Airbag Jacket Evaluation Test

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Japan Automobile Research Institute

1. Outline of the Test

This study was conducted to evaluate the performances of airbag jackets developed for the crash protection of motorcycle riders. The items of evaluation were: (a) the rider protection performance against impact and (b) the time required for the airbag jacket to fully inflate. A biofidelic dummy capable of measuring impacts on the human body was employed. Impacts were applied by a 23kg-mass impactor to the dummy fitted with an airbag jacket, and the impacts on the neck and chest of the dummy were measured in order to evaluate the rider protection performances of various airbag jackets.

2. Impact Test on Airbag Jackets

2.1 Sample Airbag Jackets

Figures 1 and 2 show the photographs of some of the airbag jackets used in this study. In the neck impact test a total of 12 different models of airbag jackets were employed, and 13 test rounds were conducted. In the chest impact test four models of protectors and four models of airbag jackets were used, and 10 test rounds were tried on the dummy wearing a protector, jacket or combination of a protector and a jacket. The airbags were each fully inflated through the manual injection of air immediately before the test round.

(a) H Model (b) R Model (c) NW Model (d) MC Model

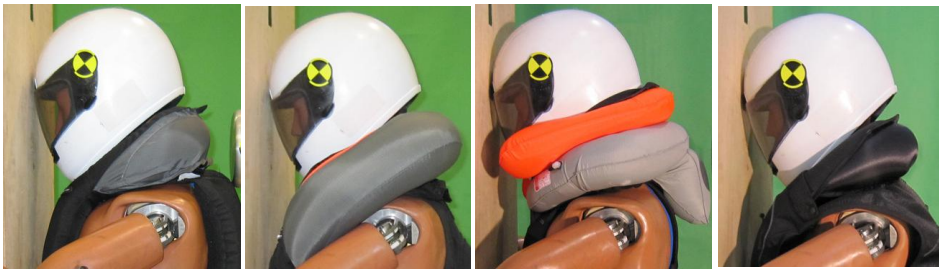

Fig.1 Some of the airbag jackets used in neck impact test

(a) Protector-A (b) Protector-D (c) POLICE (d) KOREA 1

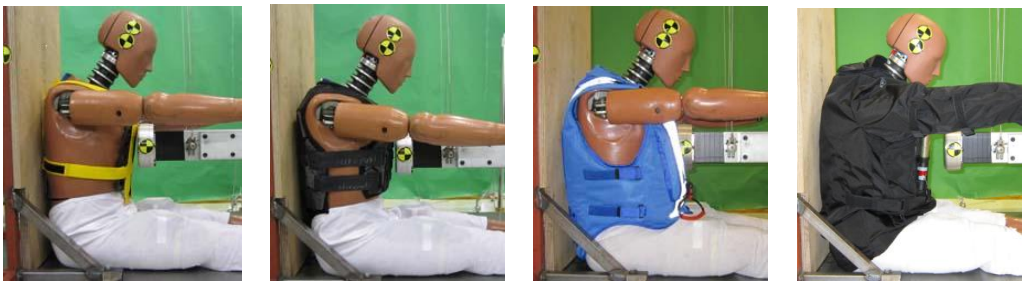

Fig.2 Some of the protectors/jackets in chest impact test

2.2 Dummy

This study was conducted using a front crash Hybrid-III dummy (Fig.3) fitted with an airbag jacket, protector or combination of a jacket and a protector. The dummy has stature of an average U.S. male adult (height 175 cm, weight 78 kg) and characteristics resembling the human body in structure, shape, weight, and the motion ranges of joints.

