INTRODUCTION OF PEDESTRIAN HEAD PROTECTION PERFORMANCE TEST IN J-NCAP

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Paper Number 05-0307

Abstract

In Japan, pedestrian accidents account for about 30% of traffic accident mortality. Head injuries are 60% of the cause of death in pedestrian accidents. Therefore, the pedestrian head protection performance test using adult and child head impactors has been conducted in J-NCAP since 2003.
The testing method was created based on the Japanese laws and regulations and proposals made by IHRA pedestrian WG. However, taking into consideration the distribution of the head impact positions for vehicles in the accident data, the impact area was extended to the windshield section (windshield, A-pillar, roof front edge, etc.). In addition, in order to cover a larger number of accidents, the impact velocity of the head impactor was set at 35 km/h, approximately 10% higher than the legal requirement.
The evaluation method was created based on the Euro-NCAP method. In order to more minutely evaluate the vehicle safety performance, the number of areas was increased in comparison with that used in Euro-NCAP. Moreover, in order to clearly evaluate the difference in the vehicle safety performance, a sliding scale was adopted to convert the injury values ranging from HIC650 to HIC2000 to the score. A vehicle is evaluated according to a 5-stage evaluation system from the total score of all the areas. In the 5-stage evaluation system, each stage was determined based on the AIS4 injury probability.
In 2003, 19 vehicles were tested, and 4 vehicles were tested in the first half of 2004. The distribution of the evaluation results classified as levels 1 to 5 (the higher the level, the better the pedestrian protection performance) indicated that 7 vehicles were at level 3, 13 vehicles were at level 2, 1 vehicle was at level 1, and none for levels 4 and 5. In general, the HIC value was higher in the section close to the side of the vehicle and the window frame.

Analysis of Pedestrian Accidents

In order to understand the actual situation of pedestrian accidents in Japan, the accident data was analyzed.

Occurrence of Pedestrian Accidents

Figure 1 shows the distribution of the number of casualties and fatalities from automotive accidents that occurred during 2001 in Japan [1].

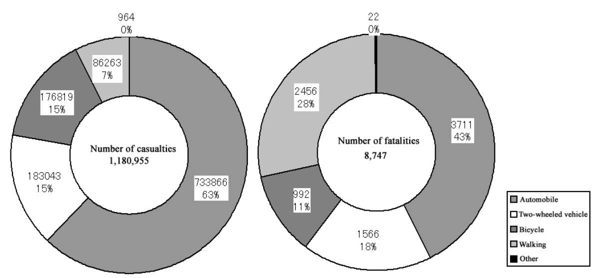

Figure 1 Number of casualties and fatalities from automotive accidents (ITARDA: 2001 Statistical Yearbook on Traffic Accidents)

Pedestrian accidents account for 7% of the total in terms of casualties, which are comparatively minor. However, in terms of fatalities, they occupy nearly 30% of the total or more than 2,400 persons only next to the fatalities while riding in vehicles.
Figure 2 shows the mortality (number of fatalities/number of casualties) by state.

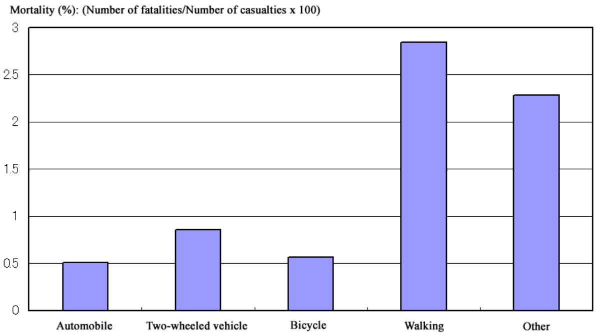

Figure 2 Mortality by state (ITARDA: The 2001 Statistical Yearbook on the Traffic Accidents)

The mortality of pedestrians is the highest at nearly 3%, or about 6 times as high as the counterpart for while riding in the vehicle.

Therefore, judging from the fatalities and the mortality, we can understand that we need protective measures for pedestrian accidents.

Table 1 indicates the distribution of the types of vehicles involved in the pedestrian accidents.

		Death		Serious injuries		Minor injuries	
		(persons)	(%)	(persons)	(%)	(persons)	(%)
Large passenger vehicle	Bus	12	0.6	37	0.4	284	0.5
	Microbus	5	0.3	19	0.2	100	0.2
Ordinary passenger vehicle	1Box	116	6.2	561	5.6	3023	5.8
	Sedan	745	40.0	4576	45.6	24680	47.6
	RV	87	4.7	322	3.2	1567	3.0
Light vehicle	Sedan	125	6.7	920	9.2	4422	8.5
	Others	18	1.0	157	1.6	749	1.4
Trailer	17t＜	7	0.4	16	0.2	37	0.1
	7t＜x≦17t	0	0.0	3	0.0	3	0.0
	≦7t	0	0.0	3	0.0	6	0.0
Dump truck	8t≦	26	1.4	57	0.6	100	0.2
	＜8t	17	0.9	49	0.5	118	0.2
Truck mixer	8t≦	5	0.3	9	0.1	17	0.0
	＜8t	1	0.1	4	0.0	14	0.0
TanTruck	8t≦	2	0.1	7	0.1	11	0.0
	＜8t	3	0.2	7	0.1	9	0.0
Truck	20t≦	30	1.6	43	0.4	85	0.2
	8t≦x＜20t	46	2.5	80	0.8	152	0.3
	7t≦x＜8t	74	4.0	134	1.3	446	0.9
	3.5t＜x＜7t	68	3.7	264	2.6	1293	2.5
	2.8t＜x≦3.5t	46	2.5	147	1.5	628	1.2
	≦2.8t	68	3.7	267	2.7	1486	2.9
	Light van	42	2.3	239	2.4	1352	2.6
Light truck	Light van	49	2.6	329	3.3	1538	3.0
	Others	181	9.7	780	7.8	3807	7.3
Motorcycle	Motor bicycle	23	1.2	587	5.8	4220	8.1
	Motorcycle	57	3.1	400	4.0	1506	2.9
Others		8	0.4	19	0.2	147	0.3
Total		1861	100.0	10036	100.0	51800	100.0

Table 1 Distribution of vehicle types involved in accidents

The state of the distribution shows that most accidents were caused by sedans of standard size accounting for 40% of the total vehicles. When vehicle types (in bold font) subject to the test method under the Japanese regulations are included, they account for 77 %.

