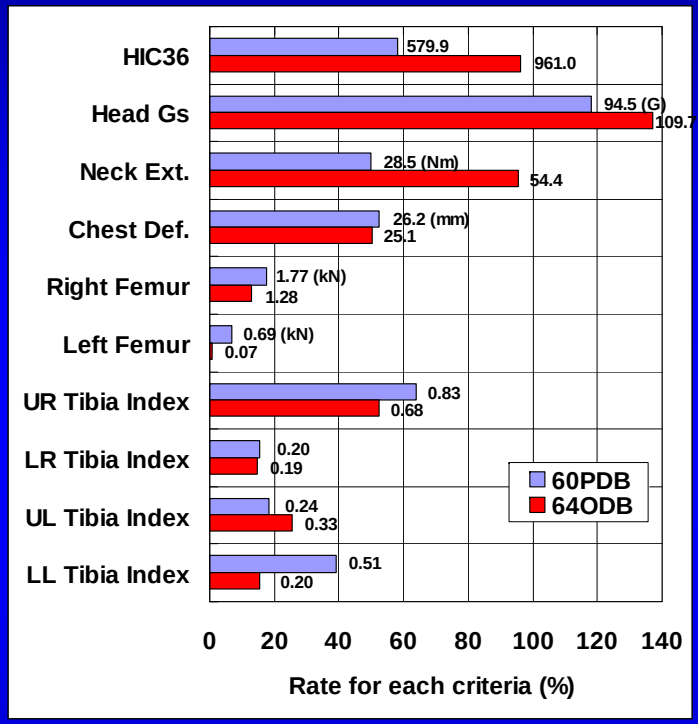
Mini-Car A

Driver



- 60PDB showed a slightly higher HIC, while 64ODB showed a slightly higher Head Gs.
- No significant difference was observed between the two tests for Neck, Chest, and Legs.
- The criteria were sufficiently met for all injury indices.

Passenger

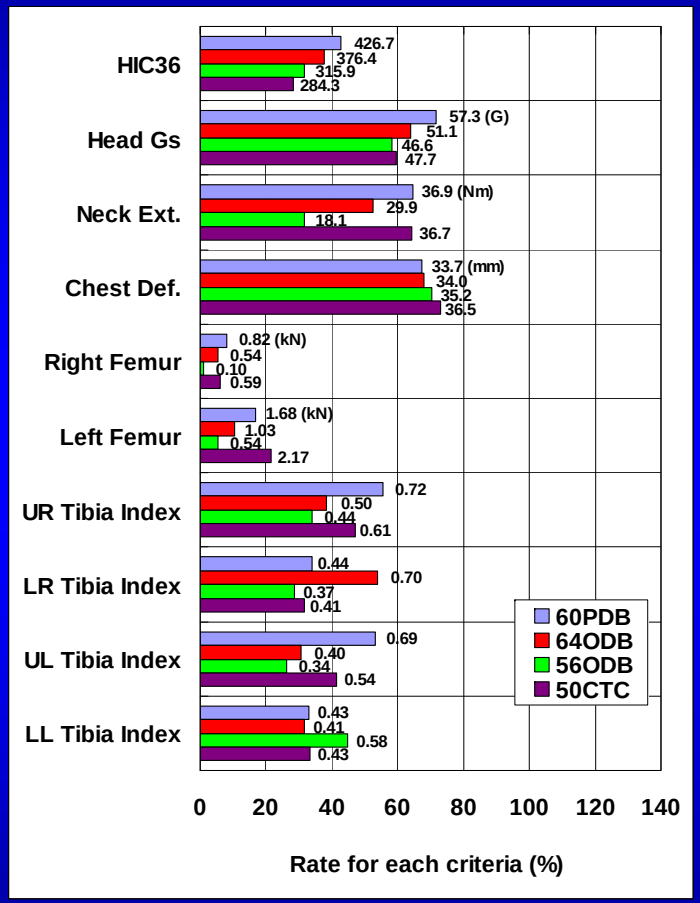


- 64ODB showed higher levels for Head and Neck.
- No significant difference was observed between the two tests for Chest and Legs.
- The Head Gs criterion was exceeded in both tests.