(a) Appearance (b) Positions of sensors

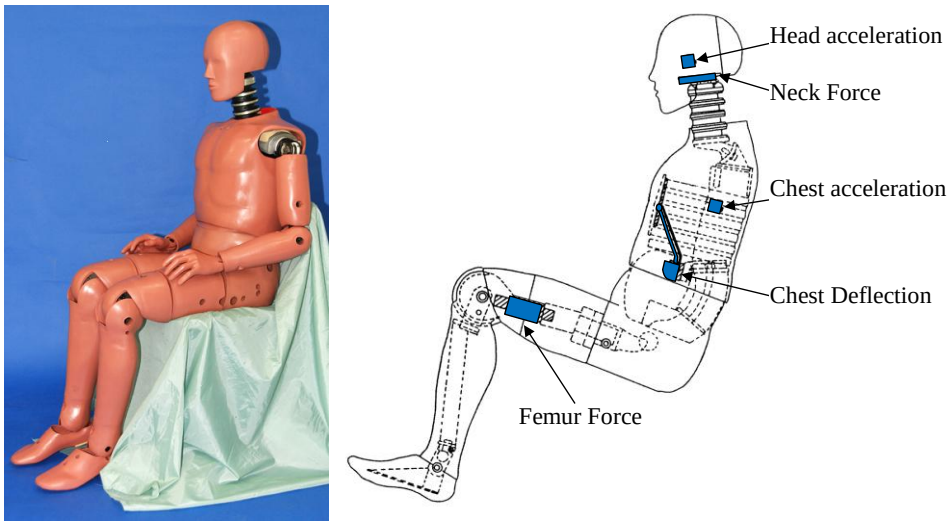

Fig.3 Hybrid-III dummy

2.3 Measurement Items

This study involved application of an impact to the neck or chest of the dummy by an impactor having an impact face diameter of 152 mm and a mass of 23.3 kg (Fig.4) at an impact speed of 5.6 m/s. In the neck impact test, forces generated on the neck were measured; in the chest impact test, crush or deformation amount in the chest region was measured. In both tests, the impact scenes were photographed by a high-speed video camera (500 frames/s) to visually determine the detailed condition of the impactor's collision with the dummy neck or chest. Table 1 lists the instruments used in this study.

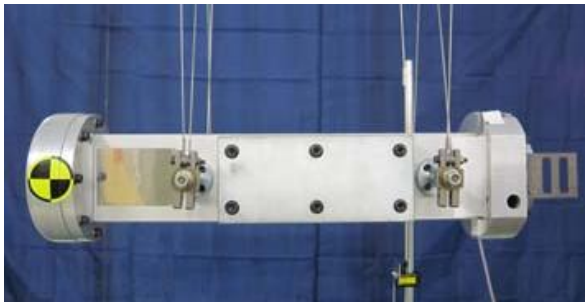

Fig.4 Impactor

Table 1 List of instruments used

Instrument	Model name	Manufacturer
Impactor accelerometer	AS100HA	Kyowa Electronic Instruments
Dummy	Hybrid-III AM50	Denton
▪ Neck load cell	1716	Denton
▪ Chest deflection sensor	Pot	FTSS
Data recorder	DIS2000	Kyowa Electronic Instruments
High-speed video camera	GX-1	Nac Image Technology

2.4 Test Results

(1) Neck Impact Test

In the neck impact test the target impact speed was set at 5.6 m/s (20 km/h). The dummy was set in the targeted impact position so that the upper end of the impactor's impact face would come as close as possible to but not in contact with the rear lower end of the helmet, while the vertical centerline of the impactor would overlap with that of the dummy. The airbag jacket was manually inflated before each test round.

Table 2 shows the results of the neck impact test. The test results were evaluated according to the injury criteria provided in the US FMVSS 208 on occupant crash protection. The criteria adopted in the neck impact test were: fore-and-aft shear 3,100 N, vertical tension force 4,170 N, and forward flexion bending moment 190 Nm. It was found that except for the 4,330 N tension force recorded in N-10 test round, all the test results clearly satisfied the neck injury criteria.

Table 2 Results of neck impact test

Test round	Airbag jacket model	Impact speed (m/s)	Neck shear (N)	Neck tension force (N)	Neck flexion bending moment (Nm)
N-01	POLICE	5.6	-1490	1758	87
N-02	KOREA 1	5.6	-1051	1078	70
N-03	FRANCE	5.6	-961	2200	49
N-04	H Model	5.6	-928	2156	56
N-05	NW Model	5.6	-1034	1582	58
N-06	R Model	5.6	-1064	2474	59
N-07	MC Model	5.6	-1243	2234	72
N-08 *	SV Model	5.6	(-1185)	(2628)	(89)
N-09	MLV	5.6	-935	3041	59
N-10	SKV	5.6	-1127	4330	81
N-11	MDJ Model	5.6	-978	1460	52
N-12	H Model	5.6	-942	2879	56
N-13	KOREA 2	5.6	-1163	3374	81

Note*) In N-08 (SV Model) test, the upper end of the impactor's impact face came into contact with the helmet so that the results of this test round might not have been comparable with those of other test rounds.