Analysis of Types of Injuries

Figure 3 shows the regions of injury by the level of pedestrian injuries cited from the general data held by ITARDA for 1993 to 2000[2].

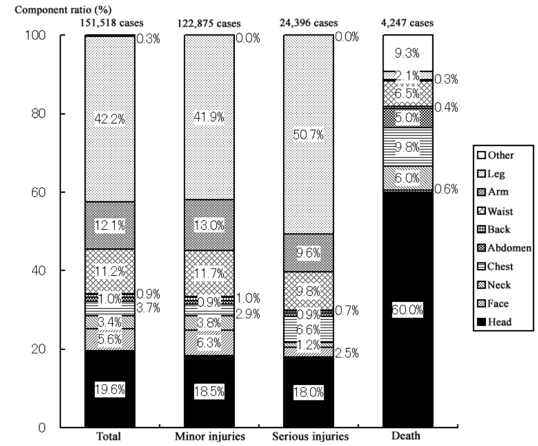

Figure 3 Pedestrian regions of injuries (ITARDA: The 2001 Statistical Yearbook on the Traffic Accidents)

Legs have the highest ratio for serious injuries, accounting for over 50% of the total regions of injuries. On the other hand, in the case of fatalities, the legs hold a small ratio while heads occupy 60%. Compared with the fatalities, serious injuries involve a greater number of cases. Therefore, to take measures for a number of serious injuries, it is necessary to reduce injury to the legs. Conversely, we find that a reduction of head injuries is necessary as the measures for reducing fatalities, which have fewer cases but of a more serious level of injuries.

Figure 4 shows the cumulative percentage of the vehicle impact velocity involving the pedestrians' death and serious injuries cited from the ITARDA data of accident cases for 1993 to 2001. The data covers only those subject vehicles, excluding large trucks, whose impact velocity at the accident could be estimated.

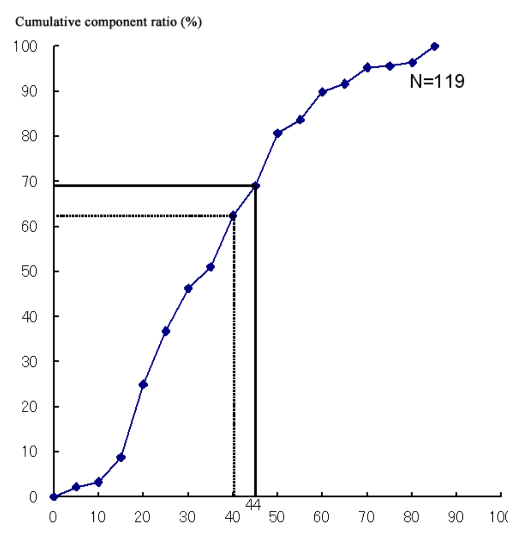

Figure 4 Cumulative percentage of vehicle impact velocity involving death and serious injuries of pedestrians

The Japanese legal test method sets the impact conditions by setting the vehicle impact velocity at 40 km/h. The figure shows that approximately more than 60% of the traffic accidents occurred at this velocity. If the impact velocity is raised by 10% to 44 km/h, the coverage ratio of the accidents rises to 70% approximately.

Analysis of Head Impact Position

Figure 5 shows the pedestrian head impact positions at different impact velocities of the vehicles causing the accidents. The velocity range was classified into 3 levels of under 30 km/h, 30 to 50 km/h, and over 50 km/h in consideration of the vehicle impact velocity (40 km/h) expected in the head impact test.

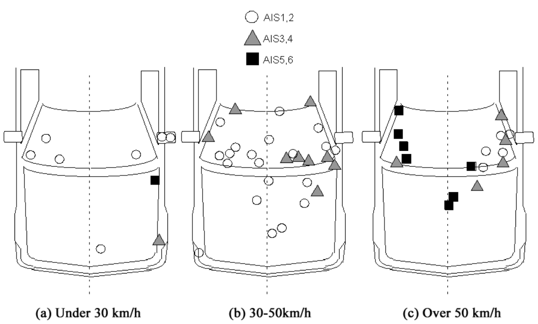

Figure 5 Head impact position for bonnet type vehicles

In the case of a vehicle impact velocity of under 30 km/h, minor injuries of AIS1 or 2 frequently occur except in the vicinity of the edge of the bonnet where injuries of AIS3 and over occur.

In the case of a vehicle impact velocity of 30 to 50 km/h, injuries of over AIS3 tend to occur at the edge of the bonnet, near the strut tower, and in the vicinity of the window frame and A-pillar.

In the case of the vehicle impact velocity of over 50 km/h, the percentage occupied by minor injuries of AIS1 or 2 drops and the higher level of injuries tend to occur near the center of the bonnet and at the windshield.

