OBJECTIVES AND EXPERIENCE OF PUBLISHING CRASH-TESTS RESULTS IN A EUROPEAN MAGAZIN

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ABSTRACT

Since 1990, "auto motor und sport" has published the results of over 70 crash tests. All tests were carried out under extremely realistic conditions with the aid of the TÜV Süddeutschland ECV system. The main advantage of this system is that the test vehicles are driven under their own engine power. A 50% offset collision into a 15° angled solid barrier at a speed of 55 kph was selected as the test configuration. This has allowed conclusions to be drawn concerning the behaviour of the restraint system and of the vehicle structure. Since the test conditions were maintained exceptionally accurately during the series, developments and tendencies could be drawn from the data. The following tendencies could clearly be seen from the database:

- The stiffness of the occupant compartment has increased
- Restraint systems have become noticeably more efficient
- The pattern of injury has changed, with injuries of the lower extremities now becoming more important

The series of published crash tests has therefore significantly contributed to turn the attention of the car driver towards vehicle passive safety. In the future the problem of compatibility will increasingly be taken into consideration in the area of personal safety. Vehicle-vehicle crash tests, which have also been presented for publication, have contributed to clarifying some of these issues. These publications may also lead to further objective conclusions.

INTRODUCTION

In our times of highly complex traffic and high sensitivity on the part of the individual concerning an enlightened attitude towards technology and safety awareness, vehicle safety forms an important element of technology and everyday life.
Technically-interested people can form their own opinion with the aid of a great number of available media, such as reports in daily newspapers, statements by consumer protection associations, television broadcasts or also specialised and independent magazines dealing exclusively with the subject of automotive engineering. In view of this large variety of information sources, a test procedure characterised by a clear evaluation pattern and continuous realistic test conditions is advantageous for the final consumer. For this reason, "auto, motor und sport" has selected a test procedure which -- with the aid of ECV technology -- gives highly realistic results.

ECV CONTROL

In order to allow driverless control, the TÜV Süddeutschland ECV (Electronically controlled vehicle) system is used for the test.

The particular advantage of this test method is that the vehicle can be driven under its own power. The ECV system can further be distinguished from other current test methods as follows:

- high longitudinal and transverse precision through electronic steering and control system;
- complete transportability, i.e. the ECV system is universally applicable to enclosed test tracks;
- the greatest possible flexibility with respect to crash configuration and vehicle combination include the collision of two moving vehicles;
- adjustable for different passenger cars and trucks.

The required speed is entered into the on-board vehicle controller before the test. The vehicle is constantly and steadily accelerated to the desired speed by an actuator. The actual speed signal comes from a tacho hub, normally mounted on a non-driven wheel. System accuracy is ensured by means of control measurements on comparison trips with the help of an external speed measurement system. An automated gear shifter can be incorporated to cover large speed ranges or for use in heavy trucks. Passenger cars are normally driven in second gear.

Path control is achieved by driving the vehicle along an electrical pilot cable. The cable is an emitter with a 10 kHz A/C signal, generating a concentric electromagnetic field. An antenna mounted on the front of the vehicle detects lateral deviations by measuring the field intensity and communicates these to the onboard computer. The required steering corrections are automatically calculated and transmitted to the steering shaft by an electric motor. Figure1 shows a functional schematic of the ECV Crash System. Detailed information about this technology can be gained from the fourth reference.

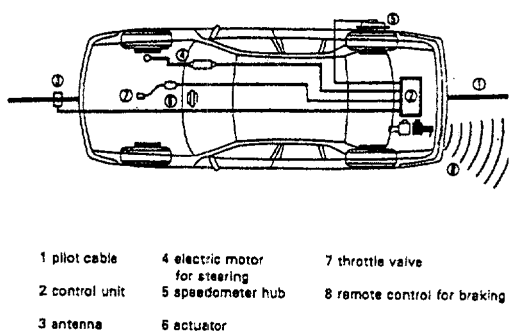

Fig. 1

CONFIGURATION

For "auto, motor sport" tests the following configuration was selected:
- 55 km/h
- 50% offset
- 15° barrier with ASD
- 2 Hybrid III dummies on the front seats
- if necessary, 2 child dummies FTSS representing children of 3 and 6 years of age
- car driven via ECV with its own engine power

Figure 2 presents the test configuration in a diagram.

