Submitted by the expert from Japan

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(69th GRSP, 17-21 May 2021,
agenda item 7)

Study of ISOFIX Booster Seats

JASIC

Ministry of Land, Infrastructure, Transport and Tourism

National Traffic Safety and Environment Laboratory

1. Background

Background

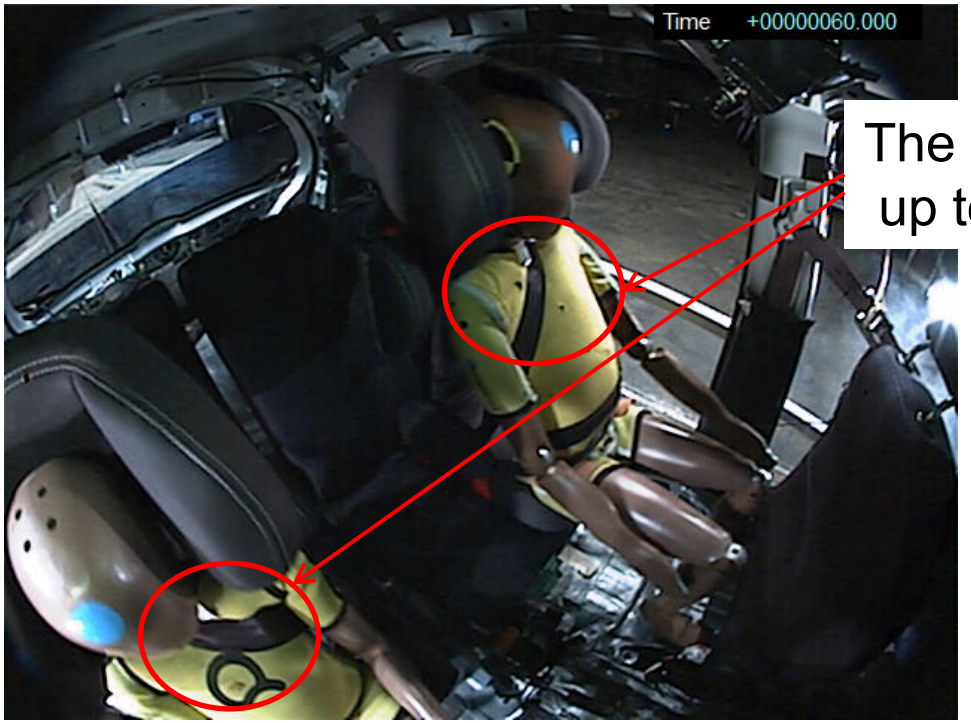
- The seatbelt slipped upward toward the dummy's neck by a larger amount in the 50kph FWRB test.
- A child occupant could suffer a neck injury by the seatbelt.

Vehicle: small passenger vehicle Dummies: Q6 and Q10

Booster seat: approved by UN R44 Attachment method: ISOFIX

Background

- The seatbelt slipped upward toward the dummy's neck by a larger amount in the 50kph FWRB test.
- A child occupant could suffer a neck injury by the seatbelt.



Vehicle: small passenger vehicle Dummies: Q6 and Q10

Booster seat: approved by UN R44 Attachment method: ISOFIX

2. SLED TEST USING VEHICLE BODY

Study Items

- We conducted the sled tests using the same vehicle body:
  1. To confirm the reproducibility of the event in which the seatbelt slipped upward toward the dummy's neck by a larger amount
  2. To compare the effects of different methods of attaching the booster seat to the vehicle

- Test conditions
  - ✓ Vehicle: Same vehicle as used in FWRB test
  - ✓ Dummy: Q6
  - ✓ Booster seat: Same booster seat as used in FWRB test
  - ✓ Attachment method: ISOFIX and seatbelt
  - ✓ Acceleration pulse: defined by UN R129

Sled Tests Using Vehicle Body

Attached by ISOFIX

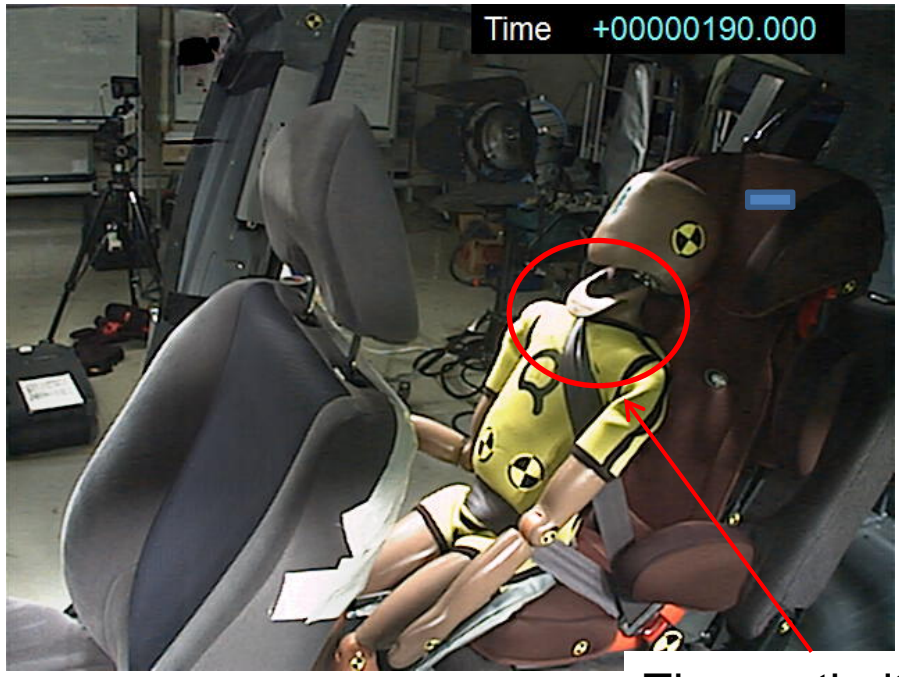
Attached by seatbelt

- The same event occurred when the booster seat was attached by ISOFIX. The seatbelt slipped upward toward the dummy's neck by a larger amount.

