DIFFERENCES BETWEEN THE KINEMATICS AND LOADINGS OF IMPACTED ADULTS AND CHILDREN; RESULTS FROM DUMMY TESTS

by

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1. Introduction

Pedestrian Protection is one of the most important areas in the field of passenger car safety. Extensive research programmes are under way, performed by car manufacturers and research institutes. The simulation scheme (Fig. 1) indicates the variety of problems which have to be solved. Mathematical and experimental simulations of car-to-pedestrian collisions, for example, clearly show that it is very difficult to find car related measures which are beneficial for all pedestrians independent from their anthropometry. In [1] Volkswagenwerk AG presented results from experimental simulations of car to pedestrian collisions with VW-production cars and a 50 percentile male dummy.

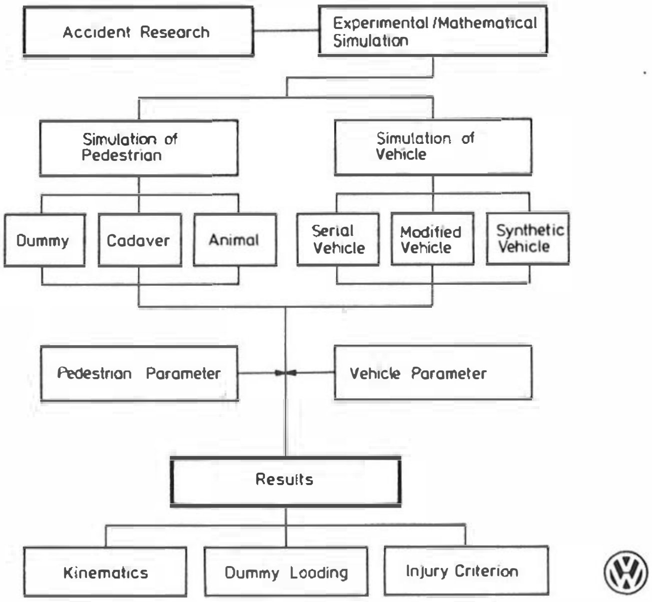


Fig. 1 Various Ways of Simulating Vehicle-to-Pedestrian Collisions

This paper is an follow -up study and presents results from similar tests with a 6 year old child dummy. These results will be compared with those from the tests described in [1] .

2. Test procedure

The experimental simulations of car-to-pedestrian collisions with VW production cars, e.g. VW-Golf and VW-Passat were described in [1] . The procedure was described elsewhere. Figure 2 gives an overview of the experiment set up.