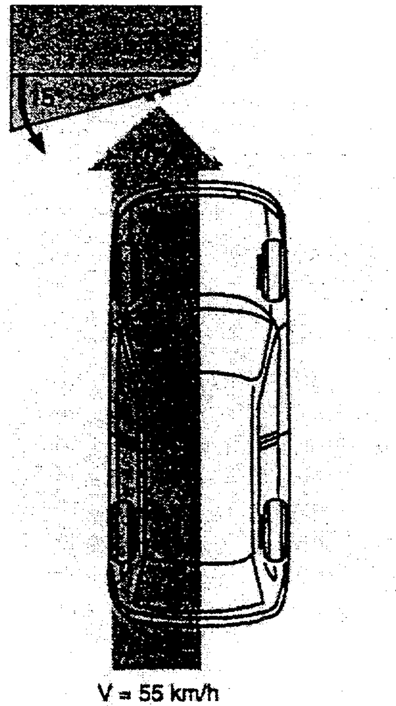

Fig 2

EVALUATION PATTERN

Vehicle evaluation is divided into three main categories. If a vehicle has low scores in all evaluation criteria, then the vehicle is evaluated as having a "low injury risk". Should one of the criteria be assessed within the range of "medium injury risk", the entire vehicle will be classified as having a "medium injury risk". Analogously, cars that achieve poor results will also be evaluated as having a "high injury risk". Figure 3 shows the limit values for dummies and vehicles. The evaluation covers the following parts: HIC (head), the acceleration values over 3 milliseconds (head, chest, pelvis), the peak load value acting on the upper thigh and the rotation of the head around the Y-axle (not including the yaw movement). At the vehicle, the following parts are included in the evaluation: footwell intrusion, belt force (shoulder belt), door opening behaviour and the displacement of the steering wheel during the test.

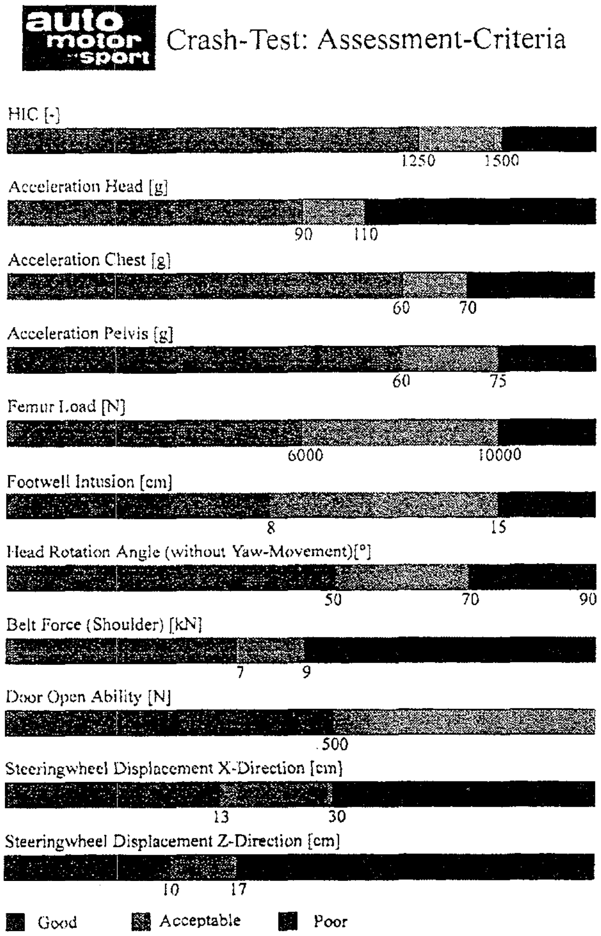

Fig. 3

IMPROVEMENT IN CAR-BODY STIFFNESS

With respect to the stiffness and strength of the car body and, in particular, the passenger compartment, the data that has been collected since 1990 allow the following conclusions:

