REAR OCCUPANT PROTECTION JNCAP TEST

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Abstract

In June of 2008, it became mandatory in Japan for rear seat occupants to wear a seat belt under the new Road Traffic Act. Rear seat occupants involved in frontal collision traffic accidents in Japan are mainly women. Considering this situation, we will start to evaluate rear seat occupant safety performance in frontal collision tests using a Hybrid III AF05 dummy. The evaluation includes not only this dynamic collision test but also the usability of the rear seatbelt and seatbelt reminder for passengers including those in the rear seat, which is not mandated by the law. We will show in detail the methods for rear occupant protection in a frontal collision and the ease of use of rear seatbelt, which will be the first introduction worldwide by JNCAP.

1. Background of introduction of this evaluation

The number of traffic fatalities in the year 2008 in Japan were dramatically reduce to 5,155 victims from the levels of around 10,000 10 years ago, This nearly met the Japanese government target established in 2003 which called for the reduction of traffic fatalities to under 5,000 victims by 2012. However, a new target was established in January of 2009 to reduce the number of victims to under 2,500 within 10 years. Under these circumstances, the Japan New Car Assessments Program (JNCAP) has the duty to contribute to the reduction of traffic accident victims.

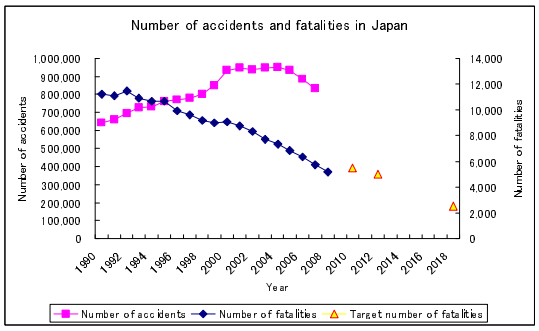

Figure 1. Number of accidents and fatalities in Japan

Since the JNCAP introduced the Full-wrap frontal collision test and Braking performance test in 1995, a Side collision test was added in 1999, followed by the Offset frontal collision test in 2000 enhancing the overall collision safety performance evaluation for driver and front passenger. But the rear seat passenger safety performance was not evaluated by the JNCAP. With the Road Traffic Act revision of 2008, making rear seatbelts mandatory, the rate has begun to improve (road : 8.8% → 30.8%; Expressway : 13.5% → 62.5%; see Figs. 2 and 3). Under these circumstances, the safety assessment for rear occupants with seat belts now has increasing significance.

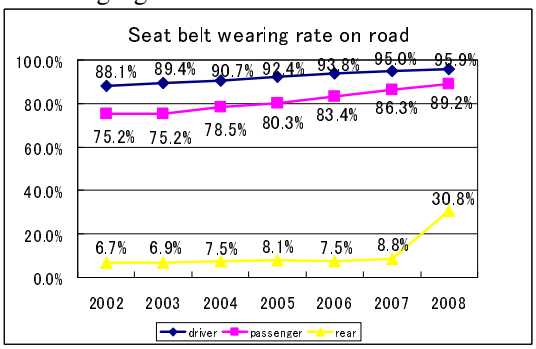

Figure 2. Seat belt wearing rate on road

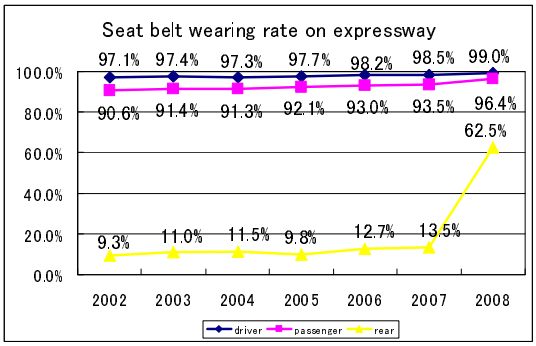

Figure 3. Seat belt wearing rate on expressway

In addition, the rear seat belt is less convenient to use than that of the front seat. According to Anders, Lee[4] and Motoki[5], although a Seat Belt Reminder (SBR) serves to increase the seat belt wearing rate, it is rarely installed for rear seats in Japan. Thus, the JNCAP decided to introduce 1) dynamic evaluation for rear seat passengers to improve protection performance, 2) evaluation of usability performance of the rear seat belt to

improve the belt fastening rate, and 3) evaluation of SBR for all passenger seats by JNCAP.