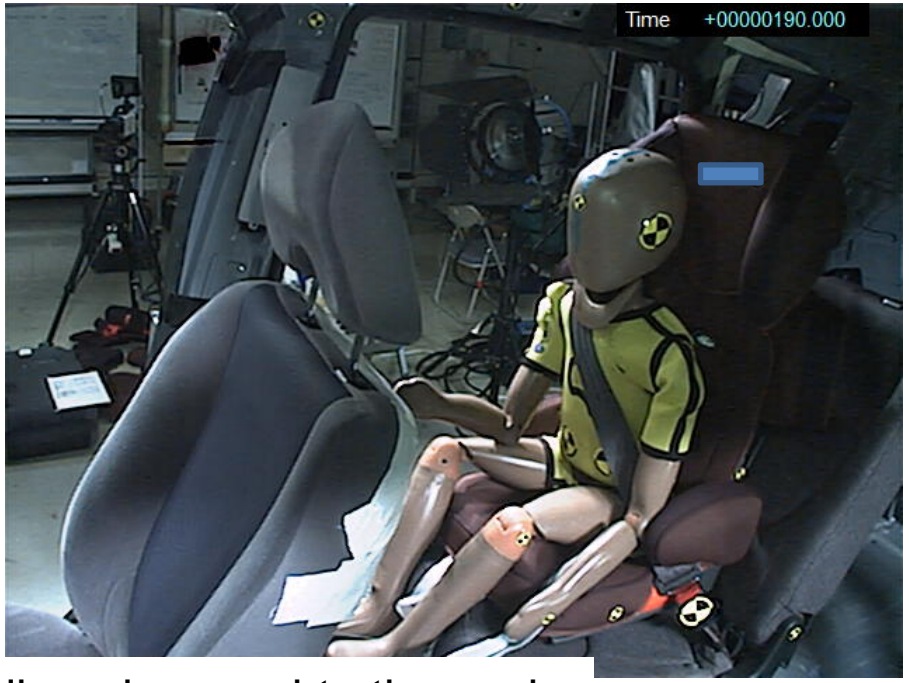
- The event did not occur when the booster seat was attached by the seatbelt. The seatbelt slipped upward toward the dummy's neck by a smaller amount than in the ISOFIX case.

Sled Tests Using Vehicle Body

Attached by ISOFIX



Attached by seatbelt



The seatbelt slipped upward to the neck.

- The same event occurred when the booster seat was attached by ISOFIX. The seatbelt slipped upward toward the dummy's neck by a larger amount.

- The event did not occur when the booster seat was attached by the seatbelt. The seatbelt slipped upward toward the dummy's neck by a smaller amount than in the ISOFIX case.

Sled Tests Using Vehicle Body

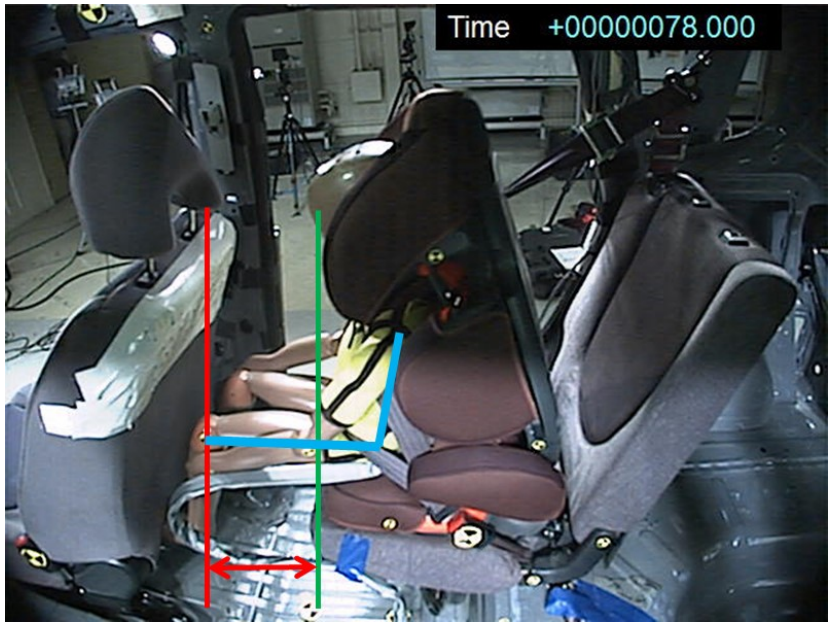
Attached by ISOFIX **Attached by seatbelt**

- The dummy’s knee position in the ISOFIX condition was located further forward with respect to the booster seat than that in the seatbelt condition.

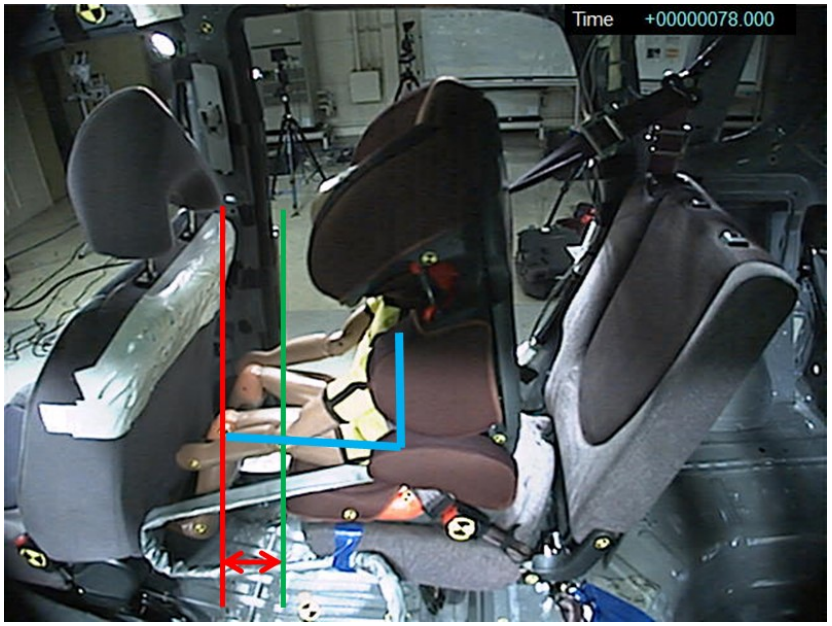
- The angle between the dummy's upper body and thigh in the ISOFIX condition was larger than that in the seatbelt condition.