The stiffness of the passenger compartment has increased due to improved deformation behaviour. Figure 4 shows a vehicle with a collapsing passenger compartment (especially in the area of the A-pillar) from an early (1990) "auto motor und sport" crash test. In contrast, Fig. 5 shows a current model of today's vehicle population with good stiffness performance.

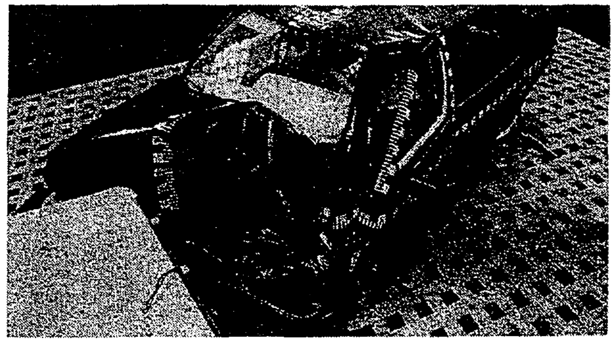

Fig. 4

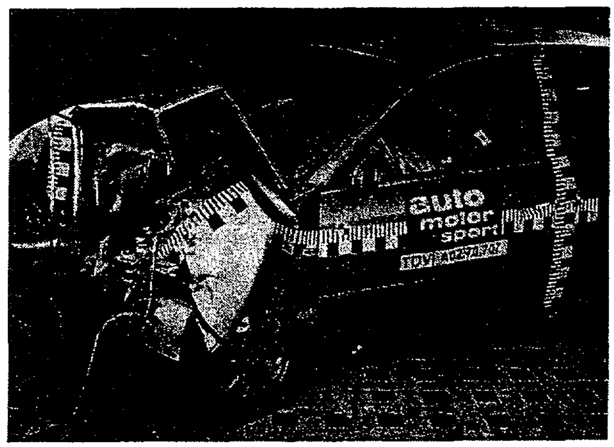

Fig. 5

The two interior pictures taken of the aforementioned vehicles' passenger compartments also reflect considerable improvement. In addition, the driver's door of the vehicle tested in 1990 could only be opened after 20 minutes and with the aid of rescue tools. Figure 6 also shows that, on account of insufficient stiffness in the passenger compartment, there were marked intrusions into the body interior. The displacement of the steering wheel in X-direction, for example, was 28 cm. The fact that the passenger compartment at the driver's side was shortened by 35 cm also points to insufficient survival space for the driver. In contrast, Fig. 7 presents a modern vehicle that was tested only 7 years later. Apart from the inflated airbag, this picture could be mistaken for a picture taken before the test. The deformation values, too, speak for themselves. A horizontal steering-wheel displacement of only 4 cm and the shortening of the passenger compartment by 10 cm represent today's state of the art.