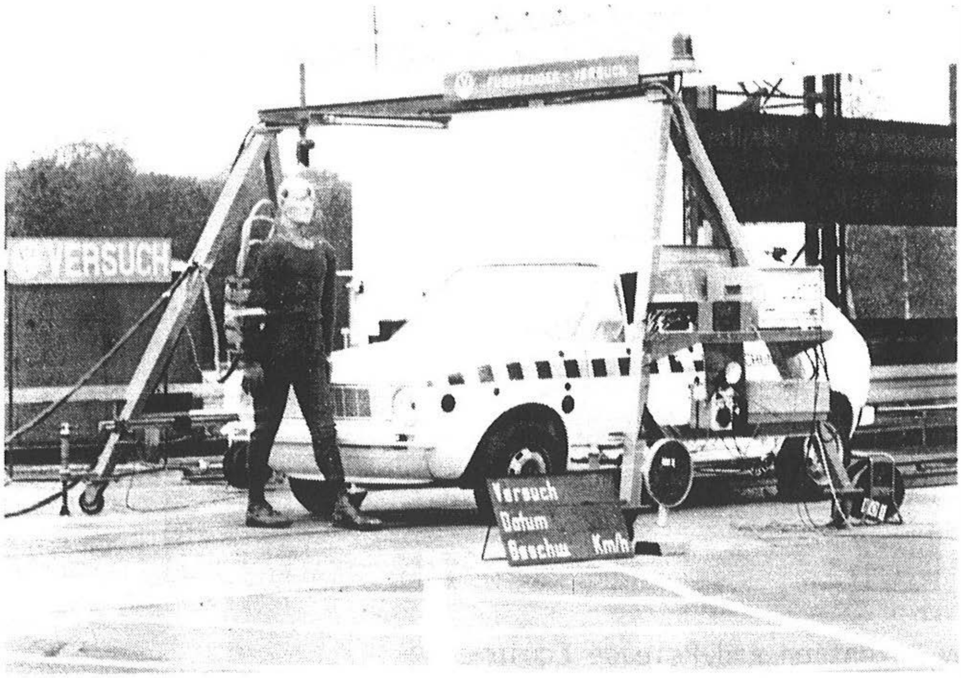


Fig. 2 Equipment Used for Simulating Vehicle-to-Pedestrian Collisions

The tests described in [1] were performed with a 50 percentile male dummy of the type Alderson VIP 50 A.

The comparative tests with the child dummy were performed by order of Volkswagenwerk AG at the Technical University of Berlin - Institute of Vehicle Technology. The test procedure was identical to that which was used by Volkswagenwerk AG for the tests with the adult dummy. The 6 years old child dummy Humanoid 572 -6c was used.

The main components of the experimental stage (see Fig. 2) are described shortly.

2.1 Dummy Retention and Release Equipment

As can be seen from Fig. 1 the vehicle is made to collide with an upright dummy. For this purpose, we developed a device which will hold the dummy upright in a standing position. When a test is made, the equipment will release the dummy smoothly enough to ensure that the experiment is not adversely affected by any restraining forces.

As soon as the vehicle used for the experiment passes a laser light barrier, a retaining bolt is withdrawn by a solenoid from a wire loop connected to the dummy.

Fig. 3 shows the equipment used for retaining and releasing the dummy.

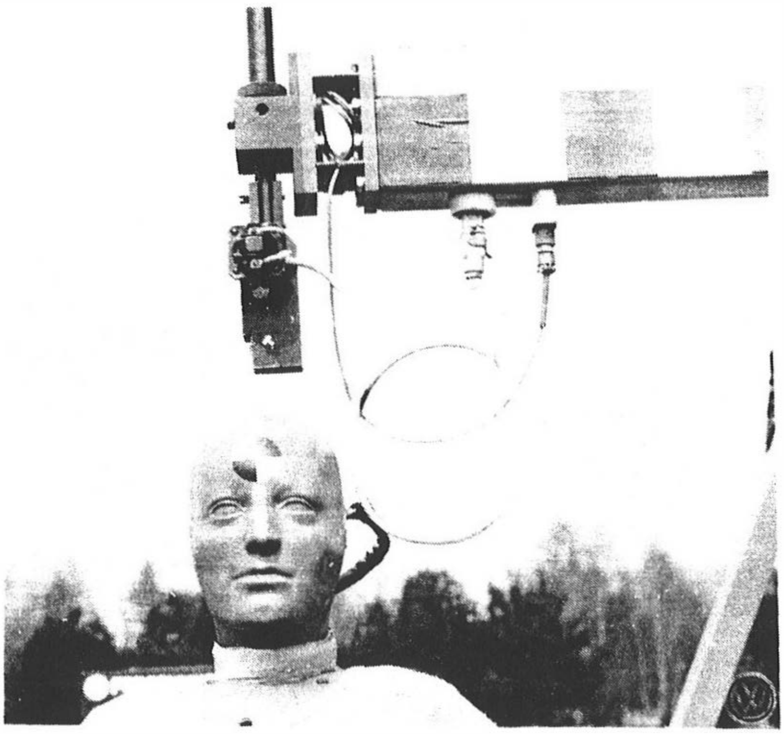


Fig. 3 Dummy Retention and Release Equipment

2.2 Equipment used to Determine the Weight of the Suspended Dummy

The device described under 2.1 is attached to a beam clamped down at one end. This beam is fitted with strain gauges connected to a calibrated monitoring device which indicates the force which causes the beam to bend under the load of the suspended dummy. In this way, it is possible to adjust the load of the suspended dummy to exactly the same amount for all experiments, thus ensuring that the friction between the shoes of the dummy and the road is approximately the same in all experiments. Fig. 3 shows the flexible beam used to determine the weight of the suspended dummy.