Setting of Test Method

The test method was set based on the actual condition of Japanese traffic accidents and the examination results of related matters domestic and overseas. As shown in Figure 3, Japanese data on the pedestrian accidents indicates the head as the top region of injuries causing the pedestrians' fatalities, while serious injuries mostly occurring to the leg region. On the other hand, regarding the discussion on the test method for the head, examinations have been almost completed with IHRA and the Japanese test method based on it. Regarding the leg region, however, discussion still goes on.

Under the circumstances, while the J-NCAP pedestrian protection performance test is intended to reduce injuries of both the head and leg regions, it has been decided to conduct tests on the head for the time being since this region has acquired consensus domestically and overseas.

In the current test method, specifications for the impactors (165 mm in diameter and 3.5 kg in weight for a child and 165 mm and 4.5 kg for an adult), child and adult ranges of impact (WAD 1000 to 1700 mm for child, and WAD 1700 to 2100 mm for adult), setting procedures for impact area, etc. were determined based on the test method described in the Japanese regulations. The following modifications were made, however, to understand the vehicle safety performance more in detail and clarify the performance difference among the vehicles.

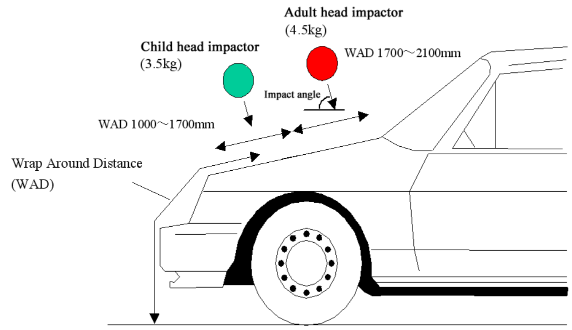

Figure 6 Test method under Japanese regulations

Impact Area

As it is thought effective to improve the head protection performance of the vehicle in these positions, J-NCAP specifies the impact range to be between WAD1000 to 2100 in principle and includes the windshield and window frame in the impact area, which was excluded by the Japanese legal test method. In addition, it made the following examinations of the impact area according to this precondition.

Examination of Rear Edge of Impact Area

The rear edge of the impact area shall be WAD 2100 mm.

The rear section was not included in the impact area because no injury cases were reported as caused by the roof although the accident data has some cases of injuries by the roof edge. Incidentally, Euro-NCAP[4] and other test methods call for no roof test, and there exists no impact condition to which an international consensus has been obtained.

The boundary between the roof and windshield is defined as the line in the latitudinal direction of the vehicle consisting of the contact points between the line inclined at 75^{o} rearward from the vertical line and the top of the window frame in the vertical section parallel to the longitudinal axis of the vehicle.

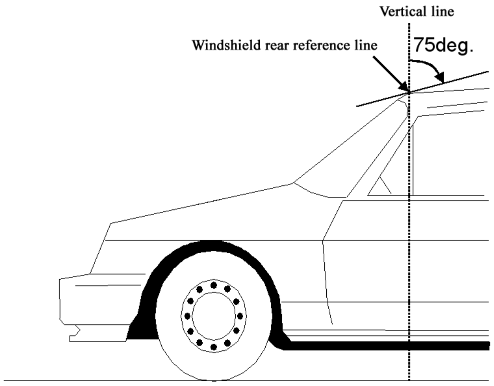

Figure 7 Boundary between roof and windshield

<u>Examination in vertical direction</u>

In a vehicle having an almost flat-formed front, WAD and the pedestrian height roughly coincide, but it is thought that pedestrians having a height of 2100 mm are rare. Moreover, if impacted by such a vehicle, it is hard to think that the head impact position shifts upward. Therefore, it was necessary to examine a limitation in the direction of height. Accordingly, it was decided to make the vehicle height of 1900 mm as the rear edge of the impact area as adopted by IHRA.

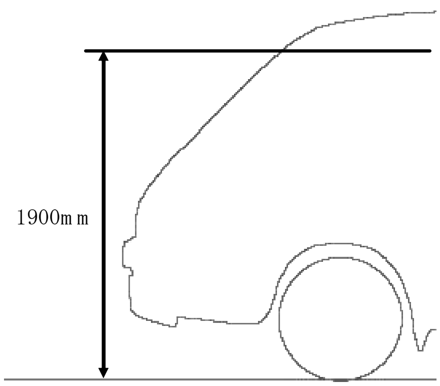

Figure 8 Limitation of height of impact area

<u>Examination of Leading Edge of Impact Area</u>

It is decided to make the front edge of the impact area to be WAD1000 mm. In addition, the same method will be used for setting the bonnet leading edge reference line as defined by the test method under the Japanese laws and regulations.

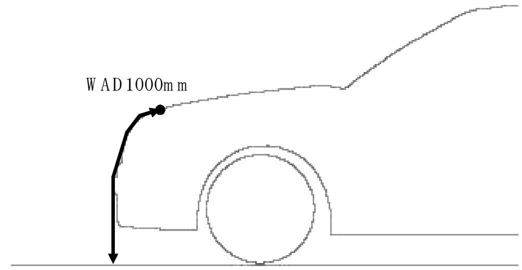

Figure 9 Leading Edge of Impact Area

Examination of Leading Edge pf Impact Area

Regarding the evaluation of the sides around the bonnet, if impact is given to a sharply slanted section such as the fender, the impactor may show a sharp behaviour in the latitudinal direction that is impossible with a human body, possibly preventing proper evaluation. Moreover, it is likely that the impactor would be damaged after rebounding. In this respect, the longitudinal line (bonnet side reference line, Figure 10) along which the fender inclines inward at 45° is defined. The line entering inward from this line by half of the diameter of the impactor (82.5 mm) will be the side edge of the impact area (Figure 11). Regarding the surrounding of the windshield, the A-pillar is included in the impact range.