2. Study of evaluation method for rear seat occupant protection performance

(1) Evaluation of occupants protection performance during crash - introduction in 2009 FY

1) Prerequisite condition

As a prerequisite condition of this test, the test will be developed without an additional new crash test due to serious budget limitations.

2) Study of evaluation for test method

"The report of Traffic Accident Case Study in 2007"[5] published by the Institute for Traffic Accident Research and Data Analysis (ITARDA) provided an accident analysis of rear seat occupants belted in by a 3-point seat belt in Japan. The report showed that frontal collisions caused the highest number of fatal or serious injuries for both car-to-car accidents (see Fig. 4) and single vehicle accidents (see Fig. 5). Therefore, the JNCAP has decided to adopt a frontal collision test to evaluate rear seat occupant protection as a first step.

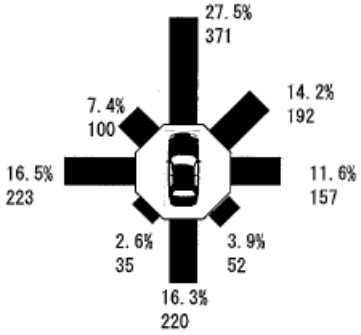

Figure 4. Car-to-car fatal or serious injury number of rear passengers with 3-point belt (N=1,180)

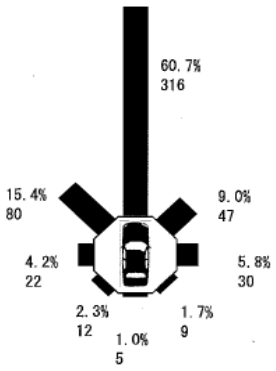

Figure 5. The number of rear passengers with 3-point belt having fatal or serious injury in single vehicle accidents (N=521)

The JNCAP conducted both a Full-wrap frontal collision test and an Offset frontal collision test. The Full-wrap frontal collision test[6] is reportedly appropriate for the evaluation of an occupant protection system such as a seat belt because of the high vehicle acceleration. The driver dummy and front passenger dummy data are used for the overall evaluation, and if another dummy was placed in the rear seat, it would be 3 dummies in the test vehicle. In this case,

a) It is rather difficult to install 3 dummies and measuring devices aboard a mini-car.

b) If 3 dummies are equipped, a rear dummy may contact a front dummy, thereby adversely affecting dummy measurements.

c) Generally speaking, there is some tendency for floor acceleration in a Full-wrap frontal collision to be more severe than for an Offset frontal collision. However, the North American traffic accident (NASS-CDS1997-2006) analysis conducted by the Japanese Automobile Manufacturer Association (see Fig. 6) shows that the injury risk to rear seat occupants in a Full-wrap frontal collision and an Offset frontal collision is nearly the same.

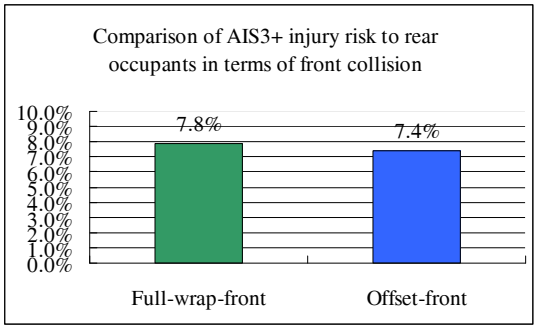

Figure 6. Comparison of AIS3+ injury risk to rear occupants in terms of front collision

The Offset frontal collision test, on the other hand, is suited to evaluate aggressiveness to the driver due to vehicle body deformation[6]. That is why the JNCAP utilizes only the driver-side dummy data for an overall collision safety performance evaluation.

d) Since the front passenger dummy measurement results are not used for the overall collision safety performance evaluation[6], and even if the front passenger dummy is moved to a rear seat, there is no influence on the overall collision safety performance evaluation.

e) In this case, 2 dummies are used, and measuring instruments are nearly the same, so it is easy to install these devices.

f) Additionally, the rear dummy does not contact the front passenger-side dummy because there is no dummy in the front passenger seat.

