SIDE COLLISION TESTING
WITH SMALL CARS

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ABSTRACT

Passenger protection in a side collision was investigated in four tests with small cars, two Ford Fiesta and two VW Polo.
The aim of this project is to investigate the resistance of small cars in side impact tests.
The results of the measurements taken on the vehicles and dummies have been presented, and the damage and load mechanics explained.
As a result of the investigations it can be stated that the small cars selected comply with the specifications of the guideline drafted by the ERGA-S working group.
The protection criteria were not exceeded; rather it was shown that all criteria fell considerably below the limit values.
The behaviour of small cars in a side collision is similar to that of the larger vehicle (VW Golf, Typ 19).
The equal performances by the small car in the tests can be explained by similar behaviour of the car side construction in the door area and lower inertia.

INTRODUCTION

The protection of passengers in private vehicles involved in a side collision is an important aspect of vehicle safety research. A directive which will establish a test procedure for vehicles to be licensed in Europe is at present being drafted by the **ERGA SAFETY GROUP** of the European Community.
The principle marginal conditions of this test were considered as early as 1982 by the Working Group 6 of the EEVC[1] [1].
Numerous vehicle and barrier tests were carried out in order to test these parameters. Representative smaller vehicles (VW Golf) as well as vehicles from the upper medium class (DB W123) were used in test series conducted by the BASt (Federal Highway Research Institute) [2,3] for developing the structure of the deformable barrier front.

Previous experiments revealed that dummy loads only slightly exceeded the limit criteria. Hybrid II dummies were used in earlier tests; comparative tests using **EUROSID**[2] displayed broadly the same results.

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1 European Experimental Vehicles Committee
2 EUROpean Side Impact Dummy

The aim of this project is to investigate the resistance of small cars to the loads occurring in a test conducted in accordance with the proposed european side impact test procedure. Test results should provide answers to the following questions: will the criteria of the ERGA Safety Group draft directive be kept and how does the behaviour of small cars compare with that of larger vehicles?

TESTCONDITIONS

All small vehicles manufactured in West Germany observe the construction principle of front wheel drive. For the tests, two popular vehicle types were chosen, namely the Ford Fiesta and the VW Polo. Their respective shares of the (newly licensed) car population are: Ford Fiesta 2.6% (2.1%), VW Polo 3% (2.7%).
Relevant technical data include:

		Ford Fiesta	VW Polo
Weight, unladen	:	750 kg	720 kg
Weight, total allowed	:	1160 kg	1130 kg
Vehicle length	:	3648 mm	3655 mm
Vehicle width	:	1567 mm	1580 mm
Vehicle height	:	1356 mm	1355 mm
Sill height	:	240-250 mm	240-250 mm

The vehicles described were subjected to a side impact test (only full vehicle test) according to the ERGA Safety draft directive (Document ERGA S65 Amendment 1). Every cartyp was tested in two tests.
The test conditions were:

- The vehicle to be tested was stationary and was hit on the left at an angle of 90° (collision and impact angle are identical) according to DIN ISO 6813 by a movable deformable barrier travelling at a speed of 50 km/h.

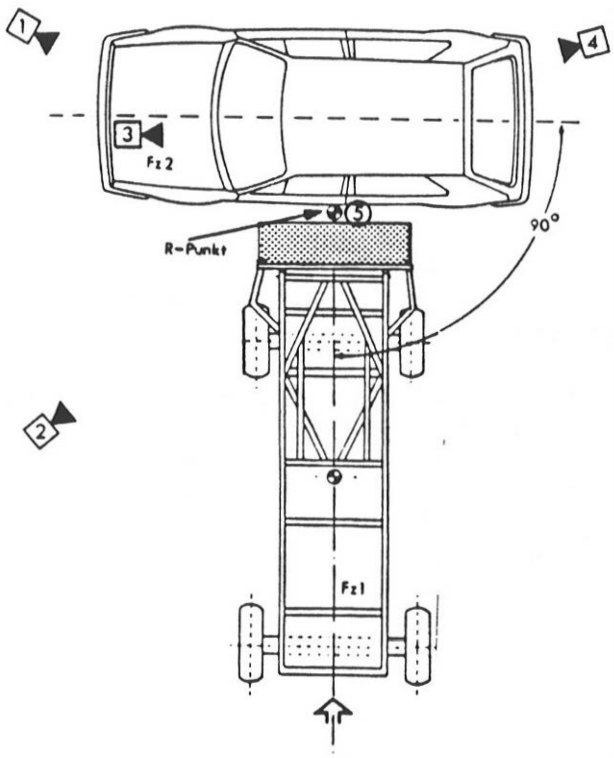
- The impact point in relation to the longitudinal centre plane of the barrier was the R-point of the test vehicle.

- The mass of the vehicle to be tested corresponded to the unladen weight plus dummy weight.

- The deformable front face of this barrier was 500mm high, 1500 mm wide, and had a ground clearance of 300 mm. The elements manufactured by Kenmont (GB) corresponded to the stiffness and energy dissipation requirements laid down in the above-mentioned ER document.

- A dummy was placed only in the driving seat.

- The EUROSID used was a model from the second production series.



Measurements on the Test Vehicle

- Acceleration 3-axial at centre of gravity
- 2x door acceleration in impact direction
- lateral deformation
- high-speed filming with 1000 frames/sec, 6 cameras

Measurements on the Dummy

- 3-axial head acceleration
- 3-axial thorax accel. above
- rib acceleration in 3 ribs
- deflection of 3 ribs
- uniaxial thorax accel. below
- 3-axial pelvic accel.
- forces on ilium, right and left
- force on pubic symphysis

ACQUISITION AND RECORDING OF MEASURED VALUES

Certain parameters for the measuring of dynamic processes in the field of impact test measuring techniques are laid down in the ISO 6487 (1980), e.g., filtering (CFC - Channel Filter Class) and signal magnitude (CAC - Channel Amplitude Class). No such regulations exist for the sort of acquisition technique to be used(e.g., whether piezoresistive or piezoelectric transducer) nor for the means of data transfer and recording.

Caused by the minimal number of fixed parameters in this ISO-regulation, different characteristics of transducers and the use of differing measuring chains could lead to different progressions in case of rapid events.

Since protection criteria will be mentioned below which allow a comparison with results from tests in other laboratories, some relevant data concerning the measuring and evaluation techniques used at BASt will be given:

- all transducers for forces and acceleration use the piezoresistive technique.
- individual measured values are filtered and sampled using different physical techniques depending on measuring position, e.g. head acceleration: CFC 1000, sampling frequency 8000 Hz, thorax acceleration: CFC 180, sampling frequency 1600 Hz.
- transfer is via PCM.

TEST RESULTS

The impact accuracy of the movable deformable barrier in tests with small cars lay within the range of 1 cm. The front structure of the barrier demonstrated good deformation behaviour, with no large undeformed pieces detaching themselves. The deformation pictures of both the vehicles and the barrier front face were very similar in all tests (c.f. Fig. A.1 and A.2 in the Appendix).

Ford Fiesta Tests

Both vehicles suffered severe deformation on the left side, which consisted of a deep intrusion into the A-pillar and wind-screen frame, side door and B-pillar and into the rear third of the wheel house. The deformation at the three measurement planes, seen in Fig. A.3 make this clear.The position of the deformation measurement points given in Fig. A.4, was similar in all tests.

Graphic representation also shows that in these tests the re-producibility of the deformation by the deformable barrier face was very good.

In addition to the known negative effects for the passenger of the deep deformation in the passenger compartment, additional dangers were presented in the form of sharp edges, resulting from the displacement and breakage of interior fittings, e.g. steering wheel, dashboard and seats, and jammed safety belts, hindering escape from the vehicle, see Fig. A.5.

In a further comparison of the behaviour of the vehicles in an impact situation, Fig. A.6 shows the speed progressions of the barrier, the Ford Fiesta and its left side door. The measurement of acceleration at the door was taken approximately in the dummy's thorax impact area. The acceleration measurement in the Fiesta's centre of gravity was faulty in the second test.

A comparison of these curves shows that, with the same test parameters and very similar vehicle damage, different speed changes can be measured at the vehicle door. The reasons why will be given in the chapter below.
The load values measured on the cars are presented in the following Table 1.

VEHICLE LOAD	FORD FIESTA SKW 01	FORD FIESTA SKW 03
a_{max} Barrier (g)	14.2	14.3
$\bar{a}_{(0-50ms)}$ Barrier (g)	7.4	7.1
$\Delta v_{(t=100ms)}$ Barrier (m/s)	7.2	6.7
a_{max} Vehicle (g)	26.8	-*
$\bar{a}_{(0-50ms)}$ Vehicle (g)	12.5	-*
$\Delta v_{(t=100ms)}$ Veh. (m/s)	8.4	-*
a_{max} Door (g)	111.0	171.5
$\bar{a}_{(0-50ms)}$ Door (g)	16.6	10.6
v_{max} Door (m/s)	9.6	12.1

* Transducer failure

Table 1: Vehicle load values in tests with the Ford Fiesta

The different high values measured at the vehicle door could not be clearly explained from EUROSID's movements. Evaluation of the film showed a very similar impact procedure in both tests:

- after approx. 10 ms the B-pillar moved inwards and the door glazing broke.
- after approx. 15 ms the intruding side structure of the driver seat moved right and accelerated the dummy first at the the pelvis.
- after approx. 20 ms thorax impact occurred.
- after 25 ms the driver's seat rest hit the passenger seat rest.
- in the first test, glancing head impact against the roof

and door frame began after 35 ms; in the second test, headimpact against the flexible upper door frame occurred later on(80 ms).
- the dynamic side intrusion was greatest at the B-pillar.

The measured values of dummy load and the protection criteria deduced from these are listed in Table 3.

VW Polo Tests

The behaviour of the vehicles in the crash phase corresponded to that of the Ford Fiesta described earlier.
The damage in the interior (see Fig. A.7) was also the same as in the Ford Fiesta tests. Details, such as a broken door panel (hard cardboard) or a shelf protruding from the dashboard, were different.

The lateral deformation in this vehicle type also extended from the A-pillar to the rear wheel house. The sill area was included in the deformation (see Fig. A.8). Fig. A.9 shows a graphic representation of the measured deformation values. Table 2 presents the measured acceleration values and the values deduced from these. Fig. A.10 shows the behaviour of the colliding vehicles on their velocity changes.

The measured values of the mobile deformable barrier were also very similar in these tests. The top acceleration measurements of the driver door were very different in the test vehicle, but the values deduced from them, $\bar{a}$ and v, are similar in size.