2.3 Test Vehicles

Various ways in which vehicle-to-pedestrian collisions may be investigated systematically by mathematical and/or experimental simulation on the basis of accident research data were described in detail in [2] .

This includes the description of various ways in which the car can be simulated. As mentioned above, for this study the production cars:

- VW - Golf and
- VW - Passat

were used.

2.4 Dummy

For this study two types of dummy were used:

- 50 % male dummy Alderson VIP 50 A and
- 6 year old child dummy Humanoid 572 -6c.

2.5 Brake Activating Device

As soon as the vehicle makes contact with the dummy an automatic device activates its brakes.

A photograph of this device is shown in Fig. 4. The device is triggered as soon as the vehicle passes a laser light barrier.

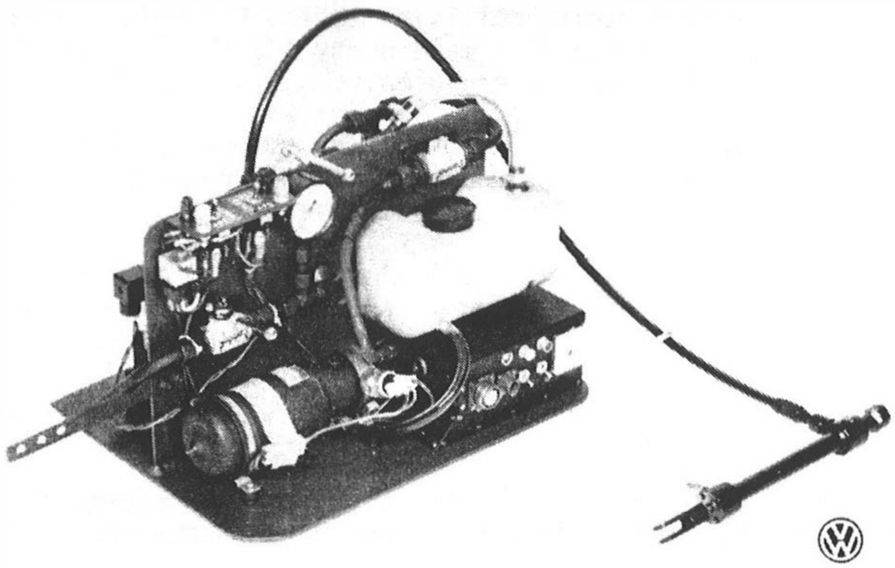


Fig. 4 Device Activating the Brakes of the Vehicle

2.6 Monitoring and Control Unit

At all stages, experiments are centrally controlled and monitored by an electronic unit developed specifically for this purpose.

3. Test Program

Any purposeful experiment program must be based on accident research findings. In accordance with the goal of this study the following parameters for the experiments were determined on the basis of [3] :

Impact Speed	:	35 and 50 km/h
Impact Point	:	Vehicle front centre
Pedestrian Position	:	The 90^{o}-position (walking straight ahead) was chosen for the test programme (Fig. 2).
Pedestrian Anthropometry	:	Accident statistics show that dummies of different sizes (child and adult) must be used for vehicle-to-pedestrian collision tests. For this special program the 50 % male dummy and the 6 years old child dummy were chosen.
Number of Tests	:	The tests with the adult dummy were performed four times for each parameter combination with the VW-Golf and the VW-Passat. The tests with the child dummy were performed 5 times for the impact speed of 35 km/h with both cars and 4 times for the impact speed of 50 km/h with the VW-Golf and twice with the VW-Passat.

4. Results

The results obtained from experiments simulating a vehicle-to-pedestrian collision can be broken down into load data pertaining to the dummy and kinematic data.

The following tables and figures present the results of the tests.