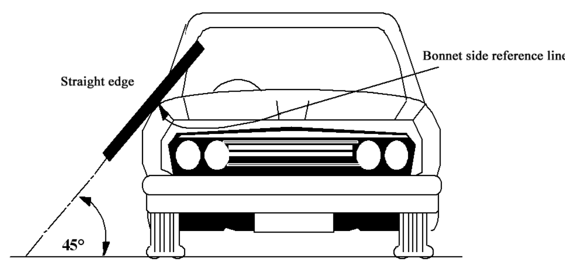

Figure 10 Bonnet side reference line

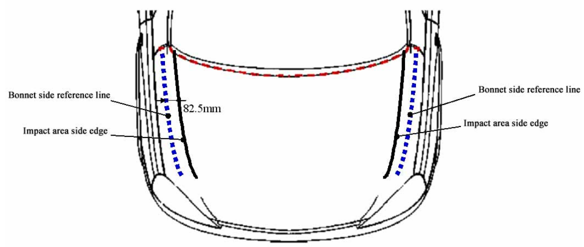

Figure 11 Bonnet impact area side edge

Impact Speed and Angle

Regarding the impact conditions, the vehicle impact velocity was set to 44 km/h, 10% higher than the Japanese legal test method requirement. This velocity setting raises the coverage ratio to approx. 70% (Figure 4) in the accidents causing fatalities and serious injuries of pedestrians.

Tables 2 and 3 outline the recommended impact conditions for adult and child impactors by IHRA. We have set the impact condition as follows based on this data:

Shape Corridor	Car impact speed 30km/h					
	Head impact velocity (km/h)			Head impact angle (deg.)		
	Bonnet	Windshield	BLE/Grille	Bonnet	Windshield	BLE/Grille
Sedan +	21.6 +/- 3.0	nc	nc	65.1 +/- 0.8	nc	nc
SUV	21.3 +/- 1.2	nc	21.3 +/- 6.0	55.6 +/- 5.5	nc	26.0 +/- 7.5
One box	20.1 +/- 0.6	nc	21.9 +/- 5.1	47.5 +/- 2.8	nc	20.3 +/- 8.0

Shape Corridor	Car impact speed 40km/h					
	Head impact velocity (km/h)			Head impact angle (deg.)		
	Bonnet	Windshield	BLE/Grille	Bonnet	Windshield	BLE/Grille
Sedan +	30.0 +/- 4.0	nc	nc	66.0 +/- 6.3	nc	nc
SUV	27.2 +/- 1.6	nc	32.0 +/- 3.6	59.2 +/- 2.6	nc	22.5 +/- 4.2
One box	27.6 +/- 0.8	nc	33.2 +/- 3.2	49.8 +/- 1.8	nc	17.4 +/- 6.1

Shape Corridor	Car impact speed 50km/h					
	Head impact velocity (km/h)			Head impact angle (deg.)		
	Bonnet	Windshield	BLE/Grille	Bonnet	Windshield	BLE/Grille
Sedan +	38.5 +/- 5.0	nc	nc	65.2 +/- 6.5	nc	nc
SUV	34.0 +/- 1.5	nc	44.5 +/- 1.0	61.9 +/- 3.8	nc	18.1 +/- 3.8
One box	36.0 +/- 0.5	nc	46.5 +/- 2.0	47.4 +/- 2.1	nc	14.8 +/- 3.6

[4] nc: No contact, [44] Child headform impact test conditions,
[444] Linear interpretation to be used to determine impact conditions for in-between speeds if required.

Table 2 Impact conditions for child impactor

Shape Corridor	Car impact speed 30km/h					
	Head impact velocity (km/h)			Head impact angle (deg.)		
	Bonnet	Windshield	BLE/Grille	Bonnet	Windshield	BLE/Grille
Sedan +	23.7 +/- 6.0	27.3 +/- 5.4	nc	78.3 +/- 5.6	48.8 +/- 9.9	nc
SUV	26.4 +/- 3.6	nc	nc	73.8 +/- 21.5	nc	nc
One box	nc	20.4 +/- 3.6	nc	nc	55.1 +/- 10.4	nc

Shape Corridor	Car impact speed 40km/h					
	Head impact velocity (km/h)			Head impact angle (deg.)		
	Bonnet	Windshield	BLE/Grille	Bonnet	Windshield	BLE/Grille
Sedan +	30.4 +/- 7.2	35.2 +/- 6.8	nc	66.0 +/- 14.0	38.4 +/- 10.9	nc
SUV	30.8 +/- 8.8	nc	nc	76.7 +/- 22.2	nc	nc
One box	nc	29.6 +/- 3.2	nc	nc	47.3 +/- 9.6	nc

Shape Corridor	Car impact speed 50km/h					
	Head impact velocity (km/h)			Head impact angle (deg.)		
	Bonnet	Windshield	BLE/Grille	Bonnet	Windshield	BLE/Grille
Sedan +	37.5 +/- 9.5	46.5 +/- 11.0	nc	56.8 +/- 11.5	33.5 +/- 11.3	nc
SUV	39.5 +/- 11.0	nc	nc	73.5 +/- 25.2	nc	nc
One box	nc	43.0 +/- 6.0	nc	nc	38.4 +/- 12.3	nc

[x] nc: No contact, [xx] Adult headform impact test conditions,
[xxx] Linear interpretation to be used to determine impact conditions for in-between speeds if required.