Sled Tests Using Vehicle Body

Attached by ISOFIX



Attached by seatbelt

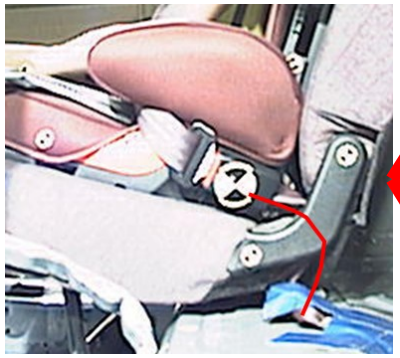


- The dummy’s knee position in the ISOFIX condition was located further forward with respect to the booster seat than that in the seatbelt condition.

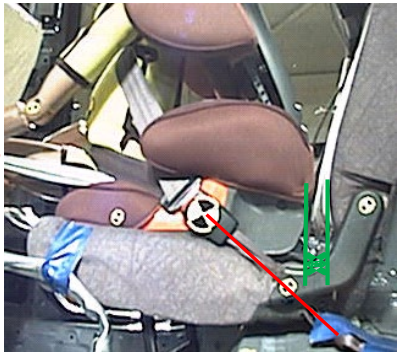
- The angle between the dummy's upper body and thigh in the ISOFIX condition was larger than that in the seatbelt condition.

Cause of the Phenomenon

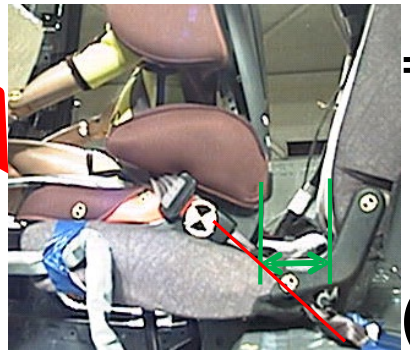
0ms



74ms



Attached by ISOFIX



Attached by seatbelt

- The buckle strap path is curved along the cushion, and the path changed to straight during the crash.
- The dummy's excursion was further forward largely due to the change in the seatbelt path.
- In the ISOFIX condition, the booster seat was directly fixed to the vehicle by the metal fittings, so the booster seat hardly moved forward.

⇒ The dummy's excursion was further forward with respect to the booster seat in case of the combination of the following two situations:

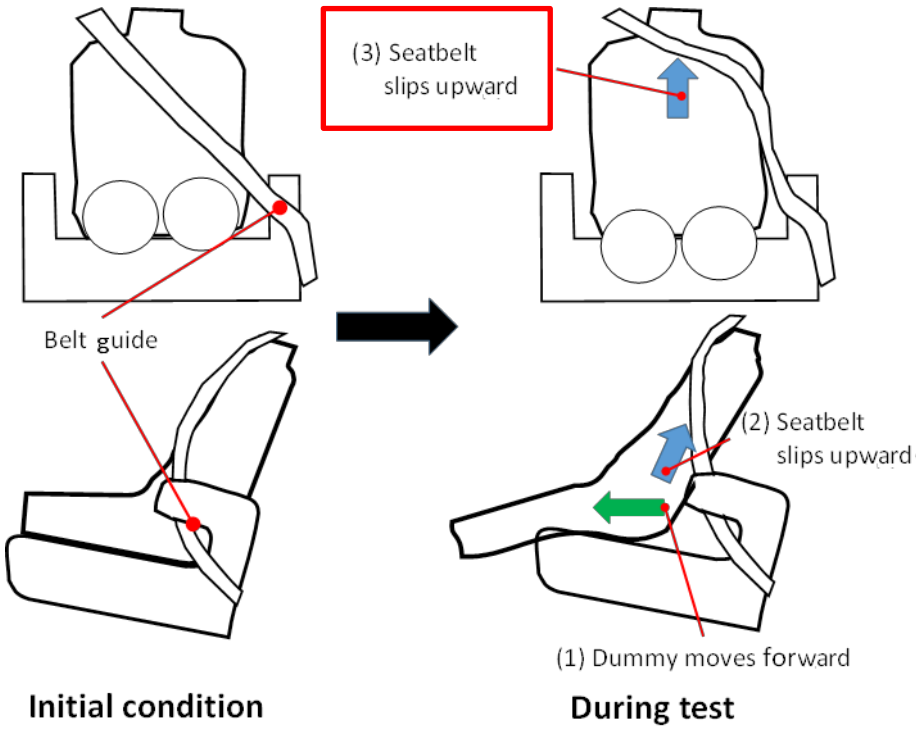
(1) The seatbelt path was curved along the seat cushion, and

(2) The booster seat was fixed by an ISOFIX attachment.