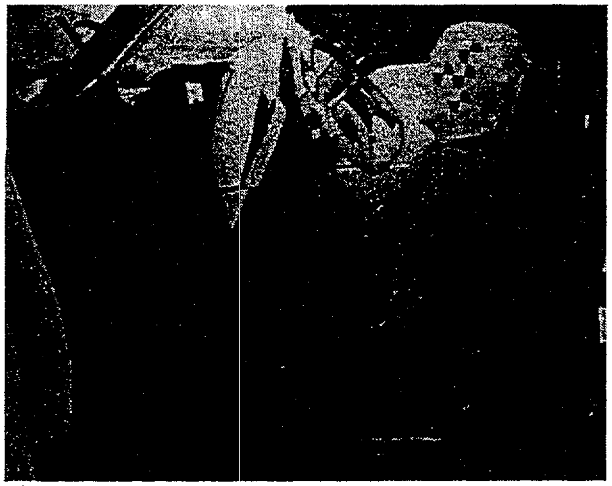

Fig. 6

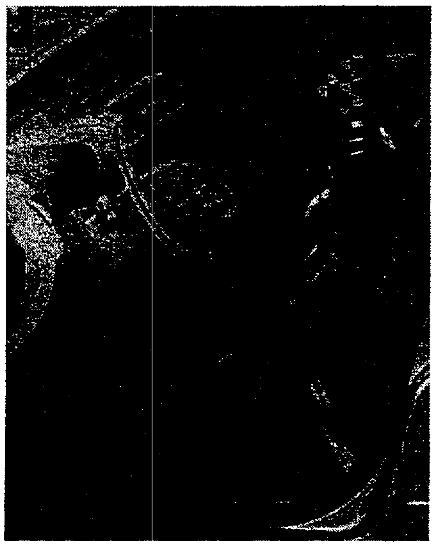

Fig. 7

IMPROVEMENT IN RESTRAINT SYSTEMS

Not only in the vehicle structure but also with respect to the efficiency of passenger restraint systems, does the data that have been collected over recent years allow statements to be made evidencing a continuous improvement in this field. From the Head Injury Criterion (HIC) to the loads acting on the upper thighs, the characteristics outlined in the following become evident.

Figure 8 shows the HIC values measured on a selection of vehicles. A decrease in divergence over the course of the years is very clearly recognisable. In this area, where HIC values of more than 1000 were not uncommon back in 1990, today's values are concentrated around a HIC value of 500. Vehicles in the sub A-range still form the exception in this case because -- due to their short deformation potential -- they have reached the limits of today's restraint systems.

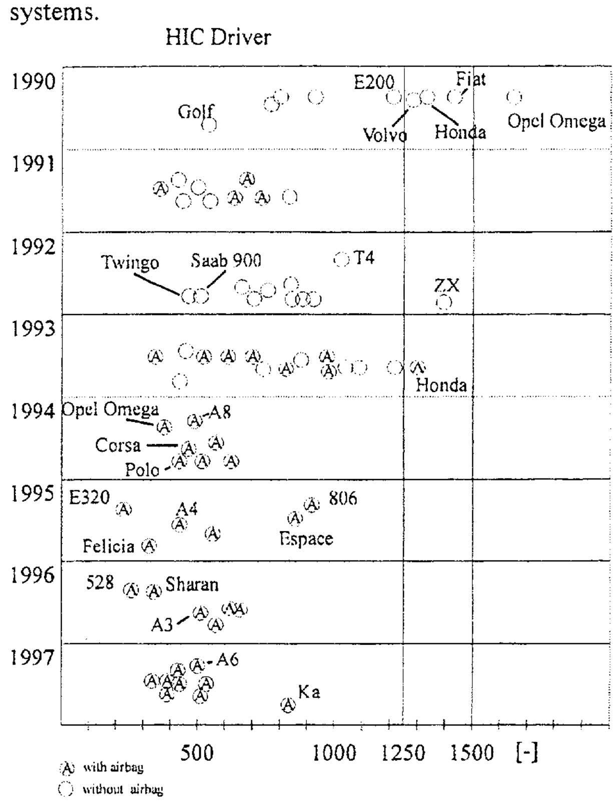

Fig. 8

Due to the same measurement point (head) similar tendencies can be seen for the head acceleration as shown in Figure 9. In this respect, where in 1990 acceleration values (3 ms) of more than 110g were measured, today's values are in the 60g-range and sometimes even far smaller than this.