The numeric results are presented in the following tables:

Table 1: Tests with the 50 % male dummy and the VW-Golf

Table 2: Tests with the 6 years old child dummy and the VW-Golf

Table 3: Tests with the 50 % male dummy and the VW-Passat

Table 4: Tests with the 6 years old child dummy and the VW-Passat

Impact Speed (km/h)	Throwing Distance (m)	Max. Res. Accel. of the Head -Primary Impact- (g)	Max. Res. Accel. of the Head -Secondary Impact- (g)	H I C -Primary Impact-	H I C -Secondary Impact-	Max. Res. Accel. of the Chest -Primary Impact- (g)	Max. Res. Accel. of the Chest -Secondary Impact- (g)	S I -Primary Impact-	S I -Secondary Impact-	Max. Res. Accel. of the Pelvis -Primary Impact- (g)	Max. Res. Accel. of the Pelvis -Secondary Impact- (g)
34,9	9,0	38	50	244	66	17	40	49	59	44	61
35,2	9,5	52	96	367	155	29	67	103	144	45	95
34,6	8,5	42	116	203	299	18	26	45	38	48	43
34,0	9,0	34	120	234	323	50	53	108	108	18	21
50,7	15,4	120	52	1877	195	41	85	219	219	58	202
49,9	16,0	110	152	1916	884	31	32	68	68	28	20
50,1	15,5	90	158	1654	958	51	63	211	211	39	47
50,5	16,0	124	98	1688	191	33	147	639	639	66	82

Table 1: Tests with the 50 % male dummy and the VW-Golf

Impact Speed (km/h)	Throwing Distance (m)	Max. Res. Accel. of the Head -Primary Impact- (g)	Max. Res. Accel. of the Head -Secondary Impact- (g)	H I C -Primary Impact-	H I C -Secondary Impact-	Max. Res. Accel. of the Chest -Primary Impact- (g)	Max. Res. Accel. of the Chest -Secondary Impact- (g)	S I -Primary Impact-	S I -Secondary Impact-	Max. Res. Accel. of the Pelvis -Primary Impact- (g)	Max. Res. Accel. of the Pelvis -Secondary Impact- (g)
35,1	11,5	146	214	461	1355	43	17	210	299	143	40
35,1	11,3	89	181	342	757	45	56	225	94	102	39
35,2	11,3	43	186	199	867	57	30	312	48	152	76
35,2	11,2	63	232	230	1501	50	63	299	188	115	72
35,1	11,5	67	63	264	100	51	35	277	55	130	80
50,2	21,0	106	175	1250	506	87	54	897	107	157	125
50,2	19,0	151	262	1185	2118	100	133	866	505	115	73
49,9	21,0	116	244	1366	1501	129	68	1220	168	155	91
50,1	20,8	219	91	2003	197	72	78	661	229	172	99

Table 2: Tests with the 6 years old child dummy and the VW-Golf

Impact Speed (km/h)	Throwing Distance (m)	Max. Res. Accel. of the Head -Primary Impact- (g)	Max. Res. Accel. of the Head -Secondary Impact- (g)	HIC -Primary Impact-	HIC -Secondary Impact-	Max. Res. Accel. of the Chest -Primary Impact- (g)	Max. Res. Accel. of the Chest -Secondary Impact- (g)	SI -Primary Impact-	SI -Secondary Impact-	Max. Res. Accel. of the Pelvis -Primary Impact- (g)	Max. Res. Accel. of the Pelvis -Secondary Impact- (g)
35,9	8,3	80	56	380	87	27	40	85	75	77	63
35,3	9,0	55	94	367	185	26	17	71	28	73	47
35,2	9,9	37	93	246	382	18	29	51	39	65	56
35,0	9,3	68	106	350	205	22	24	50	29	77	82
51,6	17,9	91	141	1572	1203	39	77	217	190	86	65
50,2	18,9	82	43	1405	147	36	90	218	212	101	27
50,2	16,8	96	20	1164	31	40	21	201	31	68	162
50,1	17,0	105	58	1653	643	28	54	89	179	100	34