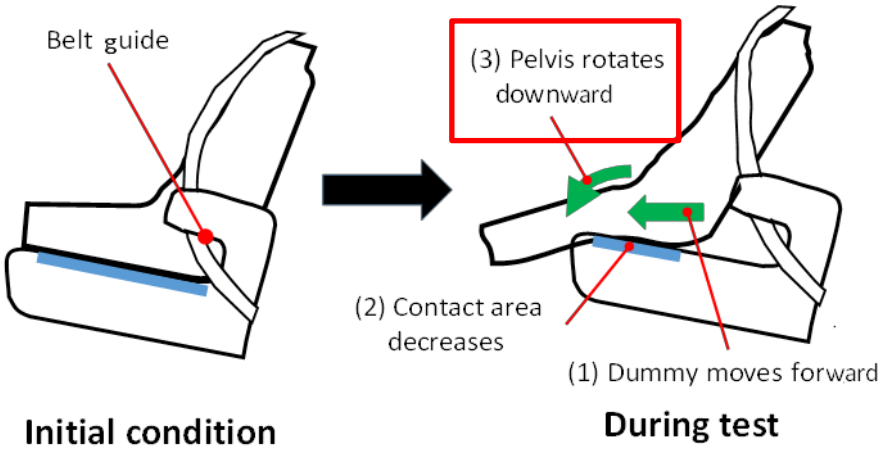
Cause of the Phenomenon

- **Why the phenomenon of the seatbelt slipping up to the neck and submarining occur when the dummy moves more forward with respect to the booster seat.**

Seatbelt slips up



Angle between dummy upper body and thigh increases



⇒ **Submarining may occur**

⇒ **Seatbelt slipping up may occur**

3. SLED TEST FOR RESEARCHING THE RELATION BETWEEN THE SLACK OF THE SEATBELT AND THE DUMMY'S RESPONSE

Study Items

- We conducted sled tests using the R129 test bench:
  1. To confirm the relation between the slack of the buckle belt and the dummy's response.

- Test conditions
  - ✓ Test bench: R129 test bench
  - ✓ Dummy: Q6
  - ✓ Booster seat: Two types
  - ✓ Attachment method: ISOFIX
  - ✓ Slack of buckle belt: four patterns
    (0mm, 50mm, 100mm and 150mm)

Sled Test

Tested CRS : Two types

CRS A

CRS B

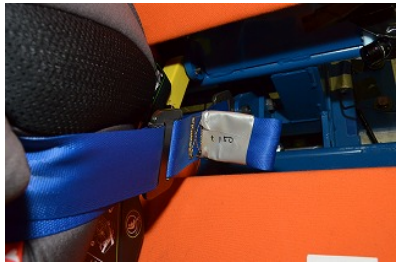
Amount of slack of seatbelt

0mm

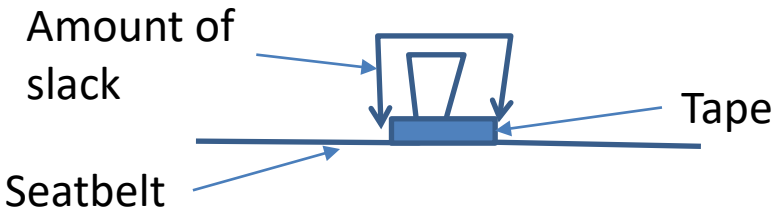
50mm

100mm

150mm



Method of making the seatbelt slack



Test Conditions

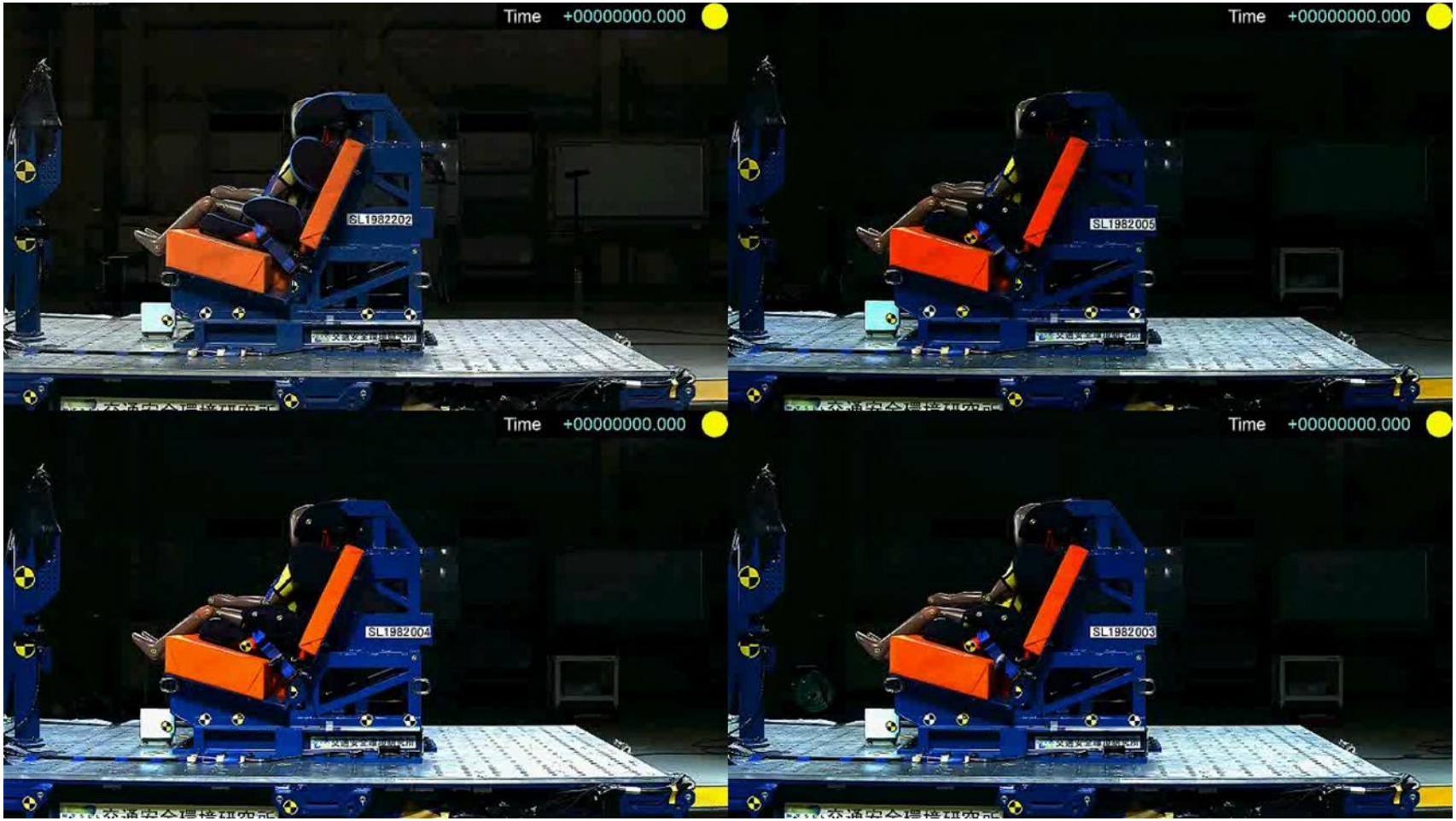
Test No.	Slack of belt	CRS
Test 1	0mm	CRS A
Test 2	50mm	CRS A
Test 3	100mm	CRS A
Test 4	150mm	CRS A
Test 5	0mm	CRS B
Test 6	50mm	CRS B
Test 7	100mm	CRS B
Test 8	150mm	CRS B