Table 3 Impact conditions for adult impactor

Test Conditions for Bonnet

Observation of the head impact velocity data at the vehicle impact velocities of 40 km/h and 50 km/h in Tables 2 and 3 indicates a tendency where the head impact velocities tend to be 80% or slightly less of the vehicle impact velocity. Therefore, if the vehicle impact velocity is set at 44 km/h, the desirable head impact velocity would be 35 km/h being approximately 80% of the vehicle impact velocity.

Moreover, when the head impact angles are observed at vehicle impact velocities of 40 km/h and 50 km/h, no major difference is observed except with the adults for sedans. Even in the case of the adults for sedans, the impact angle is presumed to be between 62 and 63°. Consequently, the head impact angle should desirably be tested under the same impact conditions as the legal Japanese test method.

Test Conditions for Windshield And Wind Frame

IHRA defines no boundary between the bonnet and windshield. In the case where the head of a pedestrian comes into contact with the vicinity of the lower edge of the windshield, the impact may be similar to contact with the bonnet. Therefore, the impact conditions for the bonnet will be applied to the impact that is made to the lower edge of the windshield.

Regarding the area from the center of the windshield to the upper edge, impact conditions will be set based on the recommended impact conditions for the adult. The estimated head impact velocity at the vehicle collision speed of 44 km/h will be 34 to 40 km/h according to the data for the head impact velocity to the windshield of the vehicle having impact velocities of 40 km/h to 50 km/h in Table 3. This head impact velocity tends to be slightly higher than the impact velocity to the bonnet. However, considering that the velocity range is great as a whole under the recommended impact conditions of IHRA, and that it is difficult to take measures for the sides of the vehicle with the window frames, a desirable impact velocity would be 35 km/h the same as for the bonnet.

The impact angle will be the rounded off value of the angle specified in the impact conditions recommended by IHRA. The same angle of 40° as sedans will be specified for SUVs since no data is available for the latter.

With some of small vehicles, the windshield and window frame may be the range in which a child impactor is used. Under the current state, no data is available for IHRA-recommended impact conditions for the vicinity of the windshield for a child as in Table 2. However, a child which collides with the windshield or window frame may be considered to have a height comparatively close to that of an adult. In this respect, the test will be conducted using the adult impact conditions for the time being.

The above statements are summarized into the test conditions as outlined in Table 4.

			Evaluation area using head impactor for child	Evaluation area using head impactor for adult
Impactor			165mm,3.5kg	165mm,4.5kg
WAD			1000-1350mm	1700-2100mm
Impact velocity (km/h)	Bonnet	Sedan	35	
		SUV		
		1BOX		
	Windshield	Sedan		
		SUV		
		1BOX		
Impact angle (deg.)	Bonnet	Sedan	65	65
		SUV	60	90
		1BOX	25	50
	Windshield	Sedan	40	
		SUV		
		1BOX	45	

Classification	Definition
Sedan	Vehicles with bonnet leading edge height of under 835 mm
SUV	Vehicles with bonnet leading edge height of over 835 mm
1BOX	Vehicles having a bonnet angle of over 30 deg.

Table 4 Impact conditions

Evaluation Method

On making evaluation, it has been decided to calculate the total scores by dividing the impact area for multiple tests to more closely understand the pedestrian protection performance of the vehicles. At the same time, to clarify the relationship between the scores and the injury probability, injury values obtained from the tests (HIC) are converted into scores representing the safety performance by using the evaluation functions associated with the injury probability.

Division of Impact Area

Euro-NCAP[5] divided the impact area and evaluated each divided areas. Scores for those divided area are aggregated and evaluated as a vehicle. The aim is to find the distribution of pedestrian protection performance of a vehicle by incorporating the concept of area, without having the pedestrian protection performance of the vehicle represented by a single point.

The more divided the area, the more accurately understood the distribution of the pedestrian protection performance of the vehicle. Excessive division, however, may lead to a sharp and impractical increase of test frequency, requiring longer time and more expense in evaluation. Therefore, it is required to develop a division method that enables an efficient testing operation while closely understanding the pedestrian safety performance of the vehicles. From this respect, J-NCAP has decided to divide the impact area using the following method:

Longitudinal Direction

Regarding the longitudinal direction, the longitudinal ratio of WAD will be approximately 2:1 in the evaluation areas using a child impactor and an adult impactor. Accordingly, the evaluation area using the child impactor has been divided into two portions.

In other words, three areas are set up with an evaluation area using an adult compactor (Area I), a rear part of an evaluation area using a child impactor divided into two parts (Area II), and the forward part (Area III).

Latitudinal Direction

The impact areas of Area I and Area II are each divided into 6 portions in the latitudinal direction of the vehicle. As to Area III, the latitudinal division is made into 3 portions because of fewer impact positions of high injury value due to the structures inside the engine compartment, and the forward section of the bonnet having the possibility of occupying a smaller area than the rear section due to the position of the bonnet leading edge.

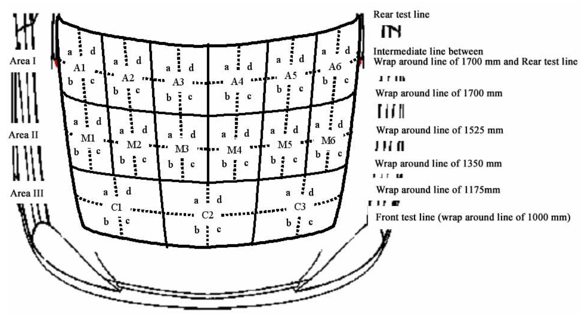

Figure 12 Area division method by J-NCAP

Subdivision of Divided Areas

The divided areas are subdivided according to the following procedure for use for evaluation:

(a) Regarding the area totally divided into 15, the secretariat selects one place where the HIC value is seemingly the highest. An impact is applied to this position and the subsequent injury value is used as the representative value with which to evaluate the area.