With respect to chest acceleration as presented in Figure 10, only a slight tendency can be shown. Apart from some exceptions, chest acceleration (3ms) was already under the magic limit of 60 g for the majority of vehicles when crash tests began. Since in the first years tests exclusively covered vehicles which were only equipped with a 3-point seat belt and since the airbag only arrived on the scene gradually, the following conclusions can be made. In addition to vehicle deceleration characteristics, the 3-point belt has a primary influence on chest acceleration. It seems that the influence of the airbag in this field is only secondary. However, this does not mean that the airbag does not possess an improvement potential in this field, too. Another reason for this behaviour seems to lie in the laws of physics. Due to increasing vehicle decelerations partly caused by the constantly decreasing space reserves in the engine compartment and on account of the increased stiffness resulting from the vehicles' higher dead weight, no essential improvement can be achieved if the passengers participate early in the deceleration of the car body.

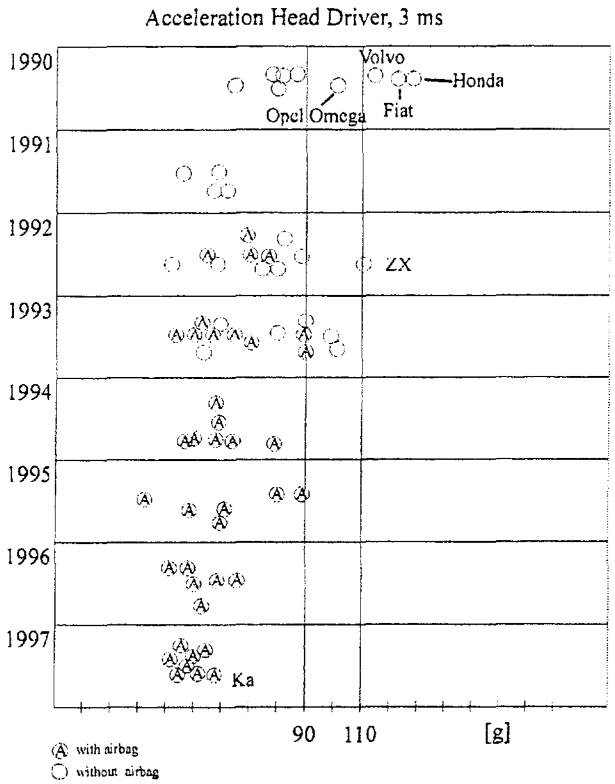

Fig. 9

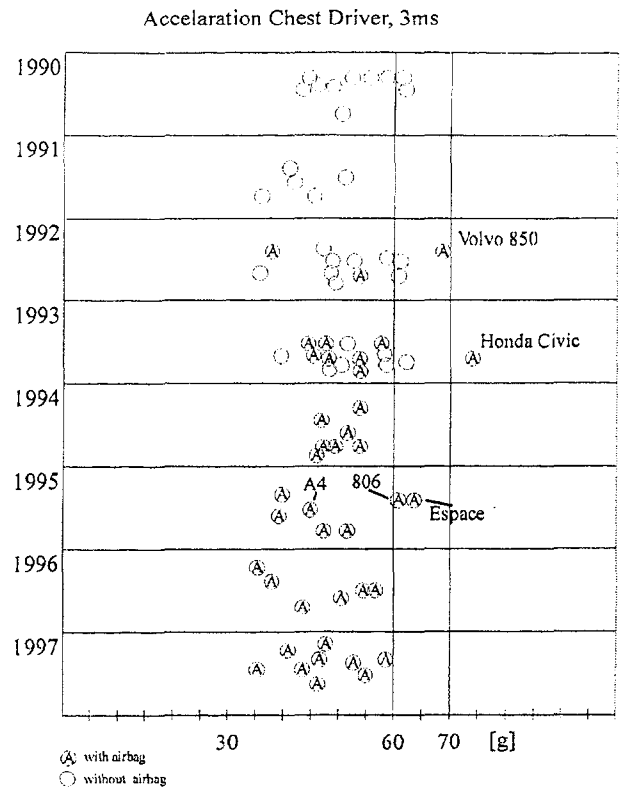

Fig. 10