Test Results

Kinematic behavior in CRS A

Slack: 0mm

Slack: 50mm

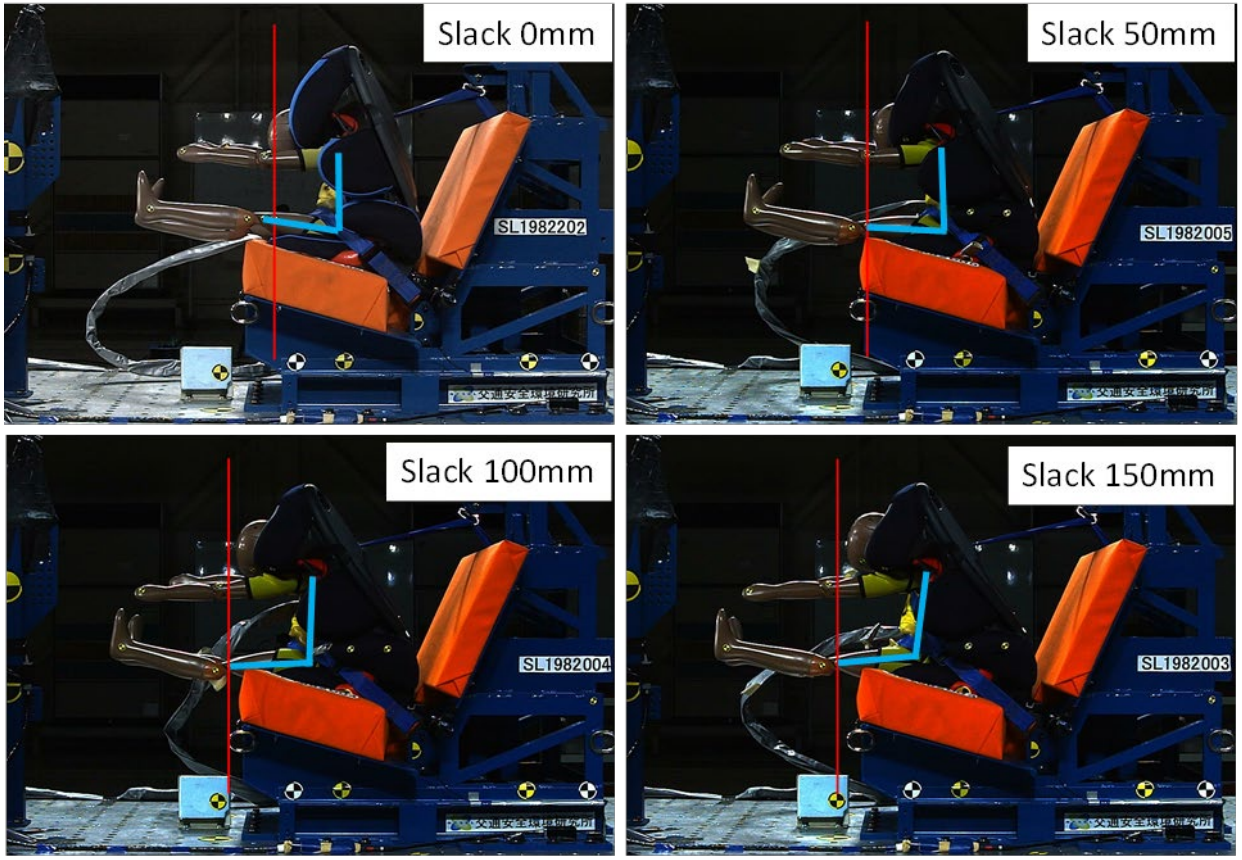


Slack: 100mm

Slack: 150mm

Test Results

Dummy kinematic behavior in CRS A (105ms)



