ARE SIDEBAGS DANGEROUS IN CERTAIN SEATING POSITIONS?

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ABSTRACT

Testing with Post Mortem Test Subjects (PMTS) has been carried out with different sidebag systems at the institutes of Forensic Medicine in Heidelberg and Hanover. Two systems, seat-mounted and door-mounted, were tested in critical seating positions with different testing procedures: static deployment tests, and dynamic impact tests into the door. The PMTS, equipped with three-dimensional accelerometers near the shoulder joint, the wrist, the elbow, the thorax, and the pelvis, were examined after the tests.

The experiments produced the following result: Neither significant additional injuries caused by the sidebag in the impact tests nor significant injuries during the inflation tests could be observed by autopsy after the tests.

The goal of this study was to estimate the injury risk due to worst case situations for the driver or passenger. Therefore, the results may not be used for efficiency studies of sidebags.

SIDE IMPACTS HAVE a great risk to the life of car occupants, especially for the near-side occupants. The mostly injured body regions are the head, chest, and abdomen (Zeidler, 1994). Body shell measures are restricted because of the limited deformation zone in the side. Therefore it is urgently necessary to offer additional protection with paddings and /or sidebags.

Bag systems have the great advantage that they only should inflate if the passenger needs them. In normal driving situations the bags are hidden behind the instrument panel (front bag) or the door trim (side bag). The main disadvantage of these systems could be the aggressivity caused by high kinetic energy during inflation.

Some real world accidents with triggered front airbags and occupants in out-of-position or infants in rearward facing child seats confirmed the aggressivity in terms of fatalities. Car manufacturers and the suppliers reacted with less aggressive gas generators, reduced mass of the bag itself and deactivation devices to cut off the airbag deployment. To avoid the disadvantages observed in some accidents with front bags and out-of-position seated occupants, a major goal during the development process of sidebags was the carrying out of tests with post mortem subjects in out-of-position to sidebags located in the door and at the backrest of the seat.

TESTS WITH A DOOR-MOUNTED SYSTEM

The tested bags were made by Phoenix with a volume of about 16 litres. The gas generators were produced by TEMIC. A great advantage of this system is that no additional cover flaps are necessary. The bag unit is only covered by the door trim, where tearing seams are located to avoid an additional risk of injuries caused by airbag flaps. This mechanism is well known from the driver front bag, where flinging covers and the bag itself hit the forearm during an onehand turn crossover maneuver (Huelke et al, 1994, Crandall et al, 1997). Figure 1 shows an inflated sidebag unit.

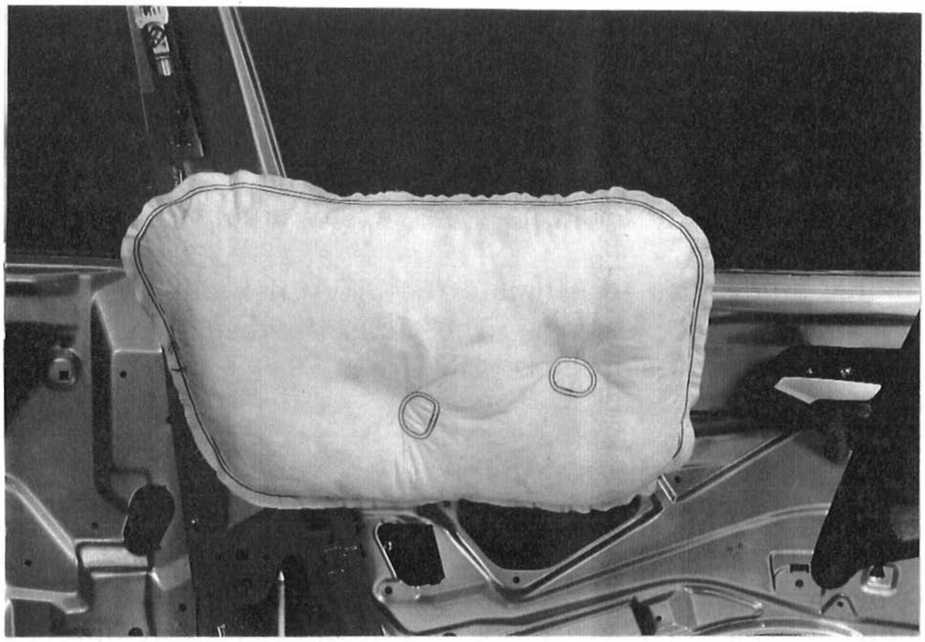

Figure 1 - Door-mounted inflated sidebag unit

TEST CONDITIONS AND INSTRUMENTATION - Static inflation tests and dynamic sled tests (fig.2) with a FMVSS 214-characteristic at 54 kph were performed. To simulate the door intrusion during the sled test, a special impactor with a contact area of 400 x 400 mm between impactor and car door was used.