VEHICLE LOAD	VW POLO SKW 04	VW POLO SKW 05
a_{max} Barrier (g)	14.7	15.0
$\bar{a}_{(0-50ms)}$ Barrier (g)	8.0	7.8
$\Delta v_{(t=100ms)}$ Barrier (m/s)	7.4	7.2
a_{max} Vehicle (g)	34.9	-*
$\bar{a}_{(0-50ms)}$ Vehicle (g)	9.6	-*
$\Delta v_{(t=100ms)}$ Veh(m/s)	7.5	-*
a_{max} Door (g)	126.8	200.3
$\bar{a}_{(0-50ms)}$ Door (g)	8.4	10.6
v_{max} Door (m/s)	11.6	12.6

* Transducer failure

Table 2: Vehicle load values in tests with the VW Polo

The acceleration measured in the door of the test vehicle is dependent on the impact of the barrier outside and the dummy inside. Since the outside impact was similar in the tests (see the comparative values of the barrier acceleration in Tab.1 and 2), the different rate of door acceleration in two tests must have been the result of a slight deviation in the dummy's positioning and seat height above the ground. This last parameter was not remeasured in the tests. Despite these clear differences in door acceleration, there were no significant differences in the dummy load (c.f. following Table 3).

DUMMY LOAD PARAMETER	FORD FIESTA SKW 01	FORD FIESTA SKW 03	PROTECTION CRITERIA NHTSA	ERGA-S	VW POLO SKW 04	VW POLO SKW 05
Head						
a_y / a_{y3ms} [g]	70/48	69/54	----	----	40/40	111/56
a_{res}/a_{res3ms} [g]	91/64	82/64	----	----	69/67	121/70
HIC	448	758	----	**1000**	836	474
Thorax						
a_y / a_{y3ms} [g]	93/83	85/75	----	----	76/74	81/78
a_{res}/a_{res3ms} [g]	94/84	87/76	----	----	76/74	82/78
SI	740	744	----	----	698	730
a_{ymax} **RIBS**						
upper [g]	145	126	----	----	103	-**
middle [g]	186	163	----	----	149	135
lower [g]	178	171	----	----	123	154
a_{ymax} **ThV*** [g]	126	117	----	----	108	97
Thoracic Trauma Index (TTI)						
upper rib [g]	131	118	**80-115**	----	101	-**
middle rib [g]	134	121	**80-115**	----	121	99
lower rib [g]	138	132	**80-115**	----	114	112
RIB DEFLECTION						
upper rib [mm]	28.1	35.1	----	**42**	27.4	35.2
middle rib [mm]	30.3	33.5	----	**42**	32.3	27.2
lower rib [mm]	30.4	32.5	----	**42**	30.7	24.1
VISCOUS CRITERION (VC)						
upper rib [m/s]	0.506	0.710	----	**1.0**	0.213	0.390
middle rib [m/s]	0.544	0.632	----	**1.0**	0.429	0.246
lower rib [m/s]	0.644	0.723	----	**1.0**	0.541	0.309
ABDOMEN Force > 4,5 kN	no	no	----	**F≤4,5kN**	no	no
PELVIC			**peak load =**			
a_y / a_{y3ms} [g]	99/91	104/97	**130-190g**	----	107/96	100/93
a_{res}/a_{res3ms} [g]	101/92	107/99		----	107/97	100/94
ilium crest						
left [kN]	1.9	2.7	----	**10.0**	3.3	4.3
right [kN]	0.6	0.6	----	**10.0**	0.9	0.9
pubic symphysis [kN]	7.3	8.1	----	**10.0**	7.0	4.5

* ThV = Thoracic vertebra ** Transducer failure

Table 3: Dummy load parameters in the tests with the small car types.

DISCUSSION OF THE RESULTS

Beside the observance of protection criteria following the EC draft directive other values used for determining the protection criteria are also considered here. The results were also compared to those from tests involving larger vehicles.

Observance of the Protection Criteria

The protection criteria to be measured on EUROSID are as follows:
(Draft Directive ERGA Side Impact Document S 65 Rev. 2a,)

- ***Head Protection Criterion (HPC)***;
  HIC ≤ 1000, this value is only used as a criterion in the case of head contact with a part of the vehicle.
- ***Thorax Protection Criterion***;
  None of EUROSID's three sets of ribs may suffer deflection greater than or equal to 42mm, and the Viscous Criterion based on the chronology of the deflection progress must be ≤ 1.0 m/s.
- ***Protection Criterion for the Abdomen***;
  In this area, the force from an impact must be ≤ 4.5 kN, i.e., the switches with a switching threshold of > 4.5 kN must not respond. At the same time, the maximal crushing must be limited to ≤ 39 mm.
- ***Protection Criterion for the Pelvis***;
  Forces were measured at three points of the pelvis: at the left and right ilium and at the pubic symphysis. Forces must be maximum 10 kN.

The small vehicles tested in this series had more or less similar dimensions and construction characteristics and displayed very similar crash behaviour. In addition to the details mentioned before, the comparison of deformation values shown in Fig. A.11 is an important comparison parameter.

As was expected, the dummy loads resulting from this crash behaviour were very similar, as shown in Table 3. A comparison of the dummy load mean values in both types of small vehicle shows that the Fiesta involves a somewhat higher load in the thorax area. The values for head and pelvis are not diffent.
Unlike the loads on the thorax and pelvis, the head load in the side collision test is highly dependent on the position of the dummy. The position laid down for the test rarely resulted in the head hitting the rigid B-pillar. In the case of the small vehicles tested here, it was generally the glancing impact against the roof which led to notable head acceleration. The dummy kinetics and the relatively late contact meant the impact was no longer as powerful as in the lower parts of the body fixed in the seat.For the higher head load in the second Polo test no reasons would be given by the film analysis. In no test the limit value of the head protection criterion (HIC 1000) was exceeded.

The somewhat higher average thorax load in the Ford Fiesta cannot be related to clear differences in the load values of the vehicles. A comparison of the chronological progress of dummy load in Figs. A.12-15 shows that both the beginning and the duration of the acceleration and force signals are approximately the same. The distances between door and dummy determined by seat position and interior design are also approximately the same, with the distances between door and upper arm and door and pelvis being approx. 20 mm less in the case of the VW Polo. Therefore these differences of thorax load must be explained by the vehicle door construction and/or by the somewhat earlier involvement of the dummy in the deformation in case of the VW Polo. The protection criteria for the thorax (deflection of ≤ 42 mm and VC ≤ 1.0 m/s) were fullfilled in both tests.

Similarly, only small differences between the vehicles were measured for the pelvic load. The sum of the forces affecting the pelvic region was virtually the same in all the tests. Both small vehicle types fulfil the above-named protection criteria, remaining well below the maximum permissible value.

Since the values for the protection criteria have not yet been definitively established, the EUROSID measured values not used for determining the protective criteria up to now in Europe should also be considered here.

Beside the protection criteria of the EC draft directive,the values for the thorax area include the acceleration of the thoracic vertebra, measured in the upper and lower sections, and the acceleration of the ribs. The mean values of rib and lower thoracic vertebra accelerations form the thorax load criterion favoured by the NHTSA, the Thoracic Trauma Index (TTI). If the TTI protection criterion was used to judge the results of these tests, both small vehicle types would exceed the limit value. This value, intended to prevent injuries greater than AIS 3, is quoted in [4] as 80-115 g. If a protection criterion was to be used which only took the resulting thorax acceleration into consideration, e.g. 60 g/3 ms, as in a frontal collision test, this value would also be exceeded, the loads in both vehicle types being greater, with their appropriate values consisting of 74-84 g/3 ms.
For the pelvis the acceleration measured at the centre of gravity may be used as a protection criterion, too. The value of this acceleration was the same in almost all the tests, namely 104 g for the peak acceleration and 95 g for the 3 ms value. In an US proposal [4] a protection criterion is quoted for the pelvis which considers the maximum acceleration. The range of limit values there is given as 130 - 190 g. The pelvis loads in the tested small cars were lower.

Comparison with Larger Vehicles

For comparison with larger cars only two tests with the VW Golf, Typ 19, could used.
Table 4 shows a comparison between the car load values. Here mean values from the tests with small vehicles are compared with the values of two tests with the VW Golf .

VEHICLE LOAD	MEAN VALUES FORD FIESTA TESTS	MEAN VALUES VW POLO TESTS	VW GOLF (Typ19) TEST 1	VW GOLF (Typ19) TEST 2
a_{max} Barrier (g)	14,3	14,9	14,2	15,4
$\bar{a}_{(0-50ms)}$ Barrier (g)	7,3	7,9	9,1	9,3
$\Delta v_{(t=100ms)}$ Barrier (m/s)	7,0	7,3	8,1	8,3
a_{max} CAR (g)	26,8*	34,9*	48,4	30,0
$\bar{a}_{(0-50ms)}$ CAR (g)	12,5	9,6*	8,1	8,8
$\Delta v_{(t=100ms)}$ CAR (m/s)	8,4	7,5*	7,4	7,6
a_{max} DOOR (g)	141,3	163,6	152,2	141,4
$\bar{a}_{(0-50ms)}$ DOOR (g)	13,6	9,5	13,2	12,6
v_{max} DOOR (m/s)	10,9	12,1	12,4	13,6

* Value from one test only

Table 4: Mean vehicle load value (n=2), comparison of small vehicles with the VW Golf (Type 19).

The differences in the values for the barrier load are small. The effects of the different vehicle masses are best deduced from the changes in speed of the barrier. The greatest differences were measured at the door (v_{max} door), although these values still provide no clear picture of the effects of the greater mass.

The lateral deformation of the larger vehicle, the VW Golf, is not very different from that of the smaller vehicles (see the comparison in Fig. A.16).

The driver seat position in the VW Golf interior is almost the same as in the small vehicles, but with more room available between head and roof.
The following Table 5 shows the comparison of the dummy load values for the small vehicles with those of the larger vehicles.