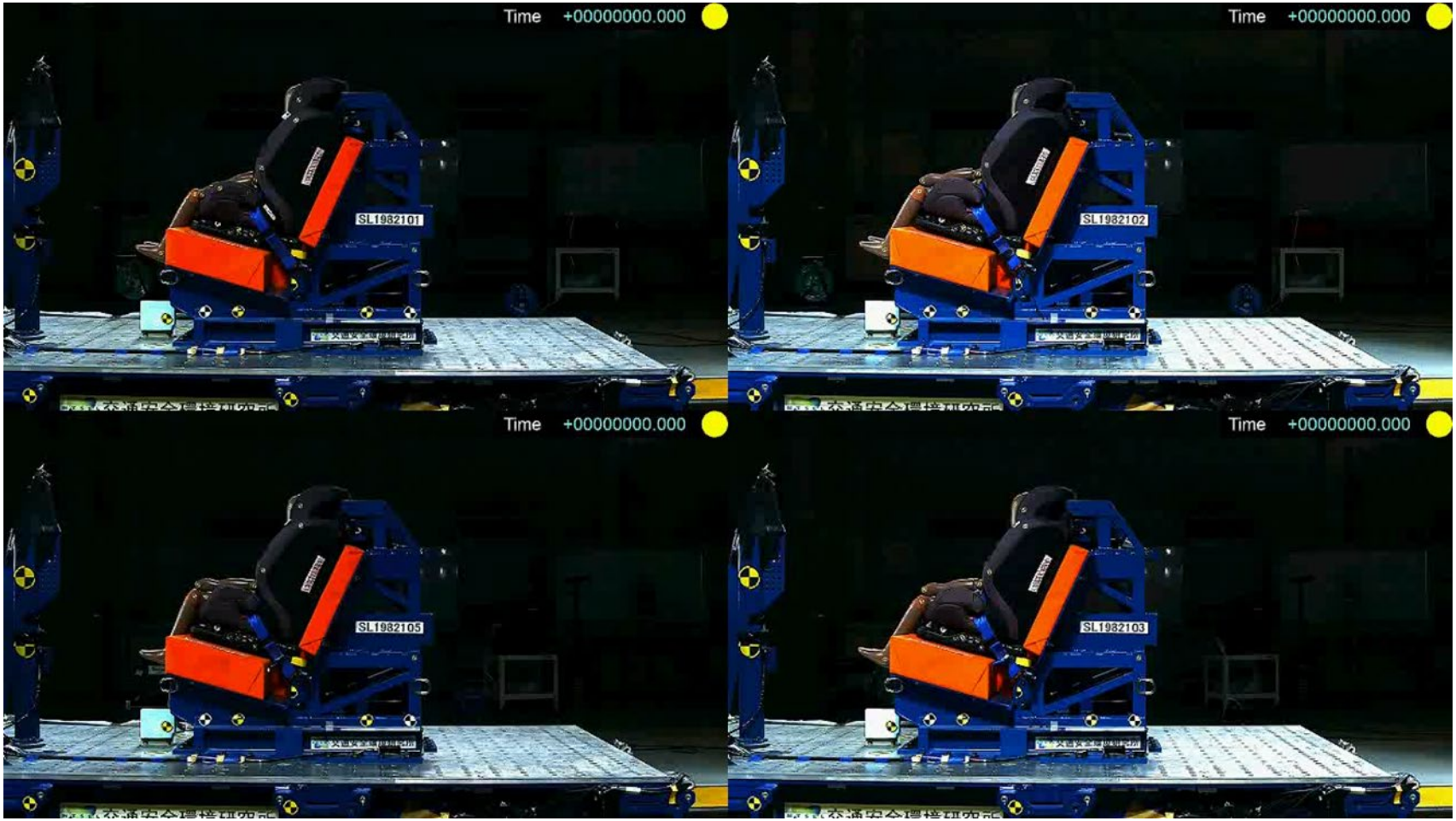
When the slack of the seatbelt was increased, the dummy's knee position moved further forward and the angle between the dummy's upper body and thigh became larger.