For all these reasons, the JNCAP decided to use

the offset frontal collision test for rear occupant protection performance evaluation (see Fig. 7).

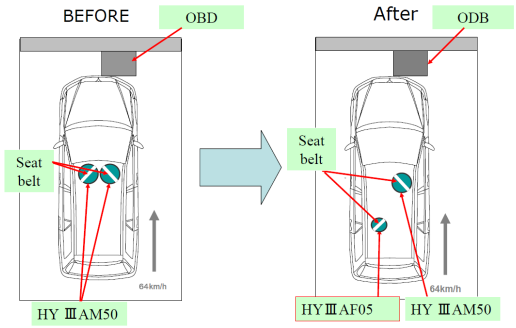

Figure 7. Dummy seating condition

We intend to popularize safety devices such as the seat belt pre-tensioner and force-limiter, and increase safety performance for the introduction of the rear seat occupant protection performance evaluation. Based on the traffic accident data in Japan[5], it is shown that women have a high rate of occupancy in rear seats, so we decided to use the Hybrid III AF05 Dummy.

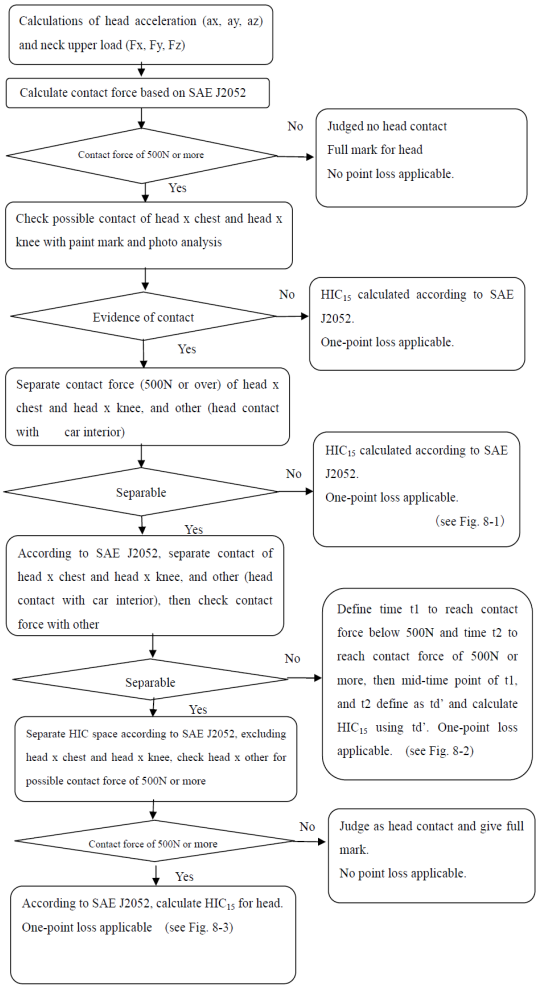

Figure 8. Proposed point calculation procedures for rear seat dummy head

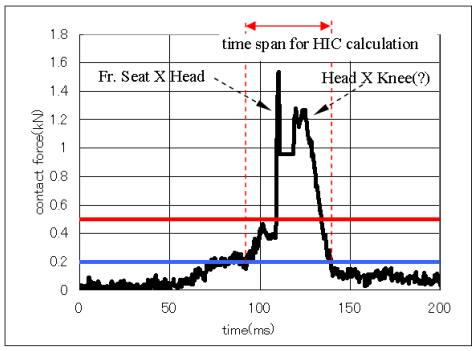

Figure 8-1. Example: Contact force not separable

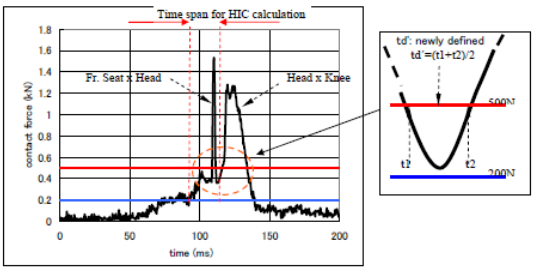

Figure 8-2. Contact force separable, but time not separable for HIC calculation

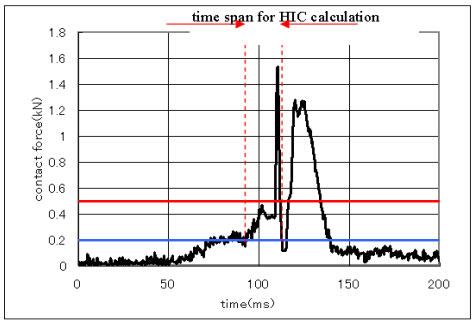

Figure 8-3. Both contact force and time span separable for HIC calculation

Referring to FMVSS 208[7] and US new NCAP[8], the injury evaluation criteria for rear seat occupants were established. Dummy parts for evaluation include the head, neck, chest, abdomen and lower limbs. Under secondary impact, we evaluate the head in HIC_{15} and also apply a -1 penalty point (see Figure 8.). When the external force acting on the head exceeds 500N according to SAE J2052, a secondary impact is considered to exist. In addition, we decide to exclude the secondary impact from a calculation of HIC, when a secondary impact occurred, since the secondary impact between the head and the vehicle interior is clearly separate as seen by the on-board camera. Here, we present an example of head contact with another body region. Figure 8-1 gives an example when dummy head contact with the vehicle interior and the head contact with

another body region cannot be separated. (In these cases, all contact forces are used in the calculation to be on the safe side.) Fig. 8-2 shows an example in which the dummy head contact with dummy knee, etc. can be separated, but the HIC calculated time cannot be separated. (Head injury measurements are calculated by separating the HIC calculation time to remove the influence of head contact with the knee, etc.) Fig. 8-3 shows an example in which the impact wave produced when a dummy head makes contact with a dummy knee, etc. can be separated. (In this case, HIC is calculated to exclude head contact with knee, etc.)