(b) As may be desired by a manufacturer, each divided area may be further divided into 4 areas, and the test can be conducted with the impact positions other than the subdivided areas that fall under the positions already tested. At this time, the manufacturer selects 1 to 3 areas for subdivision out of the remaining areas for subdivision. The secretariat selects an impact position seemingly having the highest injury value out of the areas for subdivision as selected by the manufacturer.

(c) Scores of the divided areas are evaluated using the weighted average of the scores from 2 areas. The weight varies according to the number of areas for subdivision specified by the manufacturer as the area desired for the test.

1) In the case where the manufacturer selects all of the remaining 3 areas for subdivision

Score of divided area = (1/4) x (score of main test) + (3/4) + (score of requested test)

2) In the case where the manufacturer selects 2 areas out of the remaining 3 areas for subdivision

Score of divided area = (2/4) x (score of main test) + (2/4) + (score of requested test)

3) In the case where the manufacturer selects 1 area out of the remaining 3 areas for subdivision

Score of divided area = (3/4) x (score of main test) +

(1/4) + (score of requested test)

Evaluation Function

To make the conversion from test injury value (HIC) to a score, an evaluation function is used. For the evaluation function, a sliding scale will be used after making linear approximation based on the risk curve (relations between the injury value and the injury probability). Regarding the scope of evaluation, a wide range of evaluation will be specified to prompt improvement of the pedestrian protection measures on the part of the manufacturer.

At J-NCAP, the evaluation function is also used to convert the injury value to a score in the general evaluation of impact safety related to the passenger protection. In the case of passenger protection, the head injury value does not necessarily rise remarkably thanks to the airbag, seat belt and other safety devices, hence the upper limit is set at HIC1000. On the other hand, in the case of the protection of pedestrians, it is difficult to reduce the injury value compared with the passengers under the present level of technologies due to the absence of having an airbag and other safety devices. Therefore, a wide evaluation range has to be set.

As a result, based on the pedestrian protection performance of the present vehicles, it is decided to use for evaluation a sliding scale between injury probability of 5% (HIC650) and 90% (HIC2000) from the risk curve[6] of the injury value (HIC) to conduct evaluation in a wider range (Figure 13). The evaluation range will be reviewed at a stage when the manufacturers have improved their measures for pedestrian protection.

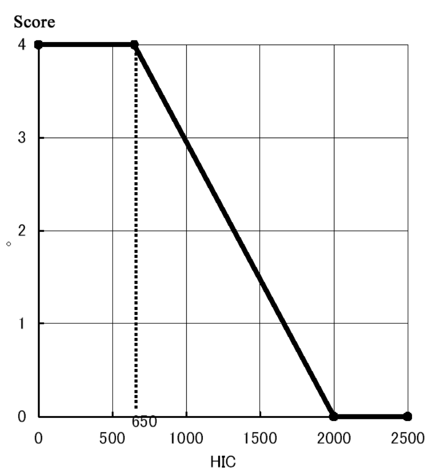

Figure 13 Sliding Scale

Evaluation of Windshield and Window Frame

When testing the windshield and window frame portions, the windshield needs to be replaced each time. Considering the time needed for fitting the windshield, the testing period is prolonged to a large extent. The injury value of the windshield is expected to be sufficiently lower unless interfering with the window frame and/or instrument panel. On the other hand, the injury value of the window frame is expected to exceed the upper limit (HIC2000) in most cases. Therefore, unnecessary tests are omitted for the evaluation of the windshield and window frame according to the following examination results.

Examination of Influence of Window Frame

Using three types of vehicles (Sedan A, Sedan B and Light vehicle), relationship between the distance from the window frame (A-pillar, roof and instrument panel upper end) and HIC on four types of windshields (one type being of thin glass) is examined (Figure 14-16). As a result, it was found that, except for the instrument panel upper end where contact occurs, the HIC becomes under 650 given a distance of more than the radius of the impactor from the window frame. Accordingly, regarding the side and upper portions of the windshield, a full mark (automatic rating) is given without conducting a test at the positions away from the A-pillar and the roof by 82.5 mm or more.

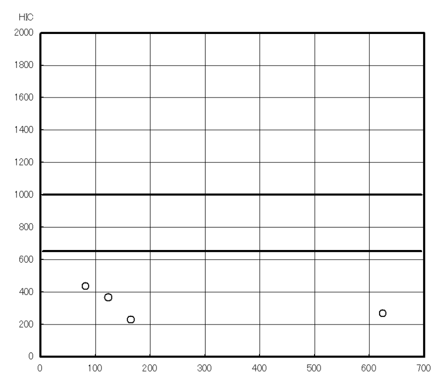

Figure 14 Distance from the window frame and HIC (Sedan A, A-pillar and adult impactor)

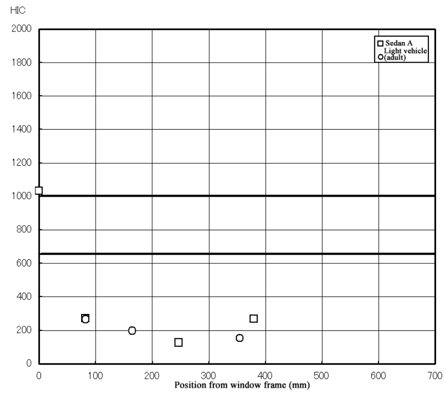

Figure 15 Distance from the window frame and HIC (Roof, adult impactor)