Dummy LOAD PARAMETER	MEAN VALUE FORD FIESTA TESTS	MEAN VALUE VW POLO TESTS	VW GOLF (Typ 19) TEST 1	VW GOLF (Typ 19) TEST 2
HEAD				
a_y / a_{y3ms} [g]	69 / 51	75 / 48	42/40	62/51
a_{res}/a_{res3ms} [g]	86 / 63	67 / 68	57/55	80/75
HIC	603	655	582	566
THORAX				
a_y / a_{y3ms} [g]	89 / 79	78 / 76	102/96	71/68
a_{res}/a_{res3ms} [g]	85 / 80	78 / 76	103/96	72/69
SI	742	714	993	637
a_{ymax} **RIBS**				
upper [g]	135	102	137	116
middle [g]	174	141	136	175
lower [g]	174	138	137	121
lower ThV *				
a_{ymax} [g]	121	102	115	88
Thoracic Trauma Index (*TTI*)				
upper Rib [g]	124,5	100,7	127,6	100,6
middle Rib [g]	127,7	110,1	125,3	115,1
lower Rib [g]	135,0	113,3	105,6	90,5
RIB DEFLECTION				
upper Rib [mm]	31,6	31,3	44,4	45,6
middle Rib [mm]	31,9	29,8	33,5	27,1
lower Rib [mm]	31,5	27,4	24,7	17,6
Viscous Criterion (VC)				
upper Rib [m/s]	0,608	0,301	1,024	0,528
middle Rib [m/s]	0,588	0,338	0,754	0,288
lower Rib [m/s]	0,694	0,425	0,294	0,140
ABDOMEN				
Force > 4,5KN	no	no	no	no
PELVIC				
a_y/a_{y3ms} [g]	101 / 94	103 / 94	105/103	112/ 89
a_{res}/a_{res3ms} [g]	104 / 95	103 / 95	107/104	114/ 90
ilium crest				
left [kN]	2,3	3,8	2,0	2,9
right [kN]	0,6	0,9	0,9	0,6
symphysis pubica [kN]	7,7	5,8	10,1	2,6

* ThV = Thoracic vertebra

Table 5: Mean dummy load values (n=2), comparison of small vehicles with VW Golf (Type 19).

The head load in the VW Golf was somewhat less, which may be due to the greater height of the roof. The differences lie within the height of expected scatter in crash tests.
The thorax and pelvis loads are the same and partly greater. Thus, for example, the deflection of the upper rib in both VW Golf tests was measured as 44 resp. 45 mm, while the relevant protection criterion limit value is 42 mm. The VC variable deduced from the deflection was determined as 1.024 m/s in one test; which is the limit value (1,0 m/s) of the protection criterion.

The force measured on the pubic symphysis in one of the VW Golf tests was 10.1 kN, which also is a value in height of the protection criterion whose limit value here is 10 kN.

The additional accelerations measured in parts of the body (thorax and pelvis) in some cases show a little higher level of acceleration than in the tests with small vehicles.
When discussing the differences in these load values , one has to consider the non-neglectable scatter of the results generally in crash tests.

CONCLUSIONS

Passenger protection in a side collision was investigated in four experiments with small vehicles. The small vehicles were two Ford Fiestas and two VW Polos.

The results of the measurements taken on the vehicles and dummies have been presented, and the damage and load mechanics explained.

As a result of the investigation, it can be stated that the small vehicles selected comply with the specifications of the directive drafted by the ERGA-S working group. This means that, in the event of a side collision where the colliding vehicle (the movable deformable barrier) has a speed of 50 km/h and a collision and impact angle of 90° on the left, these small vehicles offer the driver adequate safety.
The above-named protection criteria were not exceeded; rather, it was shown that all criteria fell considerably below the limit values. The deep lateral intrusions, which will be an additional danger together with the interior damages for the passengers is not part of the directive.

If the many measuring devices available to EUROSID are used to measure the fulfilment of other protection criteria, such as the protection criteria of the TTI or the 3 ms acceleration values for thorax and pelvis which are used as protection criteria in frontal collisions, the load situation in the small vehicles must be given a higher classification.

In the case of the TTI, the mean value from rib and lower thoracic vertebra acceleration was measured as more than 100 g in nearly all the sets of ribs. The limit value, which has not yet been definitively set, is here 80 - 115 g.

The 3 ms acceleration values at around 70-80g for the upper thoracic vertebra, which approximately represent the accelerations in the centre of gravity of the thorax, are somewhat higher than the protection criterion limit value of 60 g in frontal collisions.

The same is true of the pelvic accelerations measured at the centre of gravity, which revealed a high load of approx. 95 g. These differences in the assessment of the load situation, do not result from EUROSID, but from the sort or the level of the protective criterion; the VC in particular seems very low.

In the above experiments, accelerations of approx 95 g (3 ms value in y direction) were measured in the centre of gravity of the pelvis. This value corresponds to forces of 11 - 16 kN, according to considerations of pelvic mass (with or without abdomen mass). At the pelvis, e.g. on the pubic symphysis, forces of only approx. 8 kN were measured, and in some tests considerably less.
These differences are caused by only minor differences in force direction.
As shown by the comparison, the behaviour of small vehicles in a side collision is similar to that of a larger car (VW Golf Typ 19). Nevertheless in the tests with the VW Golf the values of the rib deflection on the upper rib, were 44 and 45 mm i.e. considerably higher than in the tests with the small cars.
The equal performances by the small vehicles in the side impact tests can be explained by the similar driver seat positions, similar behaviour of the vehicle side construction, narrower door entries and lower inertia.

LITERATURE

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[3] Sievert,W.;Pullwitt,E.:
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11th ESV-Conference, Washington, May 1987

[4] Department of Transportation:
Notice of Proposed Rulemaking on Side Impact Protection
Federal Register, Vol. 53, No. 52, Jan. 1988,
Washington D.C.

APPENDIX OF ILLUSTRATIONS AND CHARTS

ME 19 is equal SKW 01

Fig A.1 : Final Position and Deformation Picture in the Tests with a Ford Fiesta

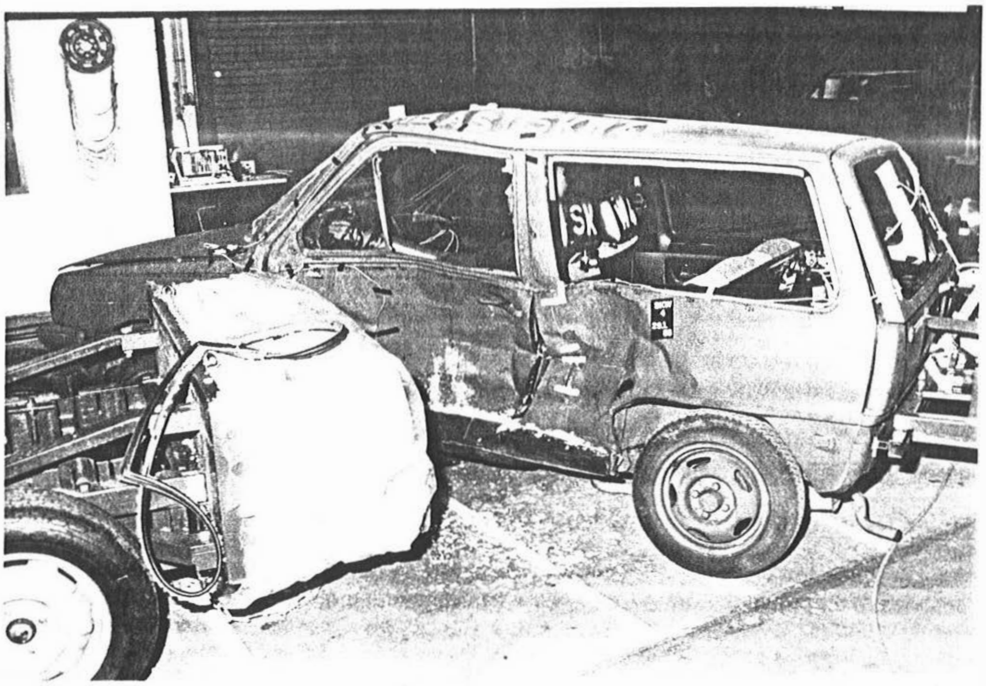


Fig. A.2 : Final Positions and Deformation Picture in the Tests with the VW Polo.