Dummy Injury Criteria

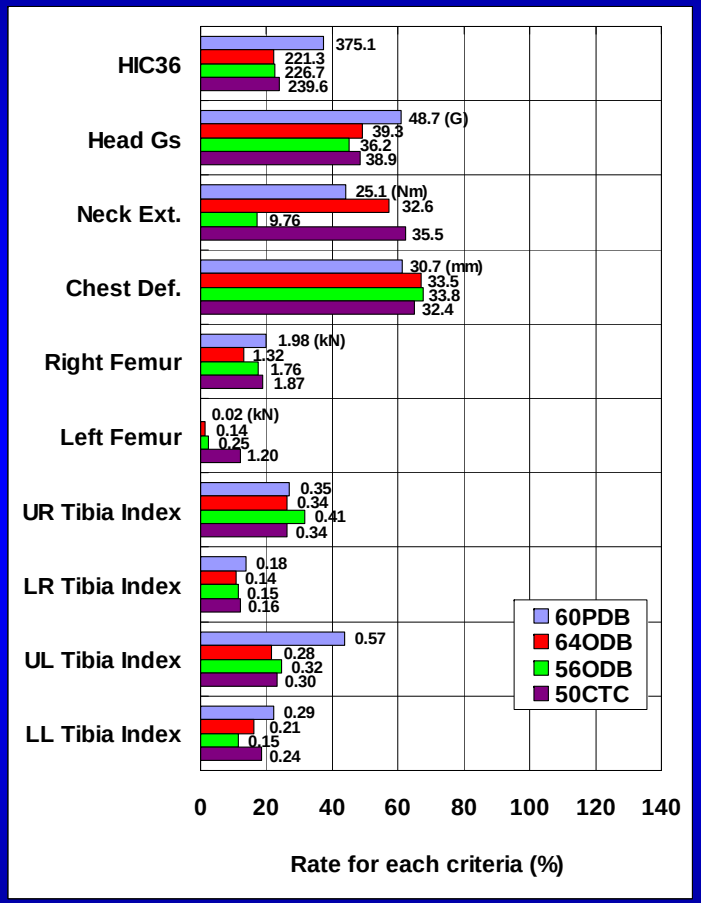
Mini-Car B

Driver



- The Head injury level became lower in the order of 60PDB, 64ODB, 56ODB, and 50CTC.
- Neck injury level was almost same between 60PDB and 50CTC.
- No significant difference was observed among 60PDB, 64ODB, and 50CTC for Chest and Legs.
- The criteria were sufficiently met for all injury indices.

Passenger

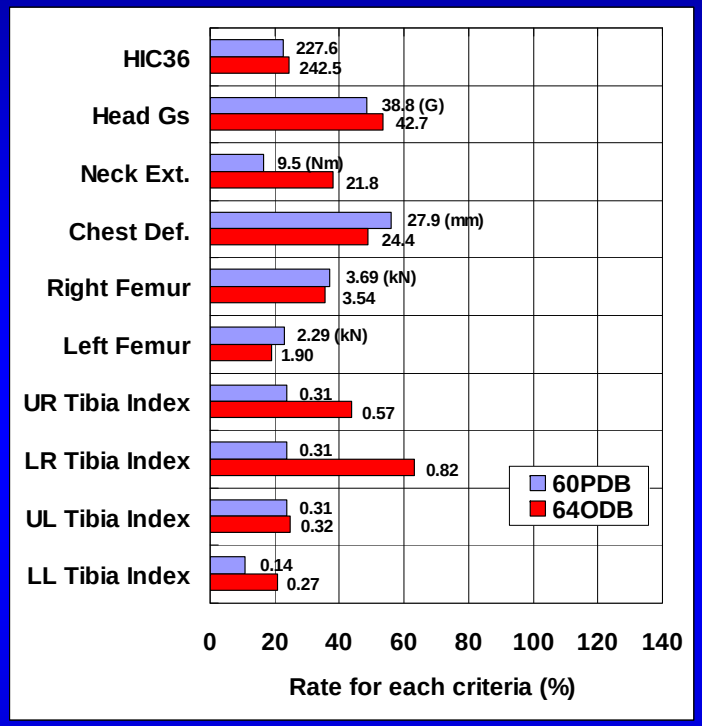


- 60PDB showed the highest level for Head.
- Neck injury level was approximately same between 64ODB and 50CTC.
- No significant difference was observed among the four tests for Chest and Legs.
- The criteria were sufficiently met for all injury indices.