Another continuous improvement in the field of passive safety is presented in Figure 11. In 1992 pelvis acceleration (3ms) peaked in values exceeding 75 g. From then on continuous improvement has been achieved. Seat-belt tensioners, airbag, car-body stiffness and the reduced intrusion resulting from this, as well as optimised design and material selection for the passenger compartment are some of the causes for this development. One exception to this is a vehicle that was tested in 1995 in which the unfavourably positioned reinforcement of the instrument panel resulted in high pelvis acceleration values.

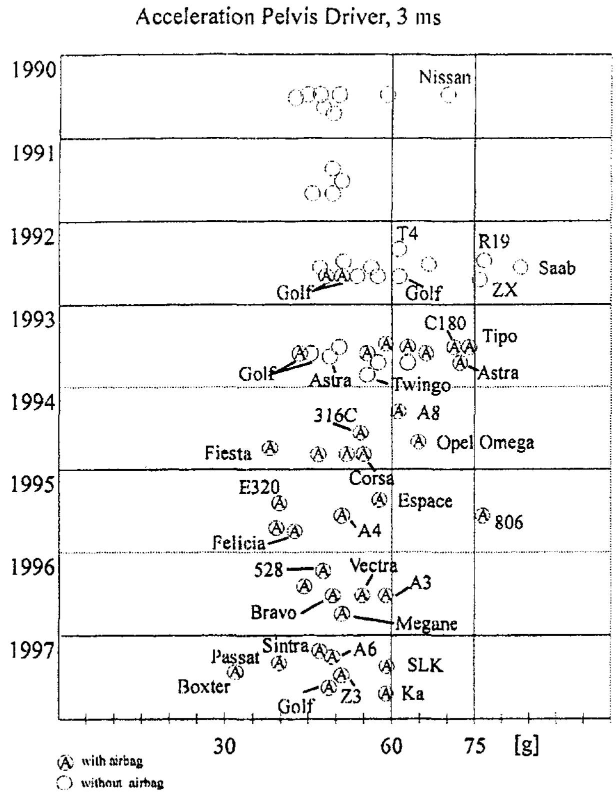

Fig. 11

The load acting on the upper thigh shown in Figure 12, as in the case of chest acceleration, do not show a significant tendency to improve. Categorisation into vehicles with and without airbags is not applicable since these values depend primarily on seat-belt function, knee-restraint quality, potential submarining effects and passenger-compartment reduction. It can also be seen that vehicles in which higher loads are acting on the upper thighs also show increased pelvis acceleration. This is caused by the direct transmission of force from the upper thigh to the pelvis. The improved design characteristics of restraint systems and knee restraints make "blunders", which were still recorded before 1996, appear unlikely in today's vehicle population.