Test Results

Kinematic behavior in CRS B

Slack: 0mm

Slack: 50mm

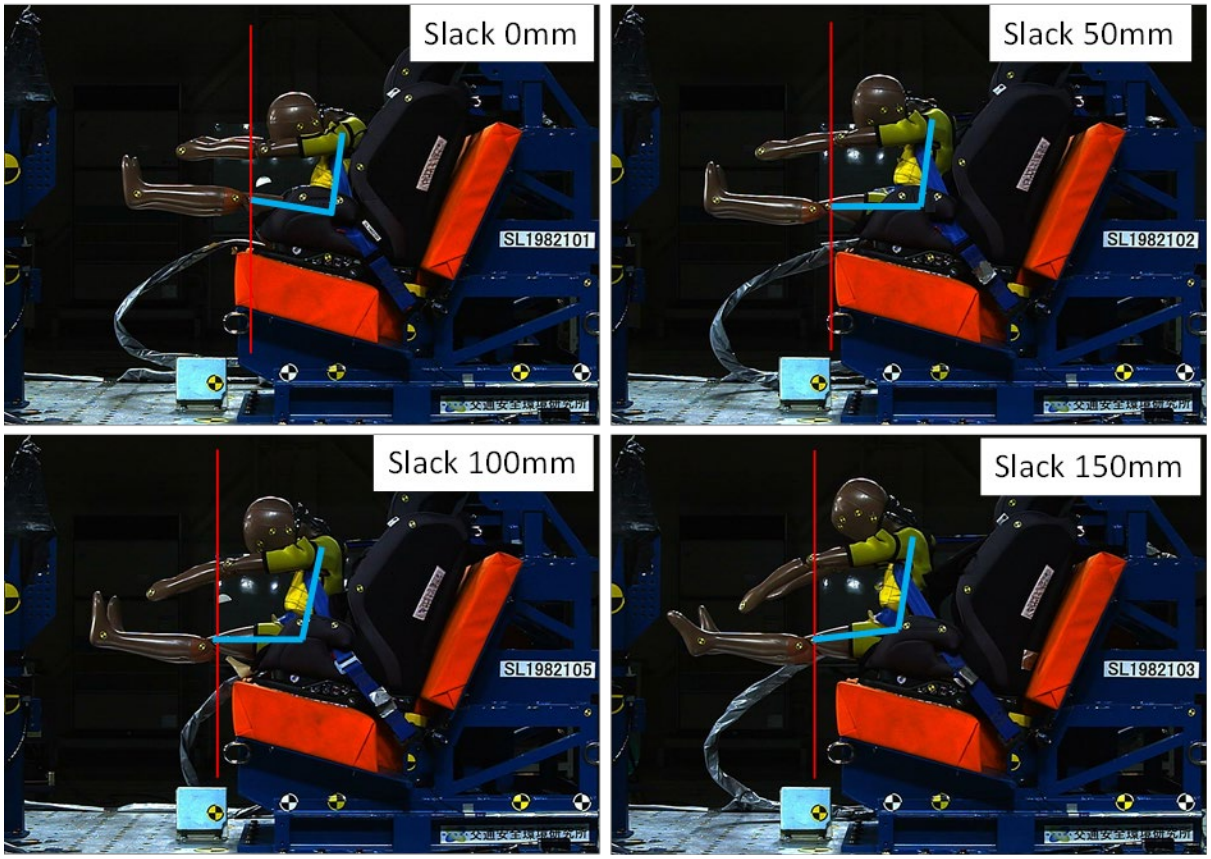


Slack: 100mm

Slack: 150mm

Test Results

Dummy kinematic behavior in CRS B (105ms)



When the slack of the seatbelt was increased, the dummy's knee position moved further forward and the angle between the dummy's upper body and thigh became larger.

Injury Data (CRS A)

Amount of slack	0mm	50mm	100mm	150mm	R129 Criterion
Neck upper tension force (N)	1437	1755	2231	3435	-
Chest 3ms maximum acceleration (m/s^2)	377	453	533	697	539
Abdominal maximum pressure (kPa)	28	42	48	55	100
Pelvis front excursion (mm)	113	154	202	236	-

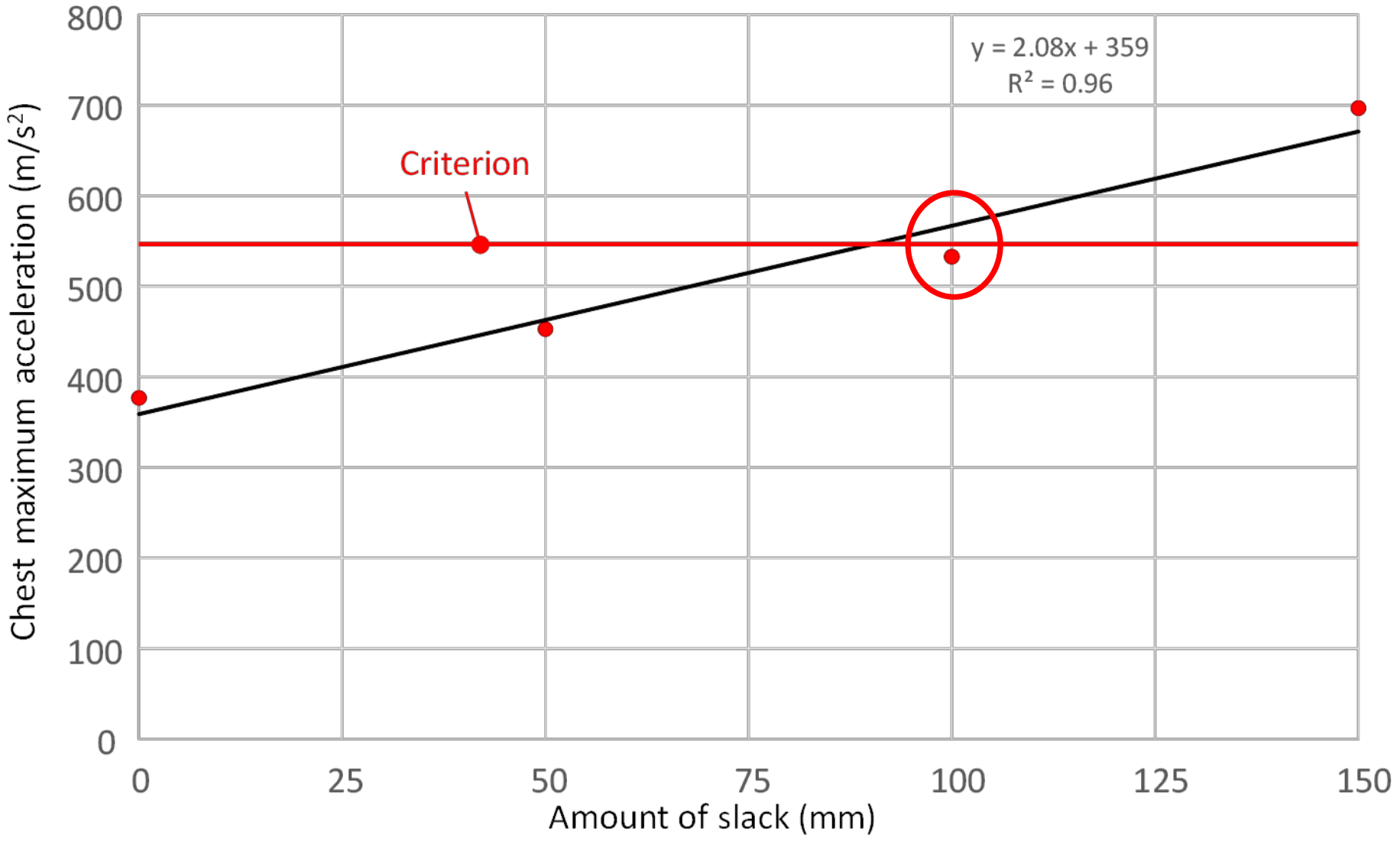
- **Chest maximum acceleration became larger with longer slack of the seatbelt.**
- **When the slack was 150mm, the chest maximum acceleration exceeded the threshold. When the slack was 100mm, the chest maximum acceleration was more than 90% of the R129 criterion.**
- **Abdominal pressure and pelvis front excursion also became larger with increased slack of the seatbelt.**