Dummy Injury Criteria

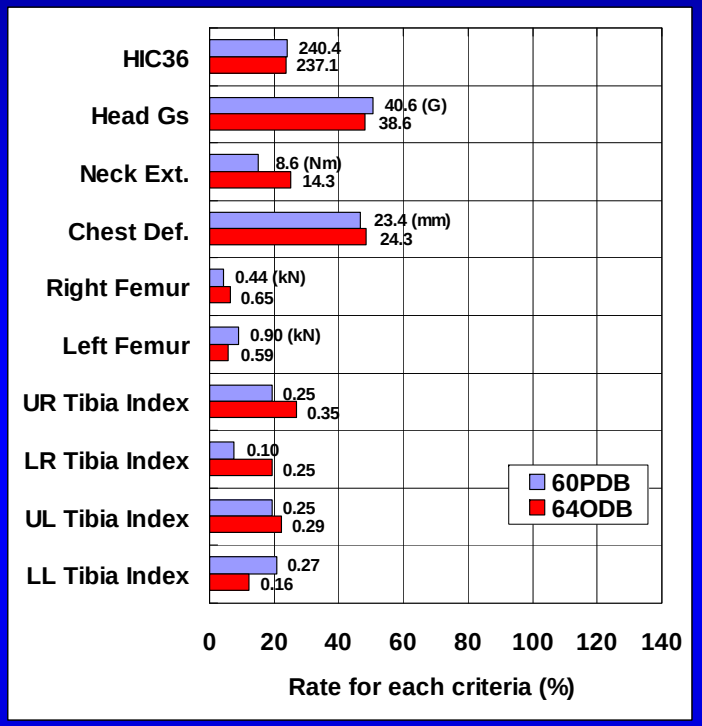
Minivan

Driver



- Overall, injury levels tended to be lower in 60PDB, though no significant difference was observed.
- The criteria were sufficiently met for all injury indices.

Passenger



- No significant difference was observed between the two tests for any injury index.
- The criteria were sufficiently met for all injury indices.

Summary

- The bottom-out of the EEVC barrier was observed with the mini-car even under the 56ODB conditions (the current ECE R94).
- No bottom-out of the PDB was observed, even in the crash with Minivan (heavy car, 2,110 kg). However, the front rail of Mini-Cars and Minivan stuck into the PDB, deforming its front block significantly (causing its front plate to break wide open).
- In Mini-Car B, the mode of the vehicle deformation was similar between ODB and CTC, but only mode of the vehicle deformation in PDB was different.
- Significant differences were seen in the deformation of the front rail between PDB versus ODB and CTC. Deformation in 60PDB was extremely smaller than that in 56 & 64 ODB and 50CTC.
- Overall, the vehicle deformation of Mini-Cars tended to be larger in 64ODB and 50CTC than in 60PDB (the intrusion into the lower part of the cabin [brake pedal and toe board, etc.] tended to be large in 64ODB and 50CTC).
- Overall, the vehicle deformation of Minivan tended to be larger in 64ODB than in 60PDB.

Summary

- **Dummy injury criteria: In Mini-Cars, no significant difference was observed among 60PDB, 64ODB, and 50CTC for Chest and Legs (in Mini-Car B, the Head injury level tended to be higher in 60PDB than 64ODB, 56ODB, and 50CTC). The criteria were sufficiently met for all injury indices, except Head Gs of the passenger dummy in Mini-Car A.**

- **In Minivan, overall, injury levels for the driver dummy tended to be lower in 60PDB than 64ODB, though no significant difference was observed. As for the passenger dummy, no significant difference was observed between the two tests for any injury index. In both tests, the criteria were sufficiently met for all injury indices of both dummies.**