While injury criteria provided in various regulations are judged in relation to maximum values, there are proposals to adopt the duration of a generated force as an additional criterion whereby the values of a generated force are judged in relation to the duration of the same force. Figure 5 shows the protection standard values of neck shear; similarly, Figure 6 shows the protection standard values of neck tension force. In both of the graphs, the measurement results are plotted in relation to the duration of neck shear or neck tension force. It was found that the measured shear and tension force values in all but N-10 and N-13 test rounds fell in the "small possibility of serious injury" zone. Therefore, it can be deduced that if a rider is to receive an impact equivalent with the impacts applied in this study (by a 23 kg mass at a 20 km/h impact speed), the rider will be able to reduce the severity of neck injury to less than serious injury by wearing an airbag jacket.

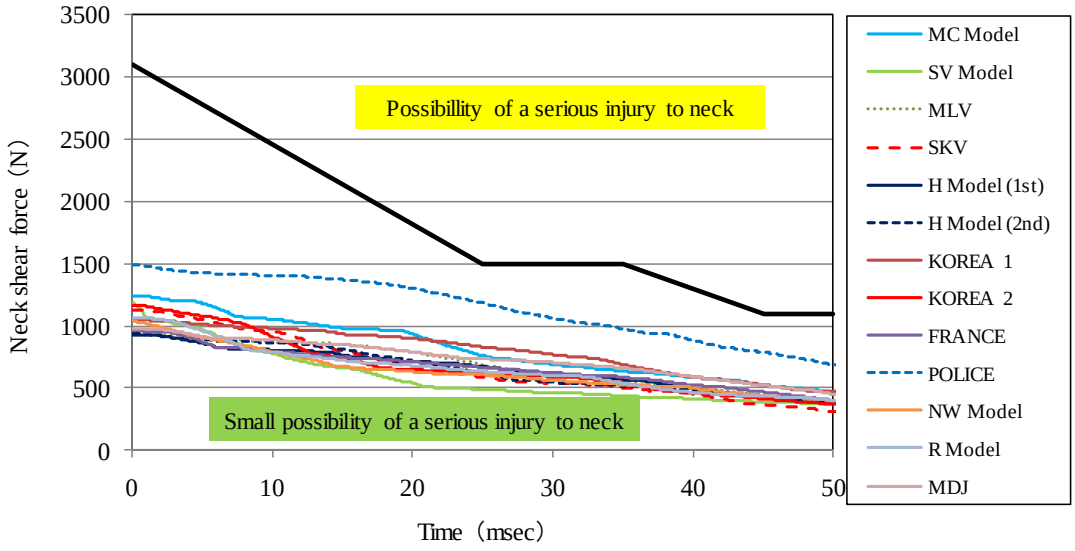

Fig.5 Protection standard on shear force

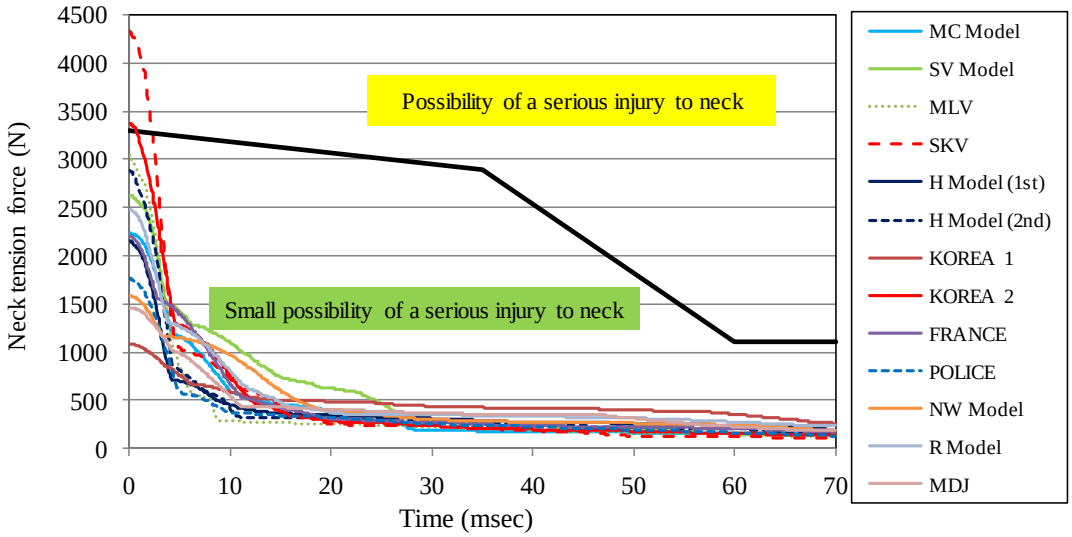

Fig.6 Protection standard on tension force

(2) Chest Impact Test

A fixed wall was set against the back of the dummy so that the impact from the impactor would be received almost totally by the front side of the dummy's chest. The target impact speed was set at 5.6 m/s (20 km/h). The dummy was set in the targeted impact position so that the impactor would hit on the longitudinal and transverse center of the dummy's ribs. Ten test rounds were conducted to determine the rider protection performances of: protectors, airbag jackets, the combinations of a protector and an airbag jacket, and the dummy without any

protective gear.