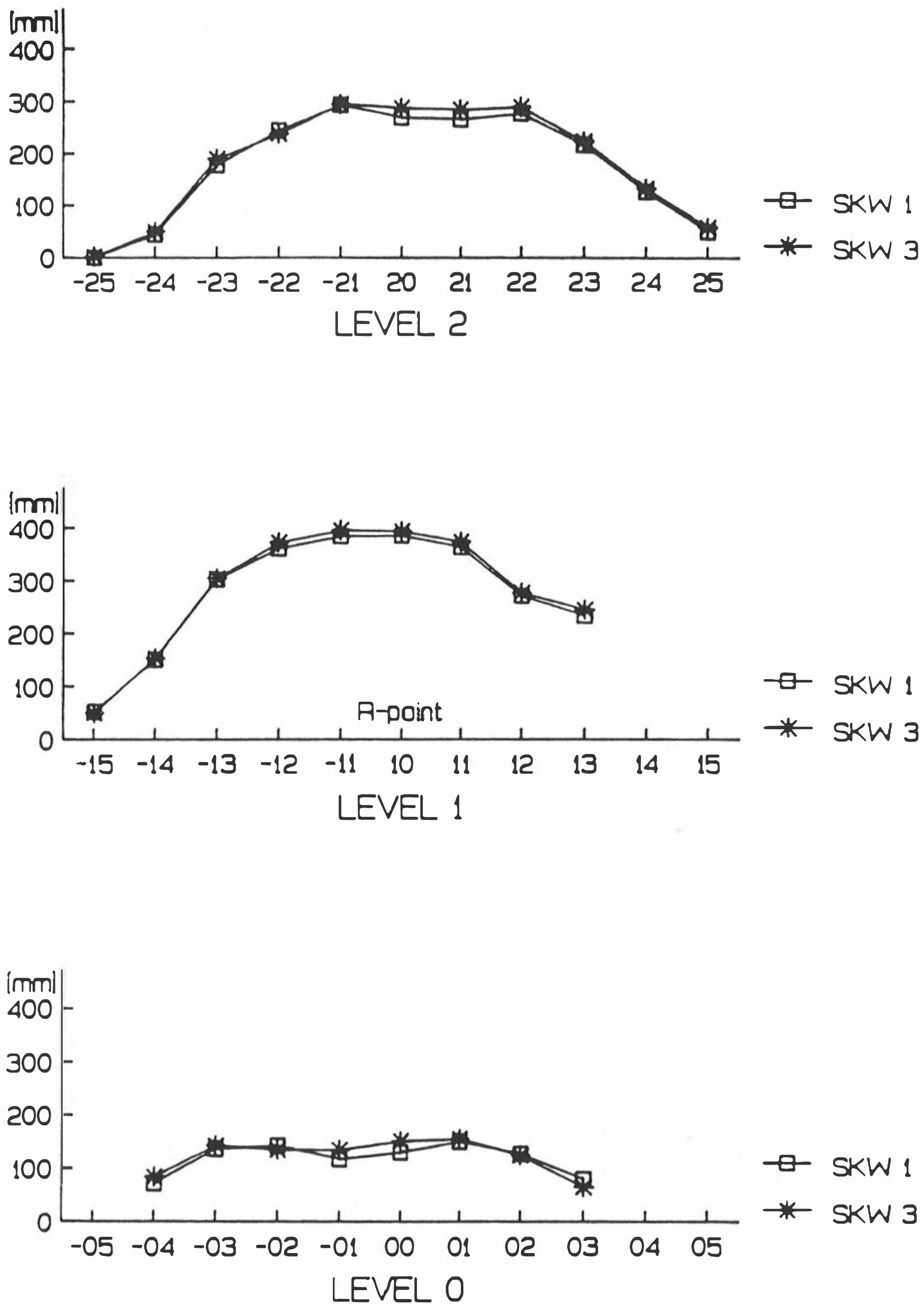
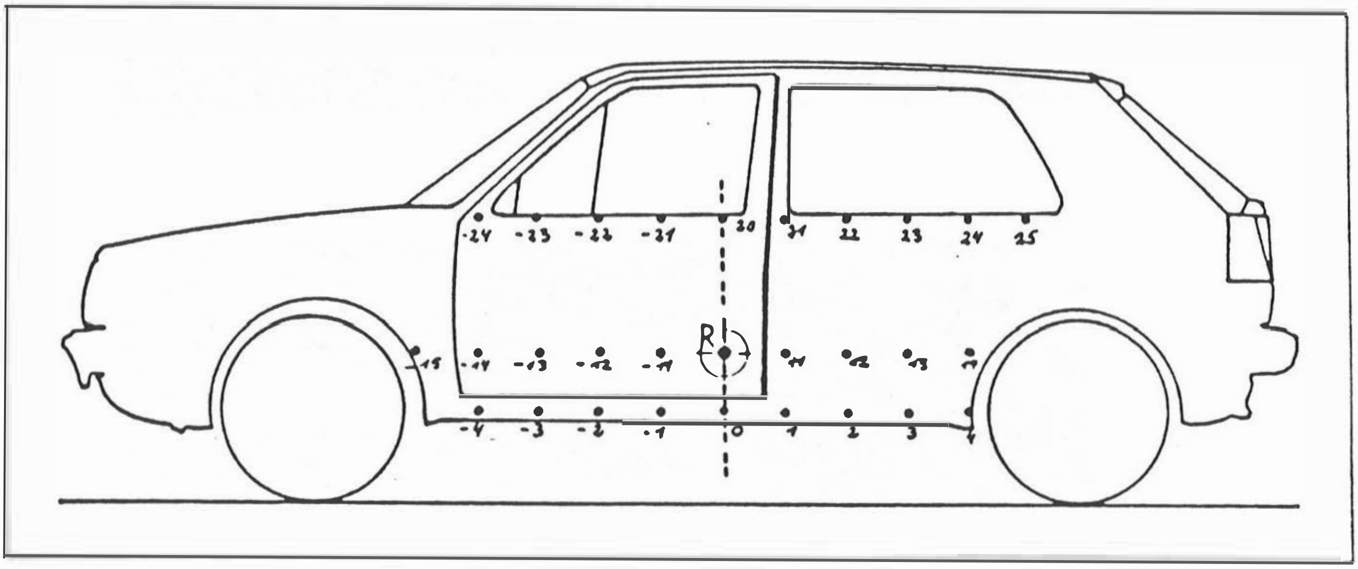
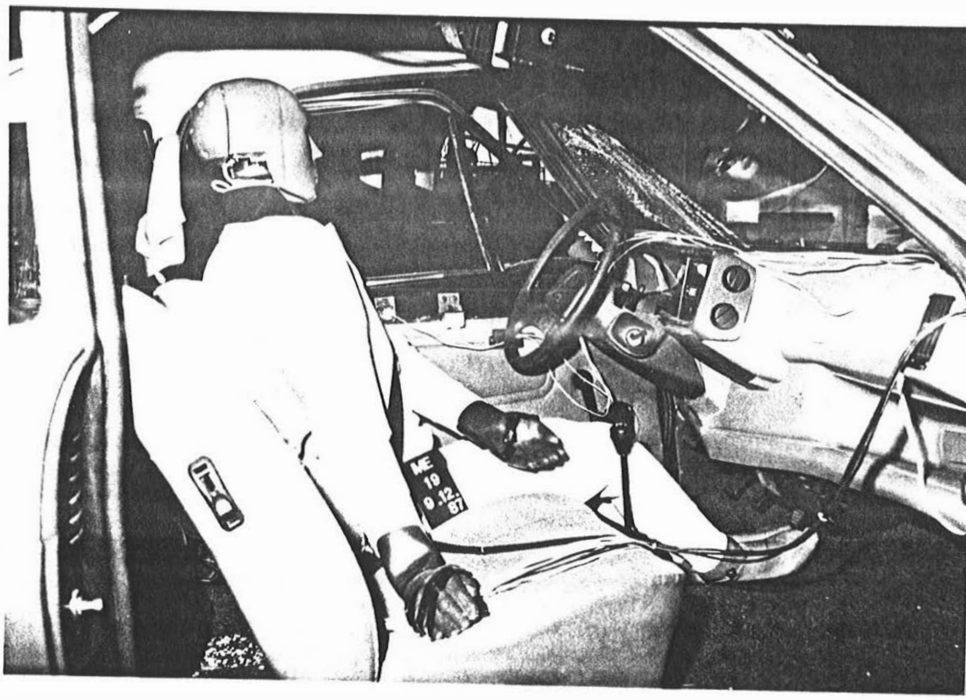


Fig. A.3 : Representation of the Residual Vehicle Deformation in the Three Measuring Planes in the Tests with the Ford Fiesta. Position of the Measuring Points. See Fig. A.4



Horizontal distance between points: 200 mm
Vertical distance between points : dependent on vehicle type

Fig A.4 : Position of the Deformation Measuring Points to Establish Residual Lateral Deformation