- **The EES in 60PDB was around the same level for Mini-Cars and Minivan.**

- **The EES in 64ODB was higher for Minivan than Mini-Cars. However, when the EEVC Barrier deformation energy was actually measured, the EES difference between Minivan and Mini-Cars was not as large as when it was calculated using the constant value of 45 kJ.**

Conclusion

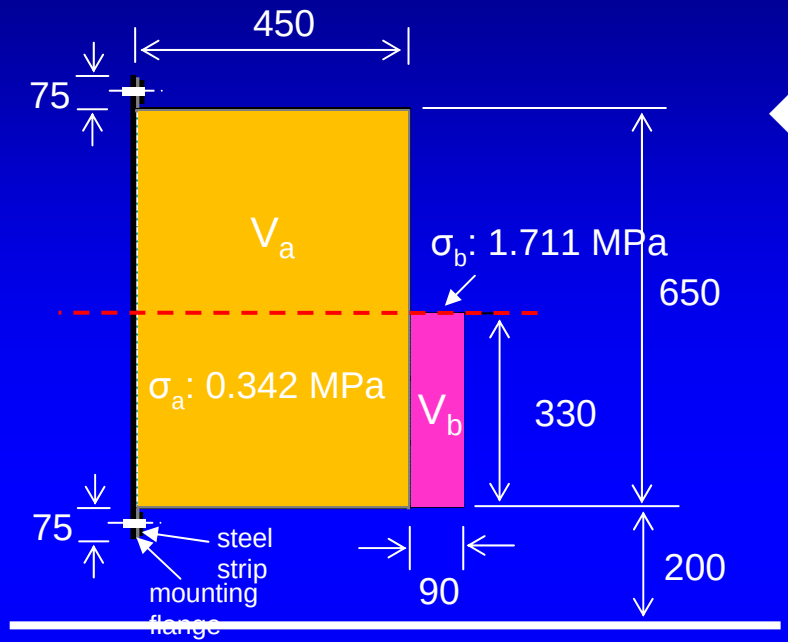
- **The dummy injury levels indicate that the replacement with PDB cannot be expected to improve “self protection”.**
  - **No significant difference was observed between PDB and ODB in dummy injury levels in the both of Mini-cars and Minivan.**

- **In the Car to Car test in this study, comparing ODB and PDB, deformation mode of the front rail in CTC was closer to ODB than that in PDB.**
  The difference in deformation of the front rail was remarkable.

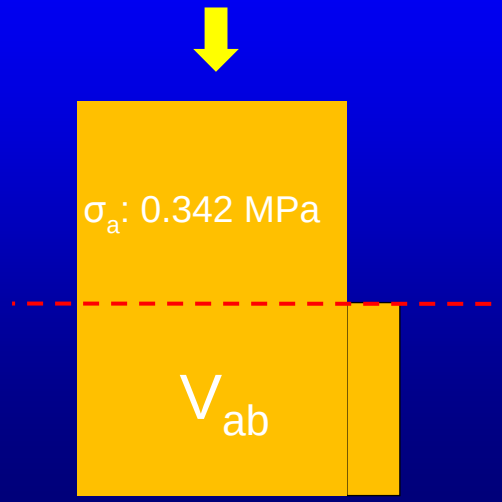
- **With Minivan (heavy car, 2,110 kg), while the bottom-out was observed in ODB, no bottom-out was observed in PDB.**
  Overall, the vehicle deformation tended to be smaller in PDB.

Calculation Method for EEVC Barrier Energy

Q. How is the energy absorbed by EEVC Barrier calculated?



EEVC Barrier Spec. (Side View) Unit (mm)



◆ Energy (E) is calculated from deformation volume (V) and honeycomb stress (σ):

$$E = V \times \sigma$$

Equation for the true value of energy

$$E_{True} = V_a \times \sigma_a + V_b \times \sigma_b$$

Equation for energy used in this study

Due to difficulties in measuring the deformation volume separately for the main body and the bumper in the area below the red dotted line, the energy absorbed by the entire barrier was calculated simply as follows (the result is estimated to be slightly smaller than the true value):

$$E_{\text{Hypothesis}} = V_{ab} \times \sigma_a$$