HIC_{15} is calculated using the above-mentioned methods, and the HIC value is evaluated between 500 (lowest) to 700 (highest) like FMVSS 208[7].

Although JNCAP examined scaling of the cumulative time of upper neck tensile load, shearing load and flectional moment using in the previous AM50 evaluation to the AF05, some industry experts voiced their concern that many car models scored 0 points for neck, although actual accidents indicated a low rate of neck injury when wearing a seat belt compared with injuries of other body regions. Taking this point into consideration, we re-studied the neck evaluation method. The FMVSS injury index is derived from the reproduction of an actual accident using a Hybrid dummy in a 48 km/h Full-wrap frontal collision. However, this index was considered unsuitable for the ODB test, due to the long duration and inadequate verification. For this reason, we used SAE J2052 and decided to evaluate the peak value of tensile load between 1700 to 2620N, without a secondary collision. If the head had a secondary collision, the neck injury would be evaluated by the peak values of flectional moment of 36/49N, neck shearing load of 1200/1950N and neck tensile peak load.

Regarding chest injury, we referred to Laitiuri's paper[9], which also referred to the US new NCAP, and considered that Japanese average age was higher than that of the US. In addition, we considered the target age for the evaluation on side impact chest deflection in ISO/TC22/SC12/WG6. We decided to evaluate a chest deflection of 23/48 mm based on the risk curve of 40-years-old in the AF05 (see equations (1), (2), and Fig. 9).

$$P\Big|_{AIS3+}^{Thorax} = \frac{1}{1+e^{-\left(-12.597+0.05861Age+1.568\delta_{HIII50}^{0.4612}\right)}}. \quad (1)$$

HIII05: $$\frac{\delta_{HIII05}}{0.817} = \delta_{HIII50}, \quad (2)$$

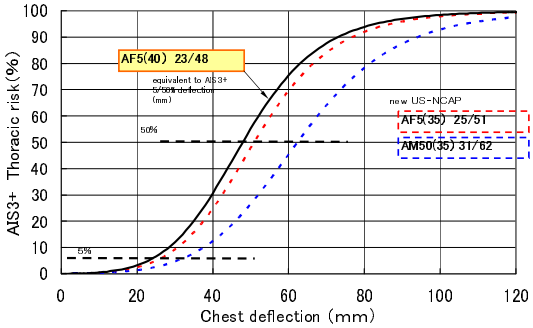

Figure 9. Risk curve of chest deflection for 40-year-old AF05

We intend to perform quantitative evaluation of abdominal injury in the future, but at this time we have tentatively decided to evaluate the pelvis restraint condition (evaluated by ilium restraint condition). (The pelvis is well restrained by the lap belt: 4 points; one side of the pelvis is not restrained by the lap belt: 2 points; both sides of the pelvis are not restrained by the lap belt: 0 points) This restraining condition will be judged using photography via an onboard camera and ilium load on both sides of the dummy.