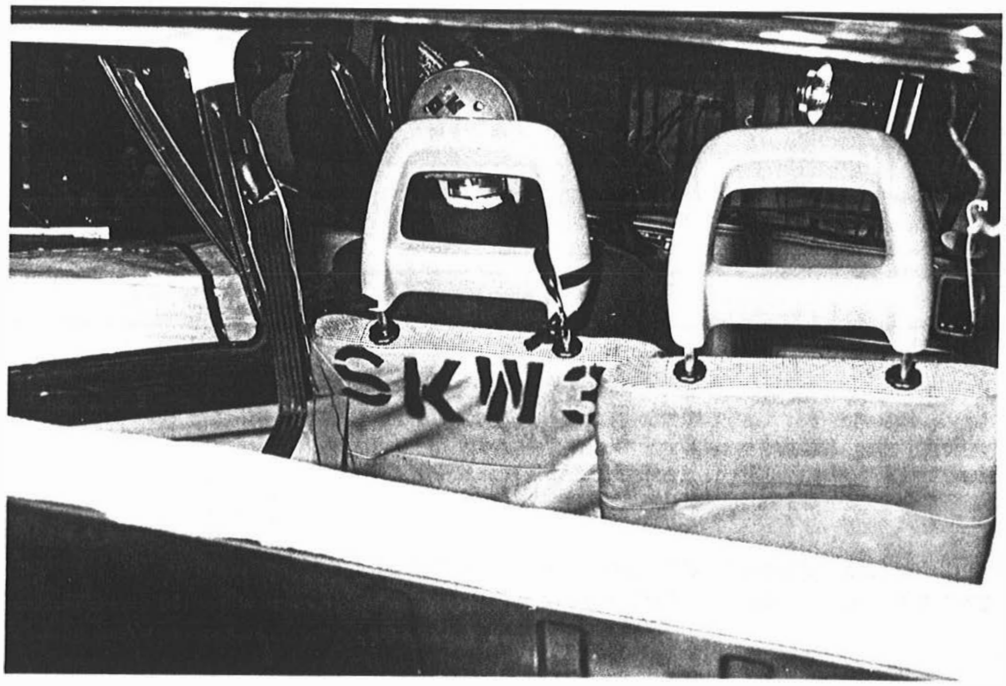


Fig. A.5 : Interior after Impact in Ford Fiesta Tests

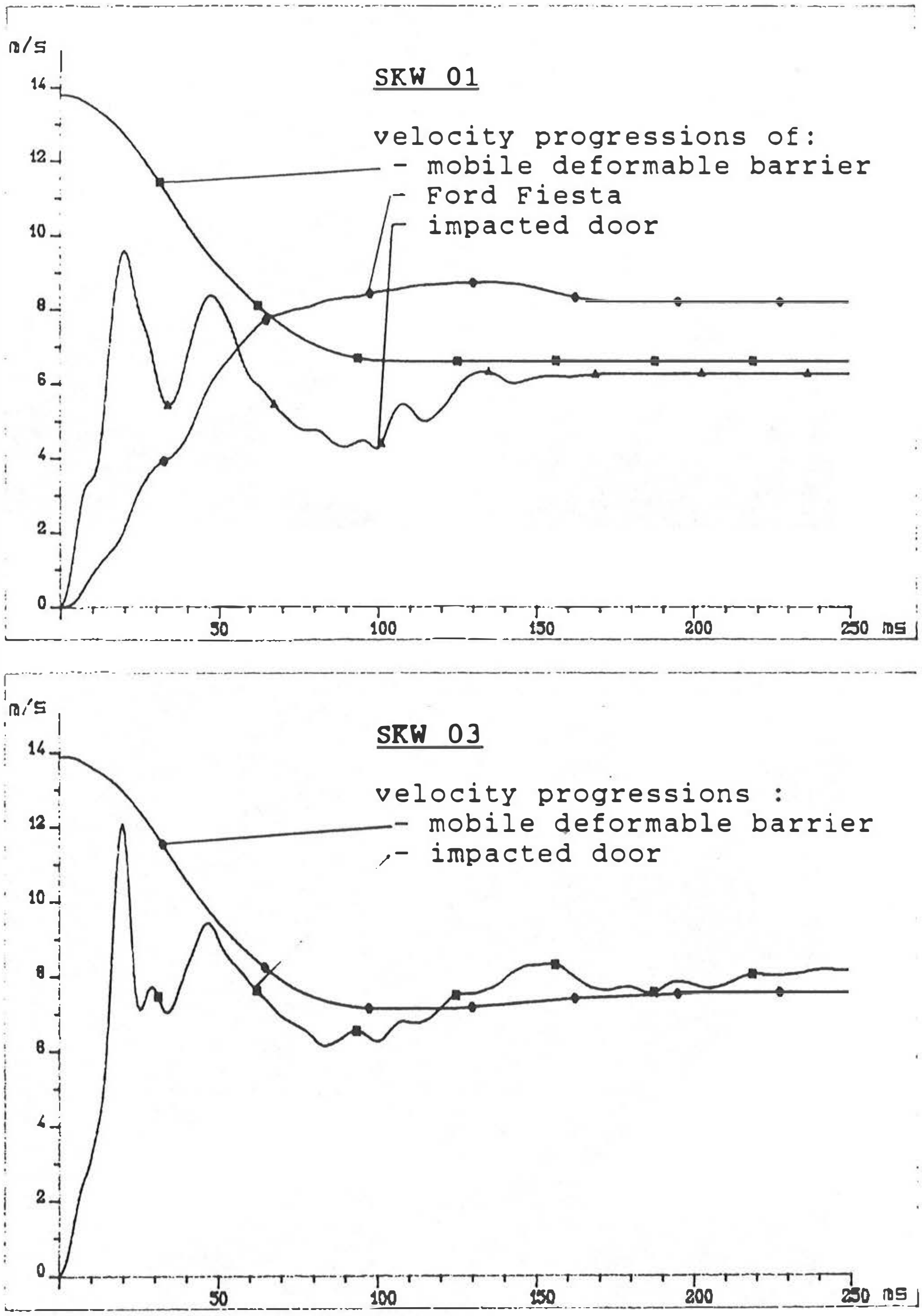


Fig. A.6 : Behaviour of the Vehicles (Ford Fiesta/m.d.b.) during Impact, Represented by the Velocity Progressions of the Vehicles and Vehicle Door

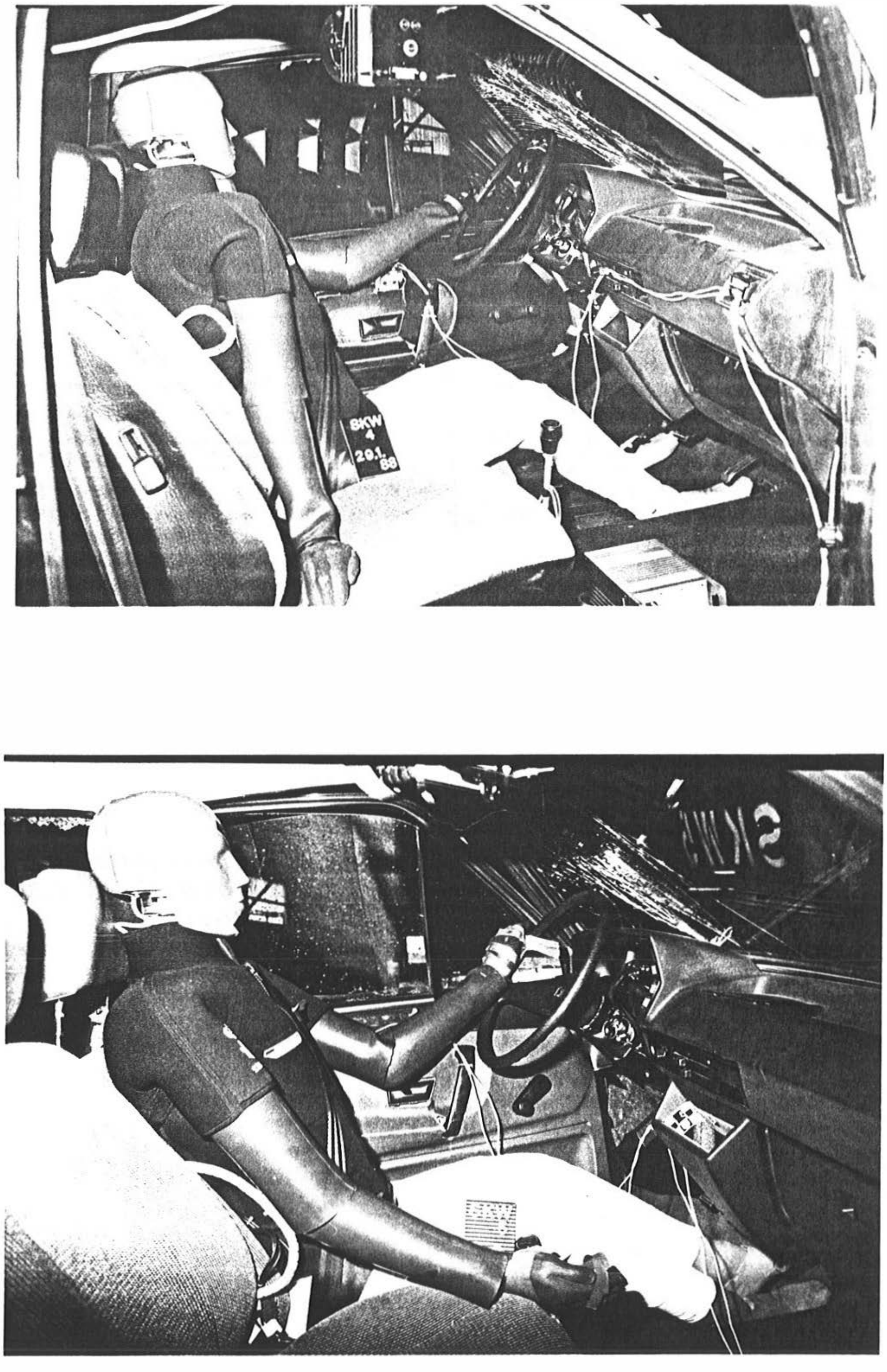


Fig. A.7 : Interior of the VW Polo after Impact.

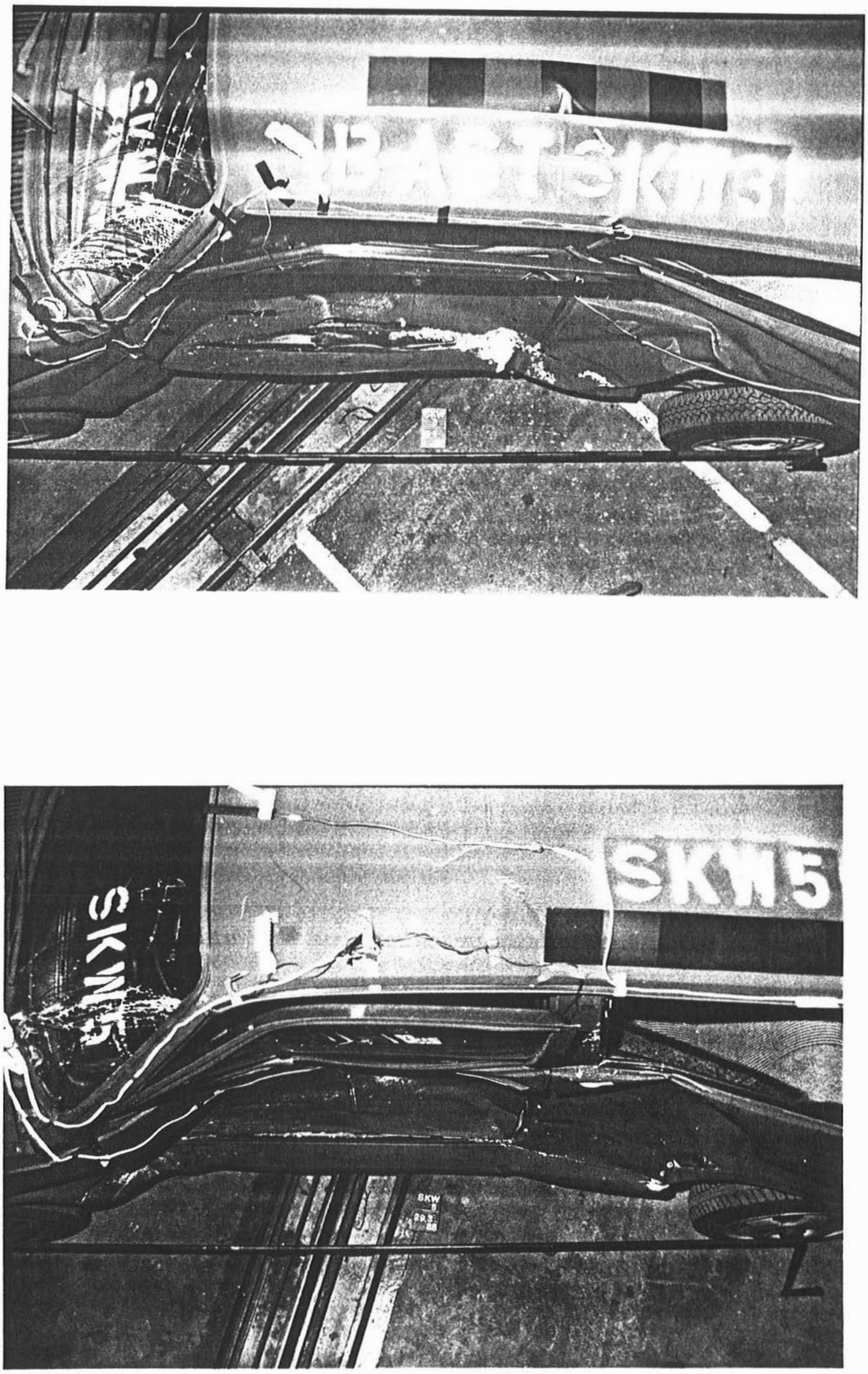


Fig. A.8 : Deformation in the Sill Area - Ford Fiesta (above) and VW Polo (below).