Table 3 shows the results of the chest impact test. The rightmost column of the table indicates the probabilities of generating a serious AIS 3 injury to the chest (i.e., fracture of at least 3 ribs) as derived from chest deflection measurements. Among the chest deflection results, C-7 the combination of Protector-A and KOREA 1 recorded the highest level of protection equivalent to the reduction of chest deflection by 16 mm as compared to wearing no protective gear.

Figure 7 shows the relationship between chest deflection and AIS 3 probability as derived from the test results with the wearing of an airbag jacket. When the dummy wore no gear (C-1), the AIS 3 probability stood at 31.7%. This probability was reduced to 17.9%, down 14 percentage points, by putting both a protector and an airbag jacket on the dummy (C-7).

Table 3 Results of chest impact test

Test round	Gear model	Impact speed (m/s)	Chest deflection (mm)	AIS 3 probability (%)
C-1	No protective gear	5.6	62.0	31.7
C-2	Protector-A	5.7	54.5	24.5
C-3	Protector-B	5.6	60.1	29.8
C-4	Protector-C	5.6	60.9	30.6
C-5	Protector-D	5.6	57.7	27.5
C-6	Protector-A + POLICE	5.6	47.7	19.1
C-7	Protector-A + KOREA 1	5.7	46.1	17.9
C-8	KOREA 1 (no protector)	5.6	51.2	21.7
C-9	Protector-B + R Model	5.7	49.4	20.3
C-10	FRANCE (no protector)	5.7	52.6	22.9

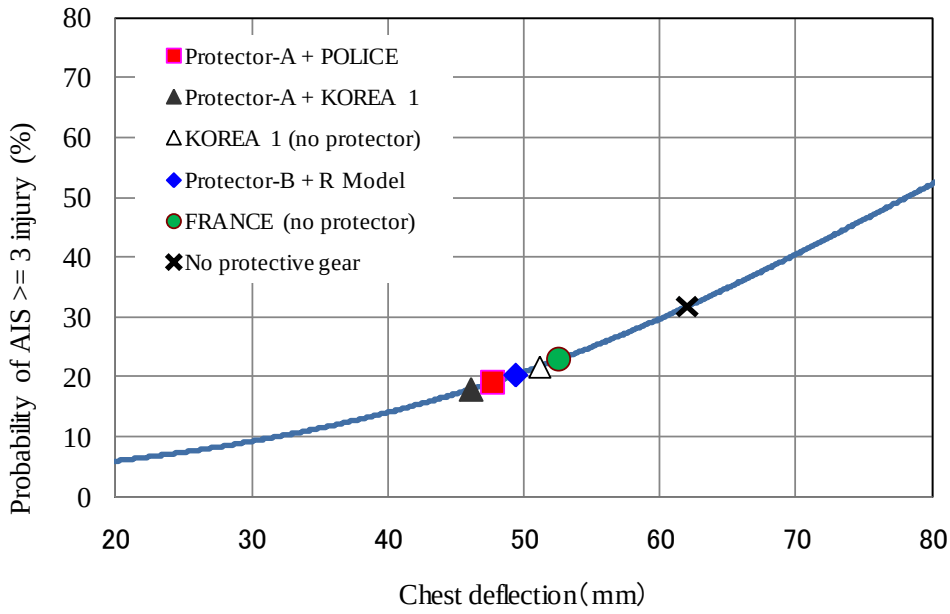

Fig.7　Relation between gear and AIS 3 probability

3. Verification Test on Airbag Jacket Inflation Time

3.1　Outline of the Test

The airbag jackets evaluated in this study had an automated system of injecting air into a tube inside a jacket upon detection of the rider's separation from the motorcycle body. This test was therefore intended to verify the time required to complete the inflation of the tube from its normal housed state.