We decided to evaluate the femoral load (4.8/6.8kN), which is already established verification method of the AF05. As weighting factors for these regions of the body, it was decided to use Japanese accident data involving fatal or serious injuries divided by the body regions for belted rear seat passengers, and average loss divided by injury levels. Based on these data, we calculated the human loss for every body region and weighting factor. The evaluation used these weighting factors (head: 4; neck: 1, chest: 4; abdomen: 4; femur: 2). For the dummy installation method, we referred to FMVSS208[7] and UMTRI developed AF05 installation method used by IIHS[12] and finalized the installation protocol.

Figure 10. Dummy seating arrangement for rear seat

(2) Usability evaluation for rear seat belt: planned introduction from 2009 FY

The JNCAP aims to increase the usability level of the rear seat belt because users have commented that the rear seat belt is not as easy to use as the front seat belt. Issues pertaining to rear seat belts are as follows;
a) Rear seat belt buckle is not readily buckled (it is difficult to insert the tang of the belt into the buckle one-handed).
b) Belt buckles for the outer seat and middle seat are not easily identified (the outboard/center passenger may not insert his/her tang into the buckle for center/outboard seat).
c) Tang accessibility may poor.
d) Rear seat arrangements vary widely, and the tang and buckle are sometimes hidden in or behind the seat.
To evaluate usability, we are planning to announce evaluation points based on an established objective evaluation procedure.
a) Easy insertion of buckle: Can the tang be inserted into buckle and latched easily with one hand?
b) Easy identification of buckle: Can the outboard and center seat belt buckles be easily identified by direction and/or layout?
c) Accessibility of seat belt: Use a 3D mannequin and measuring device to measure from the base point to the belt (evaluate at the standard seating position and most forward seating position)
d) Other: Evaluate tightening of the seat belt.
Additionally, JNCAP will announce installation of the 3-point belt for the rear center seat in our publication in advance of the regulation effective date, because the 3-point seat belt installation requirement for the rear center seat is not mandatory until 2012 FY.

(3) Evaluation of seat belt reminder (SBR) for passengers

The PSBR installation will be announced in the 2009 FY and quantitative evaluation will start in the 2010 FY.
Installation of the seat belt reminder for the driver seat is mandated, but SBR for seats other than driver seat is not. SBR for the front passenger seat is offered as an option in some car models, but very few offer rear seat SBR. Motoki[4], Lie[10] and others have reported on the effectiveness of a seat belt reminder in increasing the seat belt wearing rate. We believe the introduction of this evaluation for all passenger seats will aid in the popularization of SBR and increase the rear seat belt wearing rate. As part of the evaluation method of SBR requirements for passengers, we plan to examine methods for quantitative evaluation of the visible warning location and mode of warning, such as audible (signal, voice, etc.) and/or visual means this year. Before introduction of SBR quantitative evaluation to JNCAP, we plan to make a public announcement regarding whether or not the SBR is installed if it meets certain requirements, which referred to Japanese safety regulations or the requirements of the Euro NCAP[11].

3. Conclusions

The JNCAP has decided to introduce occupant protection methods for rear passengers to decrease the number of fatal or serious injuries to rear passengers in traffic accidents. As an evaluation method, we modified the offset frontal crash test and install a Hybrid III AF05 (female dummy) in rear seat instead of the Hybrid III AM50 (male dummy) used for the front passenger seat. The JNCAP developed its own rear seat dummy evaluation method referring to the FMVSS208 and new US-NCAP. In addition, the JNCAP introduced a usability evaluation for the rear seat belt and an evaluation of a seat belt reminder for all passengers.

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