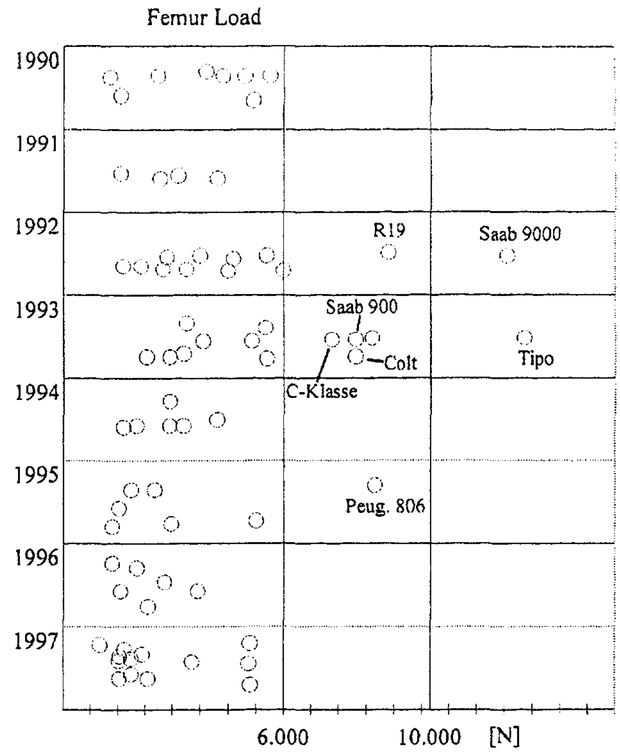

Fig. 12

INJURY PATTERN

The volume of loads has continuously decreased since the "auto motor und sport" tests began. On the account of various restraint systems which, however, act differently on the individual body regions of the dummies (passengers), the loads did not decrease equally for all body regions. As already explained in the aforementioned paragraph, the decrease in loads acting on the head was especially high. Figure 13 also shows injury traces on dummy head surfaces that often occurred in the early years. As a rule, such traces of injuries are not observed any longer today. Pelvis acceleration also considerably decreased. Since, however, there was not such a significant decrease in the loads acting on the upper thigh, it can be assumed that the injury risk has shifted to the lower extremities. Although most of the forces measured that act on the upper thigh were within the uncritical range, the limit value may easily be exceeded in case of a higher collision energy as occurs in real accidents.

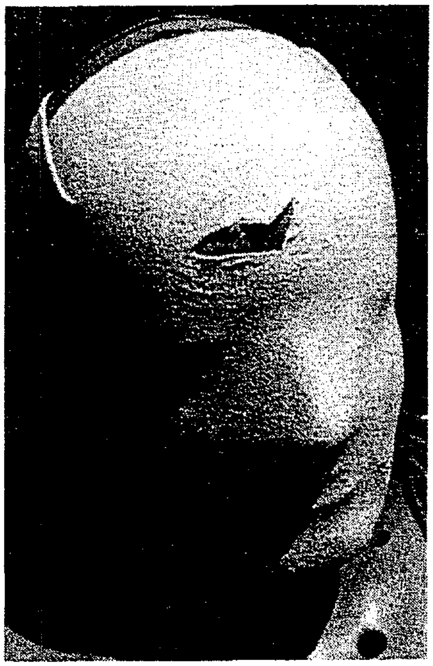

Fig. 13

Figure 14 shows traces of injuries that were caused by insufficient protection through the knee restraints. Thanks to technical progress such pictures have become less common.

Fig. 14

CONCLUSION

Thanks to more than 70 tests performed under the same marginal conditions and configuration, a large pool of data is now available which allows us to interpret the changes in passive vehicle safety that have developed over the last 8 years.

Because of continuous improvement in the structural stiffness of vehicle bodies, material quality, the design-related arrangement in the passenger compartment and the restraint systems, one can speak of a considerable reduction in passenger risk. Nowadays, small vehicles with design-related short deformation, such as the Ford Ka, achieve head acceleration values which, some years ago, some of the large vehicles could only dream of.

Since the restraint systems for standard seat positions (50%) have already been highly optimised, the future focus will certainly be directed to the injury mechanisms pertaining to the lower extremities.

Since end consumers with the power gained through their purchasing decisions can decisively influence the actions of the automobile industry, media do play a major role in the passive vehicle safety improvement process. The crash test as used by "auto motor und sport" , which in the beginning was often described as being too stringent, thanks to the public interest does not represent an insurmountable obstacle any longer, for most vehicles nowadays.

Besides all these introduced criteria of the passenger safety currently the matter of compatibility becomes more important. Therefore „auto motor und sport" realized apart the already mentioned tests against the rigid barrier also a lot of vehicle-vehicle-tests. This method of tests will complete the present test configuration.

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