Impact device on sled

Figure 2 - Test configuration for the tests: (A) without impact device = static inflation test
(B) impact device runs into the door at a certain speed

The post mortem test subjects were equipped with three-dimensional accelerometers at the shoulder joint, elbow, wrist (fig. 3), and in some tests at the head, chest, and pelvis. After preparation they were seated into the car in positions from which a risk was estimated due to accident research experts. Each test subject was used twice, on the one body side for the inflation test, on the other body side for the dynamic sled test. Next to the tests an autopsy with an examination of the upper extremities was carried out.

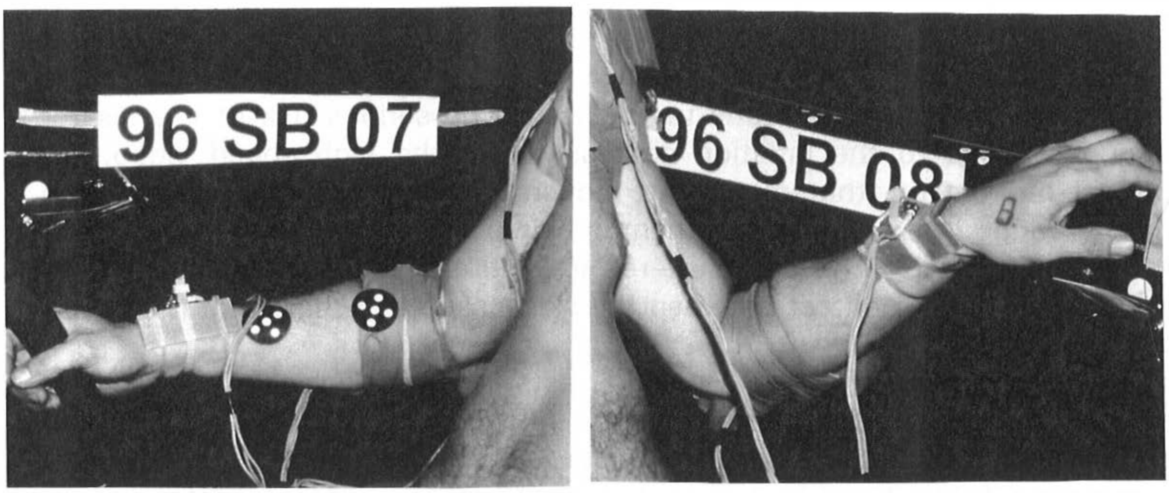

Figure 3 - Equipped test subject, left: positioned in 'forearm on armrest, hand in handle',
right: positioned in 'elbow on armrest, hand on belt line'

RESULTS - The following tables give an overview of the test matrix and the medical findings. The used filter class for all sensors was CFC600.

Table 1 - Extract of **static** inflation tests (1G = 9.81 m/s²)

PMTO	Configuration	Res. Acceleration in G's			Injury
		Shoulder	Elbow	Wrist	
male, 80 years, 162 cm, 65 kg	forearm on armrest, hand in handle (see fig. 3)	n.a.	n.a.	n.a.	Abrasion of the thumb and forefinger
male, 44 years, 180 cm, 108 kg	forearm on armrest, hand in handle (see fig. 3)	149.8	194.9	56.4	no
male, 87 years, 178 cm, 80 kg	elbow on armrest, hand on belt line (see fig. 3)	242.4	213.3	214.9	Abrasion of the elbow
		Head	Chest	Pelvis	
female, 47 years, 161 cm, 62 kg	head on belt line	57	23.8	0.9	no

Table 2 - Extract of **dynamic** sled tests with sidebag deployments (1G = 9.81 m/s²)