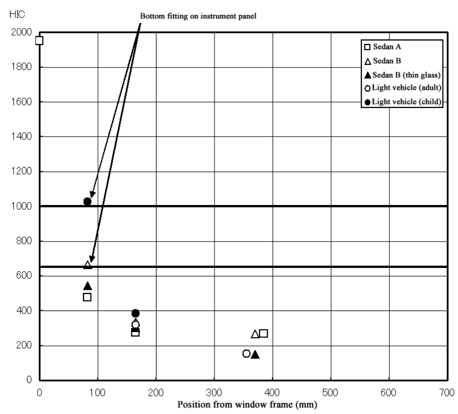

Figure 16 Distance from the window frame and HIC (Instrument panel upper end)

<u>Examination of Influence of Contact with Instrument Panel</u>

From the test result of the examination of the influence of the window frame, the relation between the dynamic deformation amount of the impactor and HIC was examined (Figure 17). As a result, regarding the lower portion of the windshield, it is estimated that the HIC will be less than 650 given a stroke of over 70 mm from the windshield to the instrument panel upper end. Accordingly, regarding the lower side of the windshield, taking into consideration the standard data deviation of 6.3 mm, full marks are given without conducting a test at the positions where the distance from the windshield and the instrument panel is more than 80 mm.

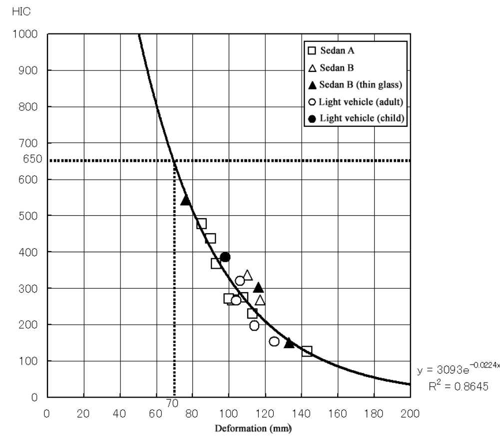

Figure 17 Dynamic deformation of impactor and HIC

When the above is summarized, the automatic rating area will be as shown in Figure. 18.

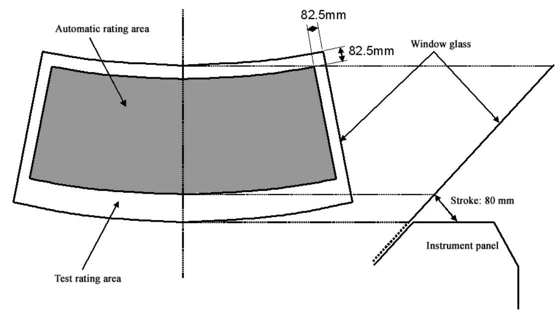

Figure 18 Automatic rating area

In addition, if evaluation is made on the windshield and window frame by 15-divided areas, the influence from the A-pillar becomes greater, tending to rate the safety performance of vehicles lower than it actually is. In this respect, it has been decided to evaluate the area near the connecting section of the windshield and window frame with the area ratio.

Ranking

The general average score is calculated on the divided areas for ranking. Calculation steps are as follows (Figure 19).

(a) The HIC value of respective impact positions is converted to the score using the sliding scale.

(b) The score for the impact position is weighted for each divided area to obtain the score for the divided areas.

(c) The average score is obtained for the divided areas in Areas I, II and III to obtain the area scores.

(d) The average score is obtained for Area I to III to calculate the general average score.

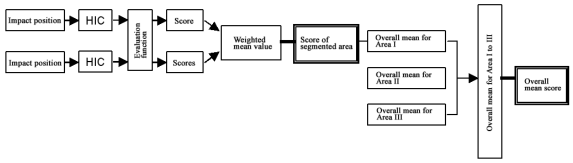

Figure 19 Calculation steps of overall average score

To give ranking, overall average scores are converted to HIC using the sliding scale. Vehicles are classified into 5 levels according to their safety performance. The method of classification is set to rank each vehicle at a different level as the injury probability drops by about 10% from the standard level of HIC1436 where the head injury probability is approximately 50% (Figure 20).

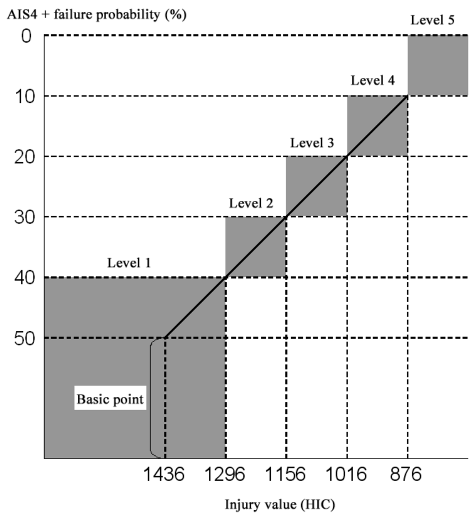

Figure 20 Ranking

Test Results

Figure 21 shows the state of the pedestrian head protection performance test by J-NCAP. In 2003, a total of 19 vehicles were tested including 9 units of passenger vehicles, 4 1Box/Mini Van vehicles, 4 light vehicles and 2 commercial vehicles (vehicle types were by the J-NCAP classification different from the vehicle classification for the pedestrian protection performance test). In addition, a test was conducted with 4 vehicles including 2 passenger vehicles and 2 1Box/Mini van vehicles in the first half of 2004. The evaluation results were distributed with 7 vehicles to Level 3, 13 vehicles to Level 2 and 3 vehicles to Level 1 and none for Levels 4 and 5 (Figure 22).