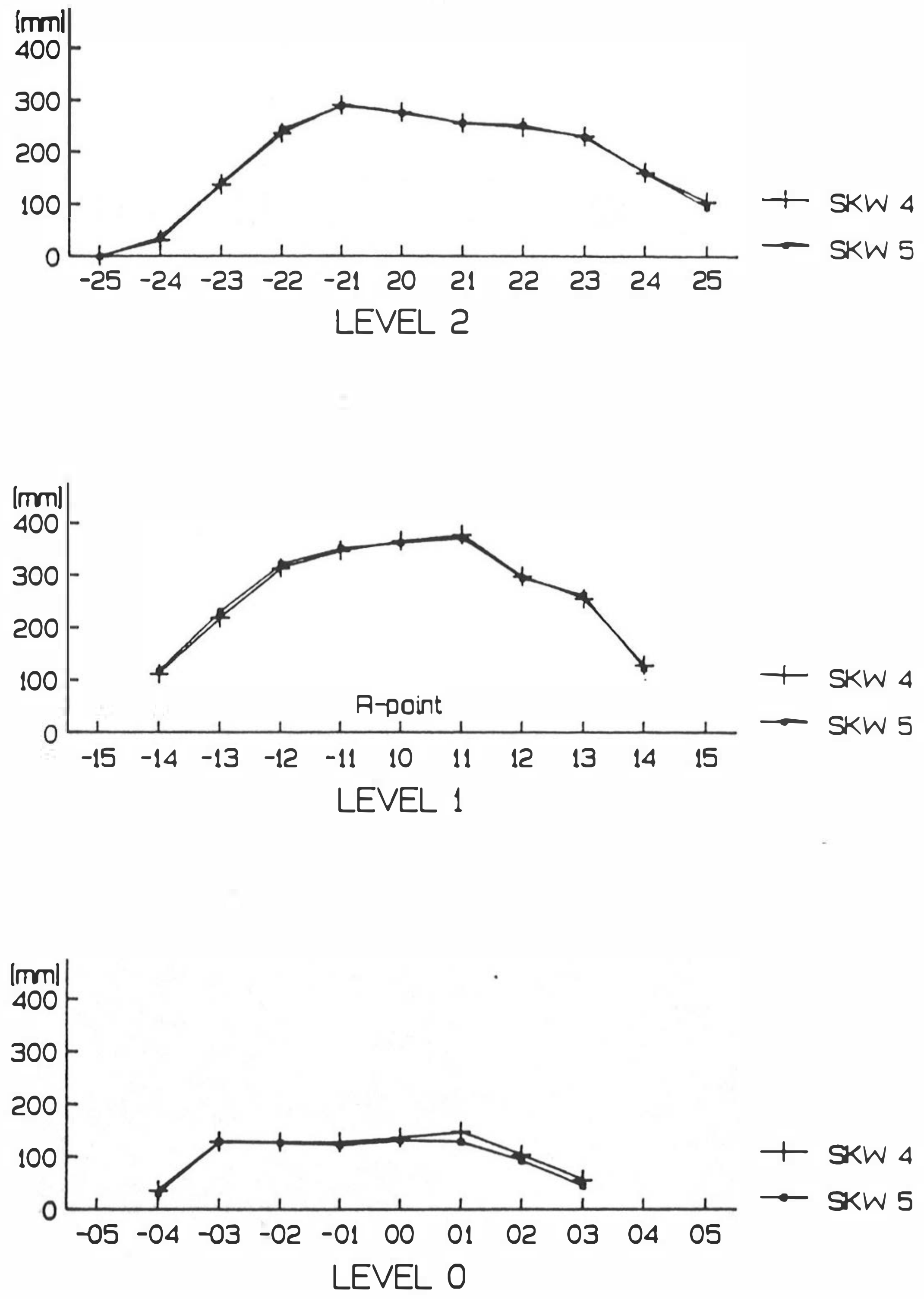
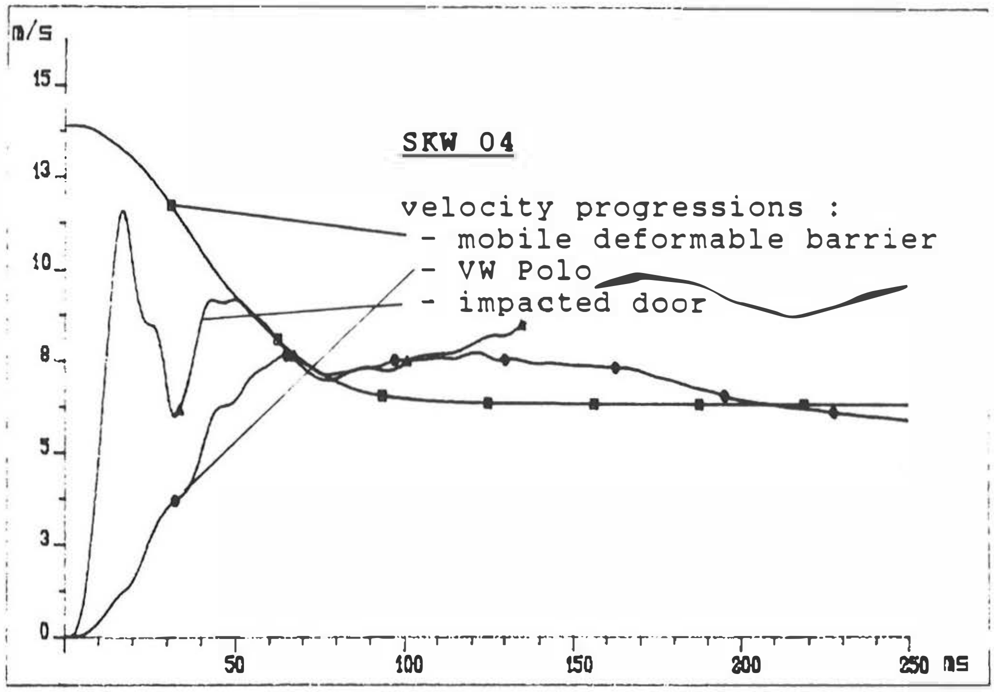


Fig. A.9 : Representation of the Residual Vehicle Deformation in the three Measuring Planes in the Two Tests with the VW Polo. Position of the Measuring Points. See Fig. A.4



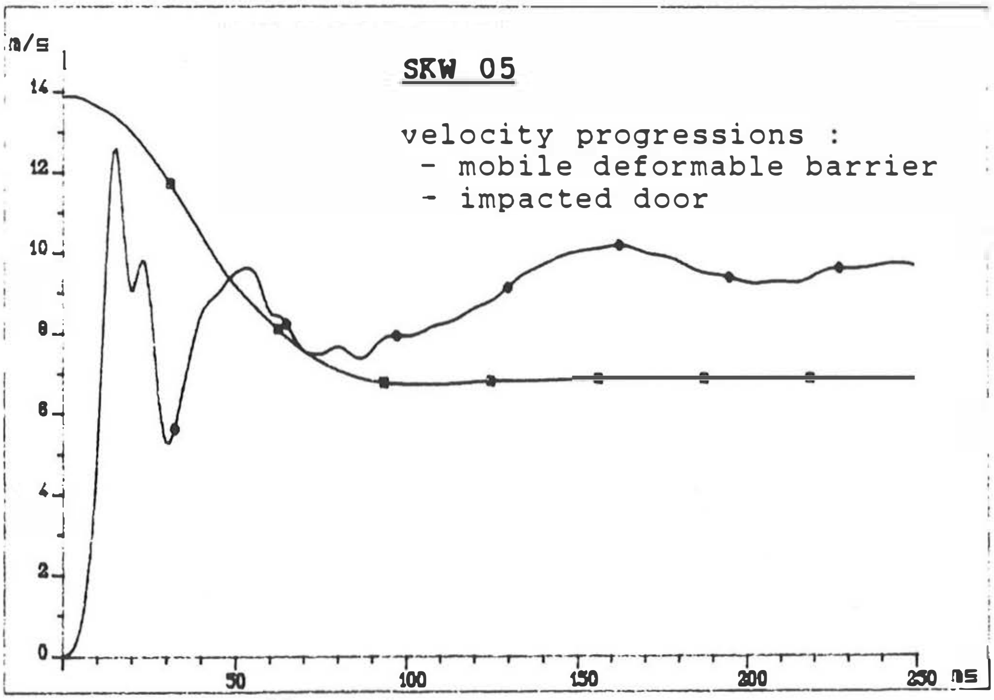
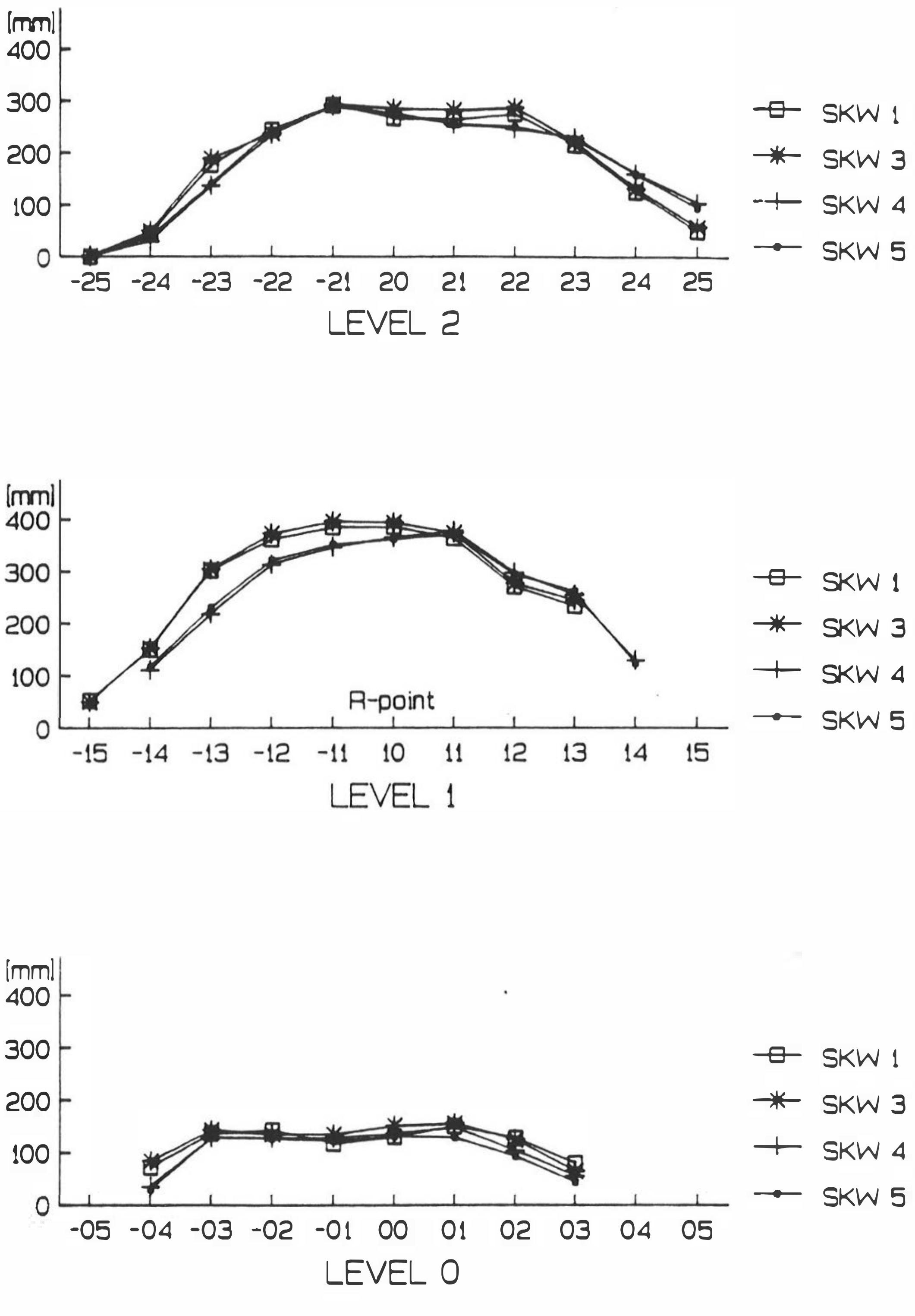


Fig. A.10 : Behaviour of the Vehicles (VW Polo/ m.d.b.) during Impact, Represented by the Velocity Progressions.