PMTO	Configuration	Res. Acceleration in G's			Injury
		Shoulder	Elbow	Wrist	
male, 80 years, 162 cm, 65 kg	forearm on armrest, hand in handle (see fig. 3)	410.5	343	281.6	Abrasion of elbow and fracture of the 3rd - 6th rib
male, 44 years, 180 cm, 108 kg	elbow on armrest, hand on belt line (see fig. 3)	98	236.6	235	Abrasion of elbow and wrist
male, 87 years, 178 cm, 80 kg	elbow on armrest, hand on belt line (see fig. 3)	338.4	405.9	280.5	Abrasion of elbow, rib fracture and sternum fracture
		Head	Chest	Pelvis	
female, 47 years, 161 cm, 62 kg	head on belt line	42.9	68.8	-	1st - 6th rib fractured, sternum fracture and clavicle fracture

Table 3 - **Dynamic** reference sled tests without sidebag (1G = 9.81 m/s²)

PMTO	Configuration	Res. Acceleration in G's			Injury
		Shoulder	Elbow	Wrist	
male, 39 years, 174 cm, 82 kg	elbow on armrest, hand on belt line	198	236,6	235	no
male, 57 years, 174 cm, 82 kg	forearm on armrest, hand in handle	338,4	405,9	280,5	abrasion of upper arm, sternum fracture
		Head	Chest	Pelvis	
male, 84 years, 164 cm, 63 kg	head on belt line	24,8	47,5	34,2	multiple rib fractures

CONCLUSION - All static tests showed no serious risk of injuries for occupants due to the inflation process. From the high speed video, no critical movement (that means no movement which is greater than the normal range of movement of a human being) or bending of the forearm or humerus is visible. The only suffered injuries are minor abrasions (AIS 1) because of direct contact between the skin tissue and the fabric (Polyamid 6.6).

The results from the dynamic tests showed basically only chest injuries (rib fractures of the severity AIS 3 and AIS 4, and sternum fractures). Bony injuries of the upper extremities were not observed. Comparing Table 2 and 3, it is obvious that without sidebag protection the same injury pattern occurs as with sidebags. From this can be concluded that in extreme seating positions like head on belt line no additional risk due to sidebag deployment is recognizable.

Also evident is the great influence of the test subject's age. While a young man (39 years) without sidebag was not injured, an old man (87 years) suffered rib fractures with a sidebag.

TESTS WITH A SEAT-MOUNTED SYSTEM

The seat mounted system was made by Autoliv. The bag is fixed into the backrest of the seat and is only covered by a thin layer of fabric with tearing seams. The volume is about 12 litres with a hybrid gas generator (fig. 4).

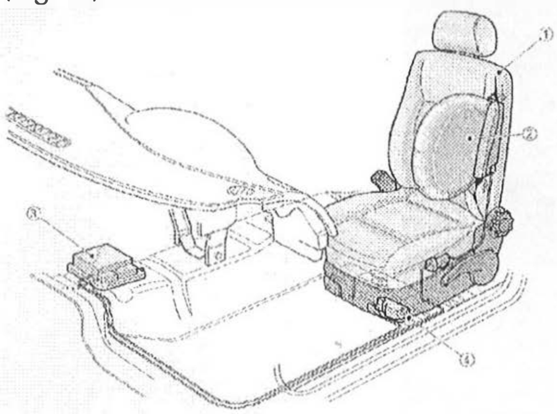

Figure 4 - Seat-mounted sidebag unit: (1) Seat, (2) Airbag, (3) Controller, (4) Sensor

TEST CONDITIONS AND INSTRUMENTATION - Unfortunately, it was not possible to perform dynamic sled tests with the seatbag, so that only four static inflation tests are available. Figure 5 shows the configuration 'hand in handle'.

Figure 5 - Test configuration: 'hand in handle'

The test subjects were equipped with three-dimensional accelerometers at the head, humerus, radius, chest, and pelvis. Figure 6 shows the instrumented arm. After the tests all subjects were examined by autopsy with special regard to the upper limbs.