As shown in Figure 8 the release force needed to activate the airbag jacket inflation system was measured by a push-pull scale, and the time required to fully inflate the jacket was verified by the pictures taken by the high-speed video camera. Time 0 was set at the instant of separation of a ball (called "key ball") from the motorcycle body. Table 4 shows the instruments used in this test.

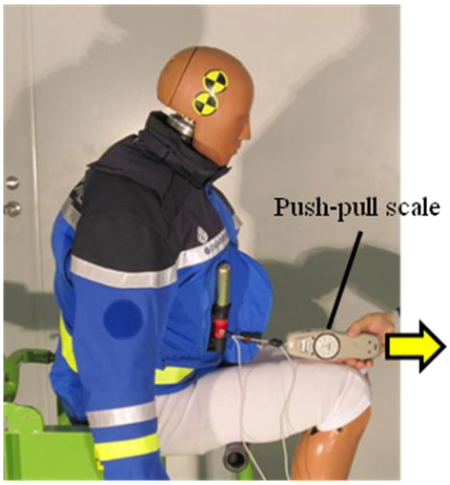

Fig.8 Airbag jacket inflation test

Table 4 Instruments used in the inflation time test

Instrument	Model	Manufacturer
Push-pull scale	PS500N	IMADA CO.,LTD
High-speed video camera	GX-1	Nac Image Technology

3.2 Test Results

Four rounds of test to verify the airbag jacket inflation time were conducted, using 4 models of airbag jackets as shown in Figure 9. Table 5 shows the measurement results of release force, inflation time at neck, and total airbag jacket inflation time. The greatest release force of 400 N was recorded by the POLICE airbag jacket. The fastest total inflation time of 90 msec was recorded by H Model, while the POLICE model required the longest total inflation time of 180 msec.

(1) KOREA (2) POLICE (3) H Model (4) FRANCE

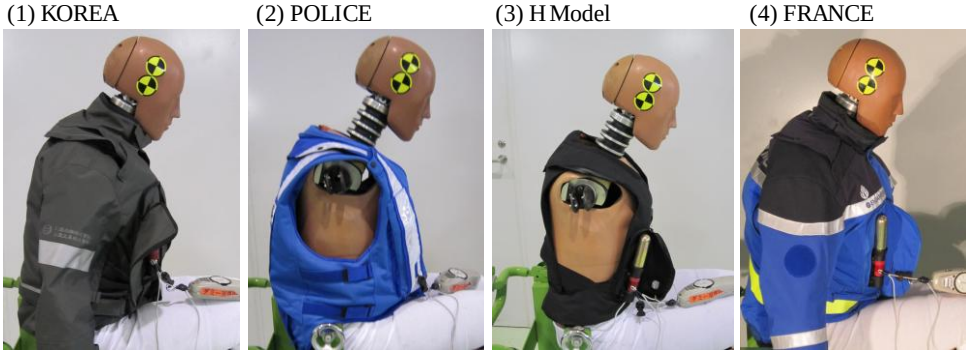

Fig.9 Airbag jackets used in inflation time test

Table 5 Results of airbag jacket inflation test

Jacket model	Release force (N)	Inflation time at neck (msec)	Total inflation time (msec)
KOREA	275	70	105
POLICE	400	80	180
H Model	375	90	90
FRANCE	245	90	105

4. Conclusions

To evaluate the rider protection performances of various airbag jacket models, an impact test and an inflation time test were conducted. The results are summarized as follows:

(1) Neck protection performance

From the measurements of shear and tension force in the neck, it was deduced that the probability of a crash impact generating a serious injury to the neck is low if the rider wears an airbag jacket.

(2) Chest protection performance

The results of the chest impact test indicated that the probability of a crash impact generating an AIS 3 injury (serious injury) to the chest region can be reduced by as much as 14 percentage points if the rider wears both a protector and an airbag jacket, as compared to having no protective gear on.

(3) Inflation time test

The time required to fully inflate an airbag jacket proved to be 90 msec for the fastest model and 180 msec (0.18 second) for the slowest model.