<u>Fig. A.11:</u> Representation of the Residual Vehicle Deformation in the three Measuring Planes of Both Small Vehicle Types. Position of the Measuring Points, See Fig A.4.

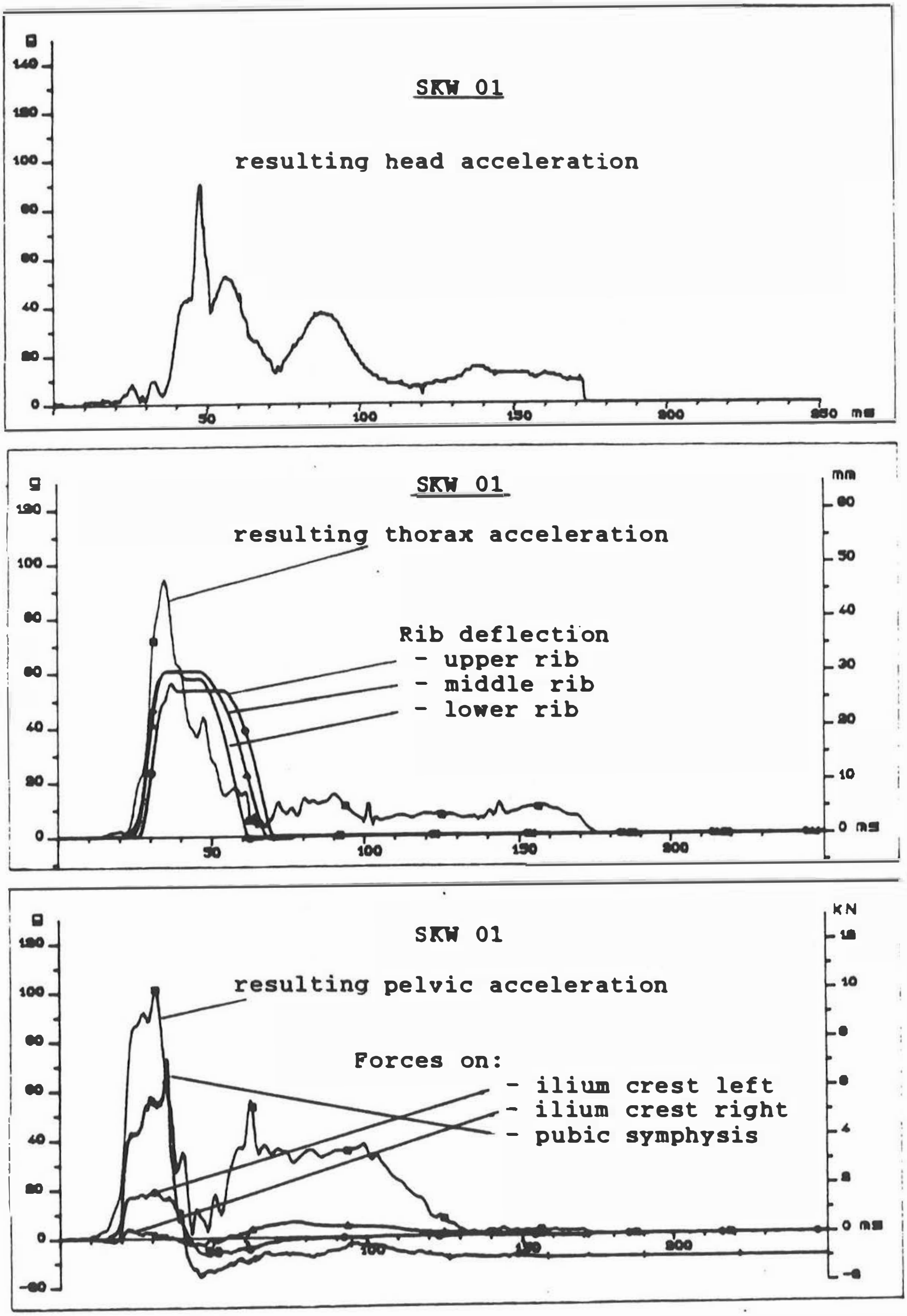


Fig. A.12 : Loads Measured on EUROSID during the Side Collision of a Fiesta with an EEVC Barrier

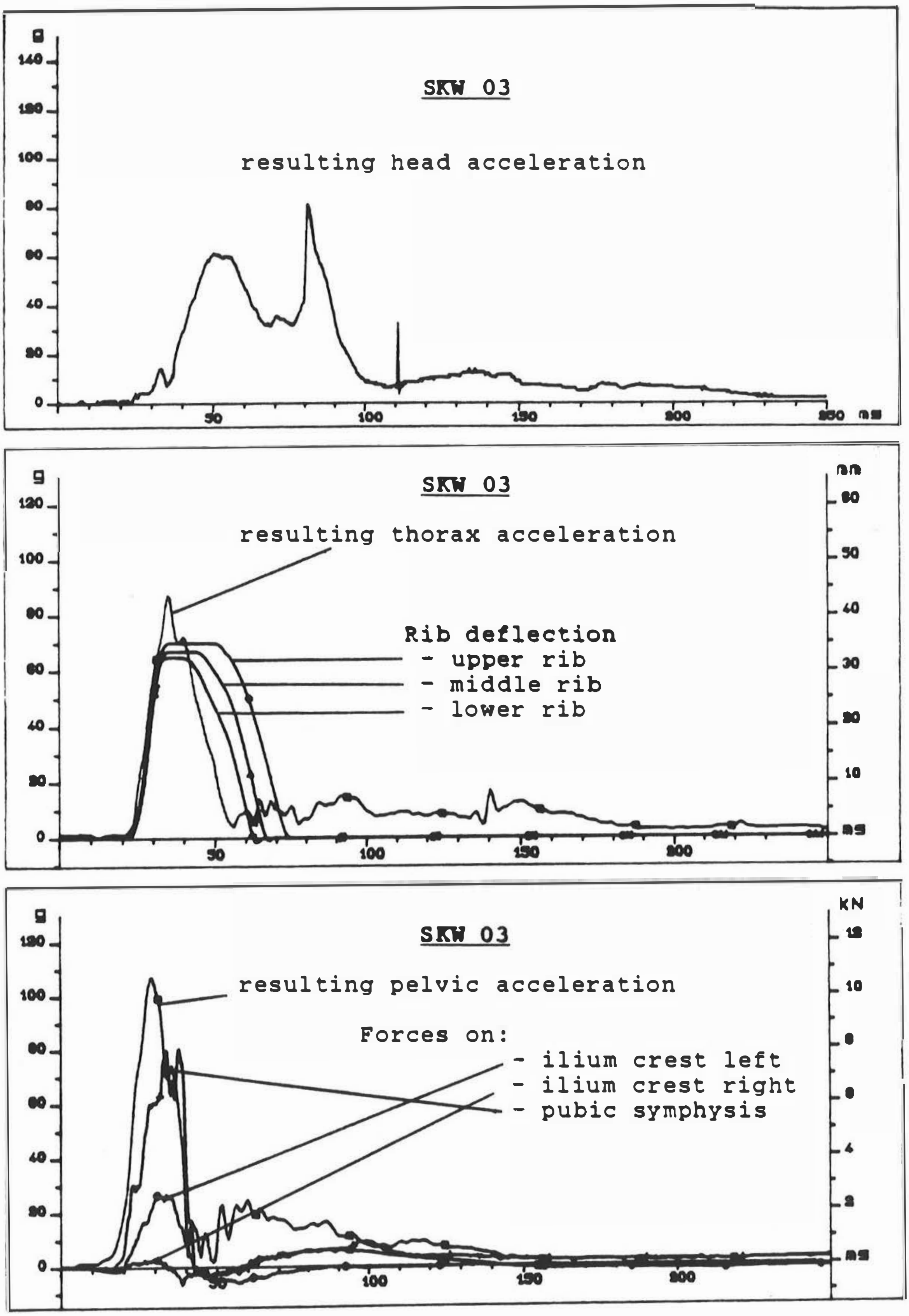


Fig. A.13 : Loads Measured on EUROSID during the Side Collision of a Fiesta with an EEVC Barrier