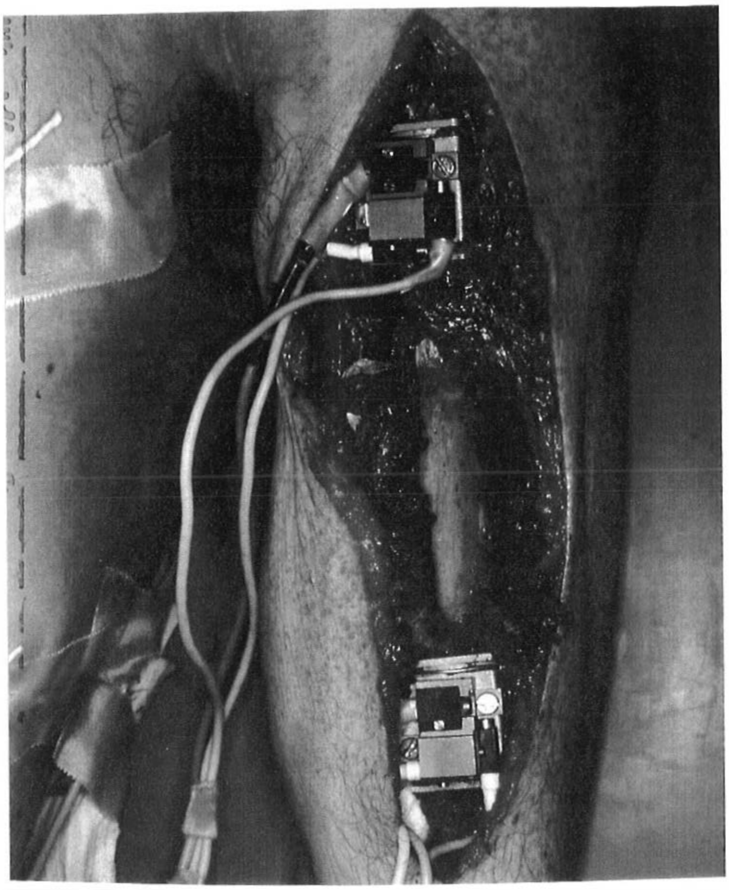

Figure 6 - Equipped arm

RESULTS - The most important findings shows table 4. The filter classes for the upper extremity were CFC180, and for the head CFC1000.

Table 4 - Static inflation tests

PMTO	Configuration	Res. Acceleration in G's (1G = 9.81 m/s²)					Injury
		Upper/Lower Humerus	Upper/Lower Radius	TH1/TH12*	Head	Pelvis	
male, 45 years, 175 cm, 90 kg	leaning against belt line	148.2/165.3	86.9/65.5	16.4/9.2	26.5	15.6	no
male, 45 years, 166 cm, 55 kg	hand on the backrest adjuster	156.1/68.1	124.6/44.2	5.4/6.8	26.6	11.7	no
male, 45 years, 175 cm, 90 kg	elbow on armrest, hand straight upwards (smoking position)	55.8/69.5	76.7/28.6	17.7/4.2	31.5	23.2	no
female, 86 years, 158 cm, 60 kg	forearm on armrest, hand in handle	110.9/246.5	143.5/99	8.2/26	7.3	12.2	Cartilage defect of the fossa olecrani of the arthritic elbow joint (AIS1)

* 12 accelerometer method

CONCLUSION - The four tests showed no serious risk of injuries due to the inflation. There was only a minor injury of a 86-year old woman, who was seated in the car with her hand fixed to the door knob. This configuration was the worst case (estimated by medical doctors and technical experts) for the arm bones, but no fracture occurred. The only suffered injury was a slight cartilage defect of the elbow joint. It is unclear, whether this injury was caused by the bag or probably existed before the test. An influence due to the sex can be excluded, more probable is the influence of the age. For the occupant, this injury would mean pain without further necessary treatment.

The anticipated dynamic tests could not be conducted due to the lack of test subjects. So, no conclusion can be drawn on the dynamic behaviour.

DISCUSSION

Both systems show in out-of-position and extreme seating positions no serious additional risk of injuries due to static inflation. Other test series (Kallieris et al., 1997) show likewise very similar results. The conclusion of the paper was that there is a very low risk of minor inflation-induced injuries to the arm.

On the other side, sled tests with intrusions into the passenger cell caused in some cases bony injuries of the chest. This was independent of the deployment event because of the obtained injuries during the sled tests with and without sidebag.

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