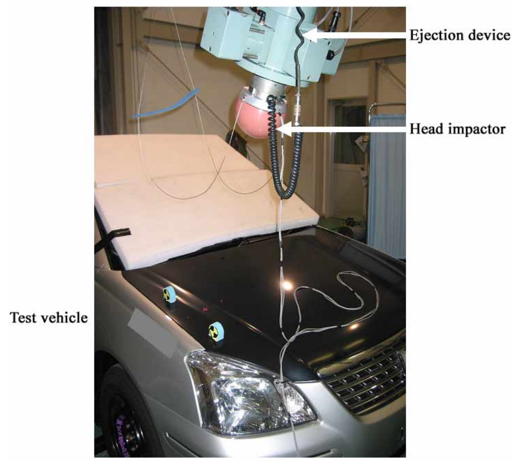

Figure 21 Testing state

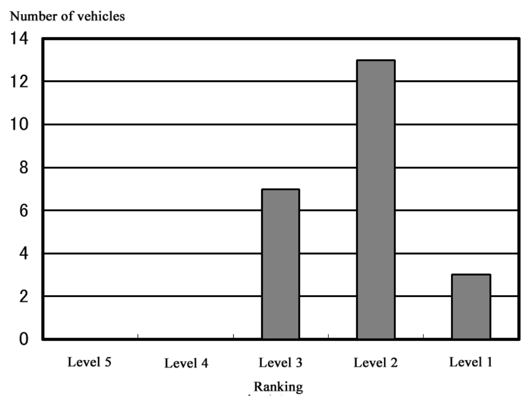

Figure 22 Distribution of vehicle levels (fiscal 2003 and first half of 2004, J-NCAP pedestrian protection performance test)

Figure 23 shows the state of distribution of injury values in the tests conducted during 2003 and the first half of 2004. A total of 283 impact positions were involved, of which the injury value reads HIC650 or under at 56 positions and HIC2000 or over at 26 positions. The reading of the remaining 201 positions was between the upper and lower limits of HIC values. The mean HIC value was 1204.1.

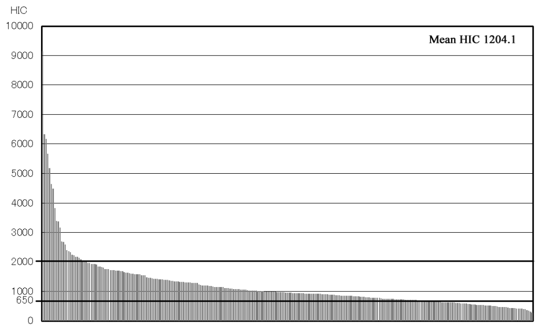

Figure 23 Distribution of HIC (2003 and first half of 2004, J-NCAP pedestrian protection performance test)

Figure 24 shows the impact positions where the HIC reading exceeded 2000 in the tests conducted during 2003 and 2004. It shows that the impact positions are mostly on the fender, lower end of the window glass, and the rear end of the bonnet. The A-pillar may be considered as another impact position where the HIC rises. It is evaluated as (zero (0) score) without a test unless specifically desired, hence no indication on the graph.

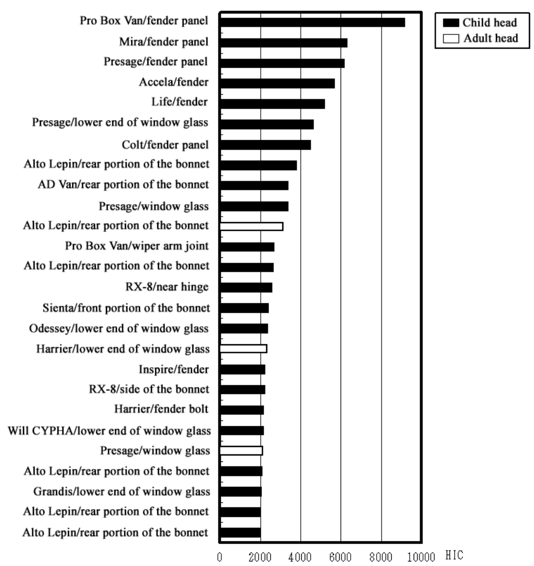

Figure 24 Impact positions where HIC reading exceeded 2000 (2003 and first half of 2004, J-NCAP pedestrian protection performance test)

Conclusions

In Japan, pedestrian accidents account for 30 percent of traffic accident fatalities and head injuries account for 60 percent of the injury regions in pedestrian fatalities. In view of these facts, J-NCAP has introduced a pedestrian head protection performance test.

The test method has been set up based on the test method under the Japanese laws and regulations and the IHRA test method. In consideration of the distribution of head impact positions in actual accidents, subject area for evaluations has been extended to include the windshield, simultaneously setting the impact velocity 10 percent higher to understand differences in the safety performance among the vehicles.

Regarding the evaluation method, the Euro-NCAP evaluation method was used to grasp the pedestrian protection performance of the vehicles in detail. Accordingly, the impact area is divided and the total score is calculated based on the scores from multiple tests. Moreover, to clearly evaluate the safety performance of the vehicles, a sliding scale is adopted to convert HIC650 to HIC2000 into the scores. The ranking of vehicles is given by a 5-level evaluation system based on the head injury probability.

During 2003, 19 vehicles were tested followed by 4 vehicles during the first half of 2004. Evaluation results were distributed with 7 vehicles to Level 3, 13 vehicles to Level 2 and 3 vehicles to Level 1 and none to Levels 4 and 5. In general, higher HIC values were observed in the portions close to the side and the window frame of the vehicles.

References

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[4] “European New Car Assessment Programme – Pedestrian Testing Protocol Version 4.0”, January 2003.

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[6] Mertz et al., “Injury Risk Curves for Children and Adults in Frontal and Rear Collisions”, SAE Paper No. 983318.