Injury Data (CRS B)

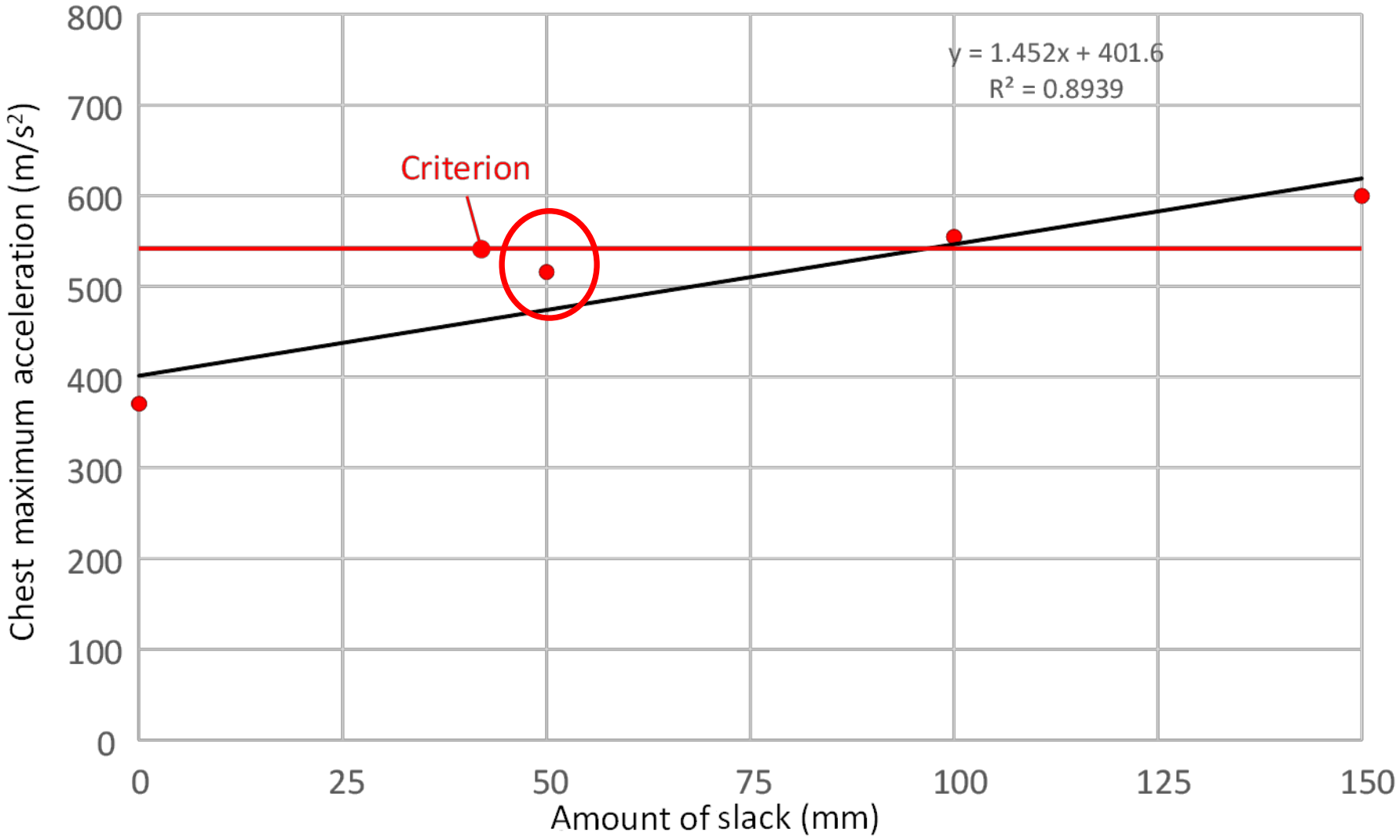
Amount of slack	0mm	50mm	100mm	150mm	R129 Criterion
Neck upper tension force (N)	1812	2002	4196	3878	-
Chest 3ms maximum acceleration (m/s^2)	371	516	555	600	539
Abdominal maximum pressure (kPa)	20	25	34	35	100
Pelvis front excursion (mm)	95	148	172	211	-

- **Chest maximum acceleration became larger with longer slack of the seatbelt.**
- **When the slack was 100mm, the chest maximum acceleration exceeded the threshold. When the slack was 50mm, the chest maximum acceleration was more than 90% of the R129 criterion.**
- **Abdominal pressure and pelvis front excursion also became larger with increased slack of the seatbelt.**

Relation between dummy chest acceleration and amount of slack (CRS A)



Relation between dummy chest acceleration and amount of slack (CRS B)



Conclusions

- The phenomenon of the seatbelt slipping up to the neck and submarining could occur with the combination of the following two situations: (1) the seatbelt path was curved along the seat cushion and (2) the booster seat was fixed to the vehicle by an ISOFIX attachment. This would increase the risk of injury to the child occupant's neck and abdomen.

- When the slack of the buckle belt became larger, the chest maximum acceleration became larger. When the slack of the buckle belt was over 50mm, the chest maximum acceleration was near the R129 criteria. When the slack of the buckle belt was over 80mm, the chest maximum acceleration was over the R129 criteria.

Potential Solution

1. CRS manufacturers and the OICA should research those vehicles in the market whose slack of the buckle belt is over [50]mm, and should inform consumers that booster seats should not be attached by ISOFIX to these vehicles.

2. Amend UN R16 to prohibit slack of the buckle belt of more than [50]mm.

→ 69-xx is the proposal to amend UN R16.