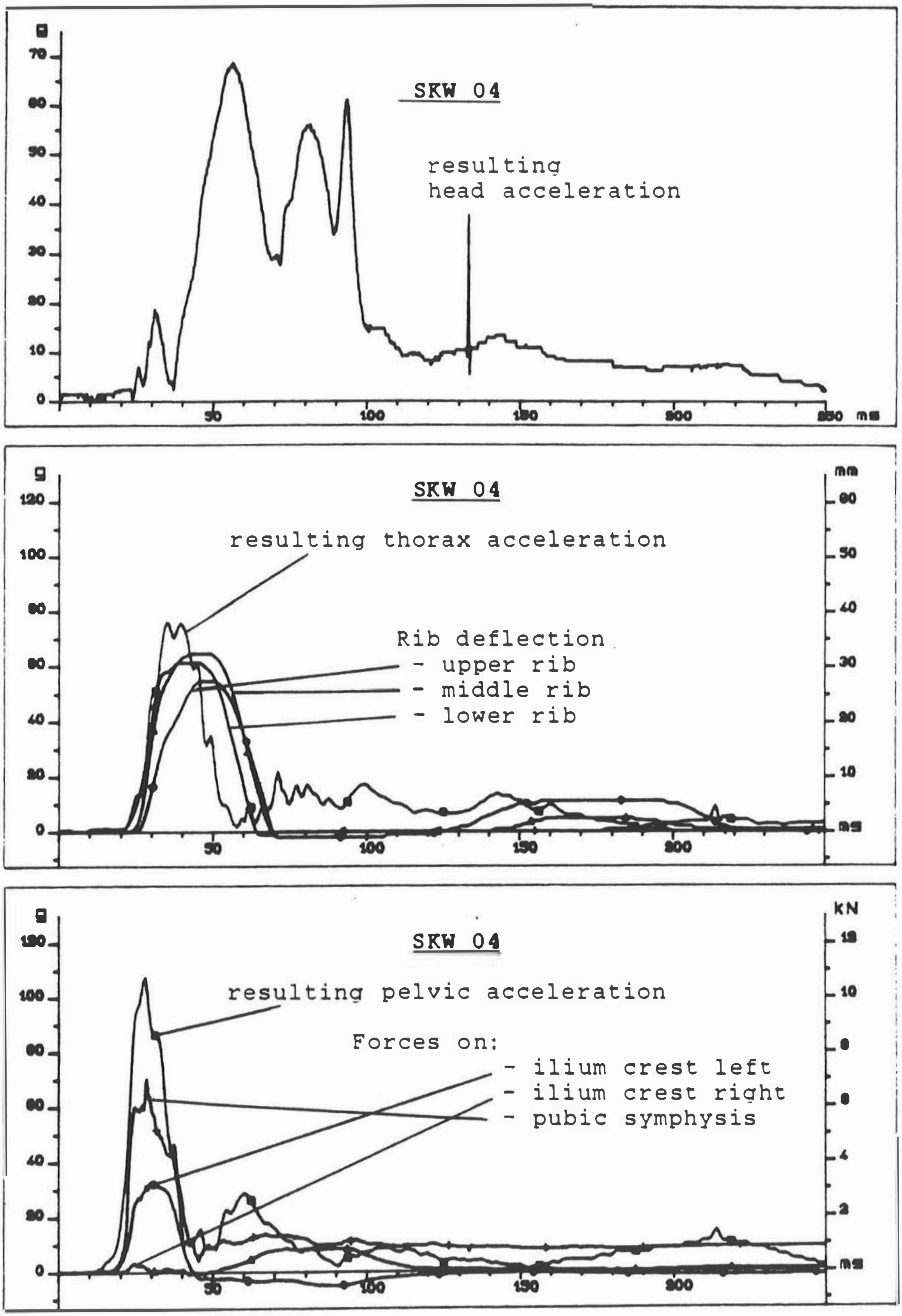


Fig. A.14 : Loads Measured on EUROSID during the Side Collision of a VW Polo with an EEVC Barrier

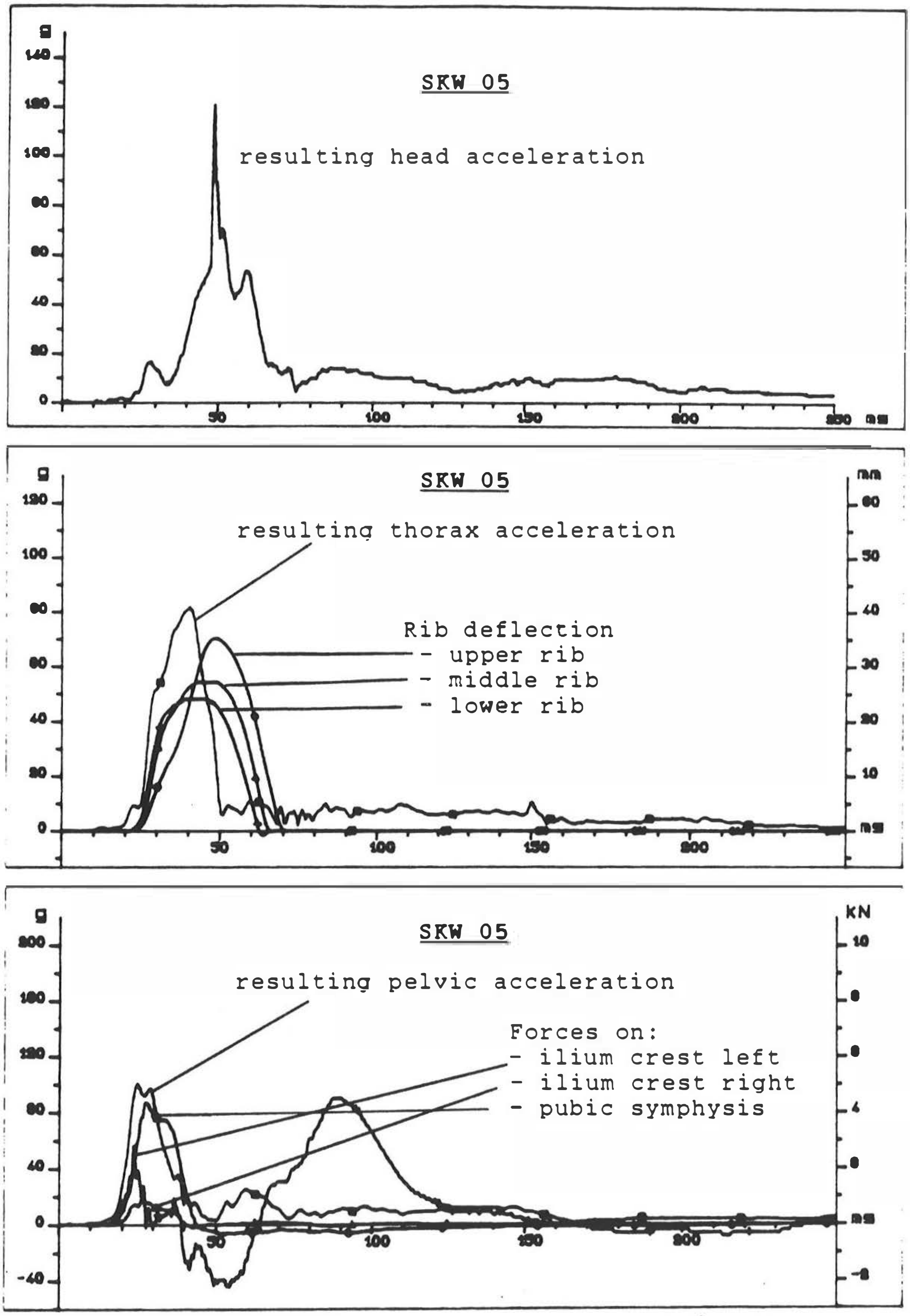


Fig. A.15: Loads Measured on EUROSID during the Side Collision of a VW Polo with an EEVC Barrier

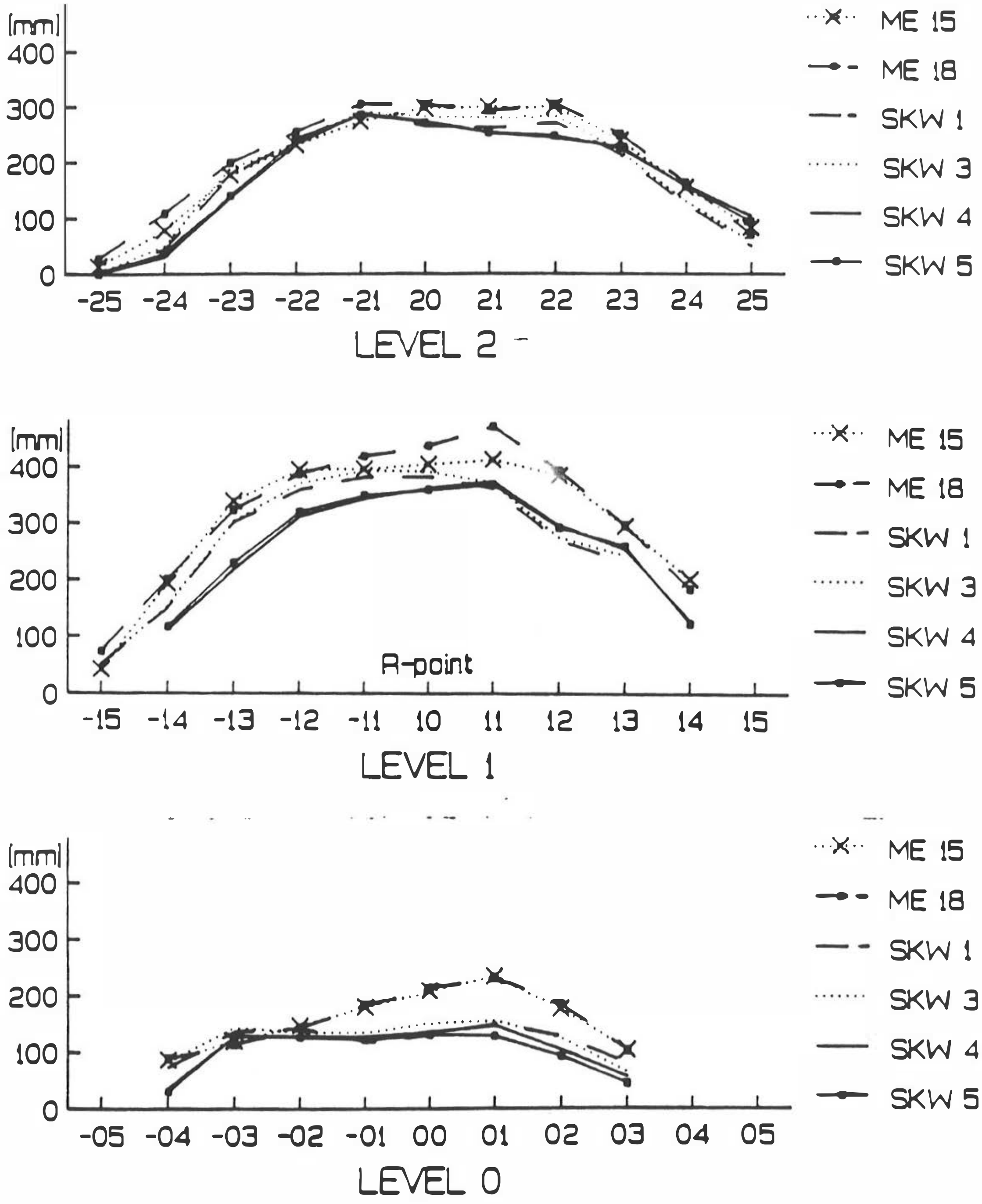


Fig. A.16 : Representation of the Remaining Vehicle Deformation inthe Three Measuring Planes in Comparison Between the Small Vehicles and the VW Golf.