Table 3: Tests with the 50 % male dummy and the VW-Passat

Impact Speed (km/h)	Throwing Distance (m)	Max. Res. Accel. of the Head –Primary Impact– (g)	Max. Res. Accel. of the Head –Secondary Impact– (g)	HIC –Primary Impact–	HIC –Secondary Impact–	Max. Res. Accel. of the Chest –Primary Impact– (g)	Max. Res. Accel. of the Chest –Secondary Impact– (g)	SI –Primary Impact–	SI –Secondary Impact–	Max. Res. Accel. of the Pelvis –Primary Impact– (g)	Max. Res. Accel. of the Pelvis –Secondary Impact– (g)
34,3	11,5	111	308	424	2880	55	40	283	104	166	65
35,5	10,5	226	111	1630	220	55	17	389	17	132	32
35,1	13,0	278	255	2621	1926	57	32	335	87	117	111
35,4	12,0	72	269	274	1592	63	38	354	100	113	83
34,8	11,4	62	290	306	2277	59	31	342	70	124	95
50,0	20,8	238	255	1694	1094	84	58	693	153	161	43
49,9	19,9	220	202	1607	1275	74	39	521	64	144	94

Table 4: Tests with the 6 years old child dummy and the VW-Passat

Figures 5 to 8 show the movement of the head relative to the car:

Figure 5: 50 % male dummy and VW-Golf

Figure 6: 6 years old child dummy and VW-Golf

Figure 7: 50 % male dummy and VW-Passat

Figure 8: 6 years old child dummy and VW-Passat

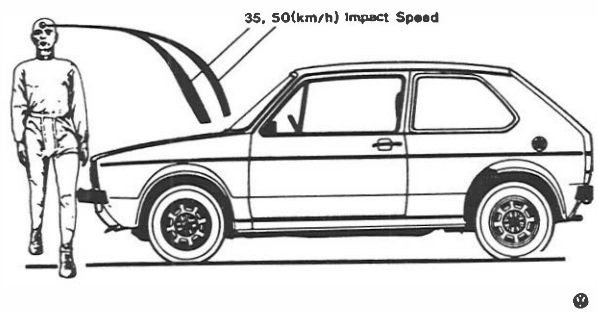


Figure 5 Movement of the head relative to the car (50 % Male Dummy and VW-Golf)

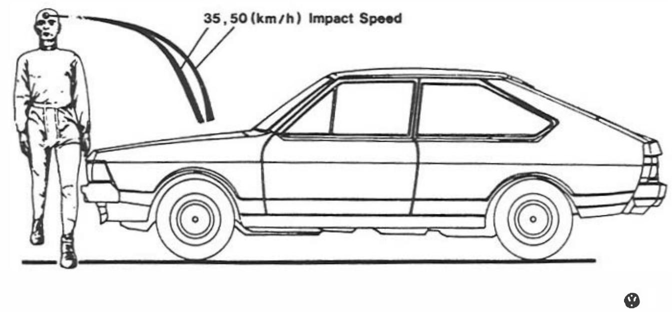


Figure 7 Movement of the head relative to the car (50 % Male Dummy and VW-Passat)

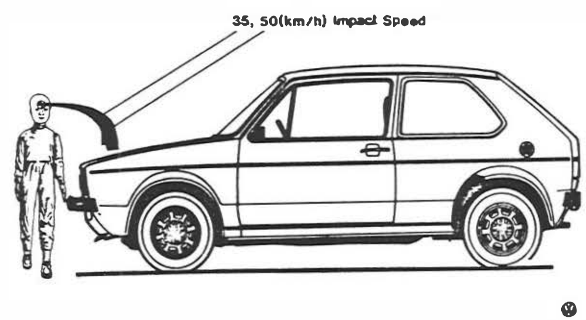


Figure 6 Movement of the head relative to the car (6 years old Child Dummy and VW-Golf)

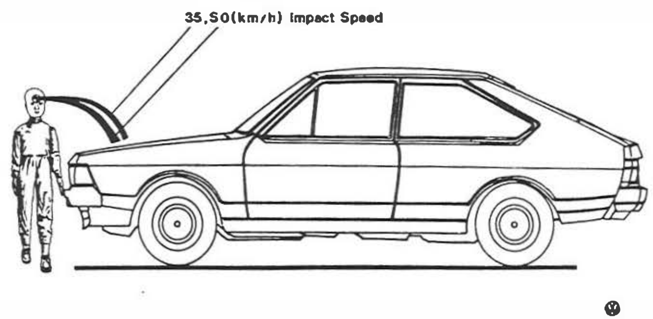


Figure 8 Movement of the head relative to the car (6 years old Child Dummy and VW-Passat)

Figures 9 to 12 show the impact points of the dummy's head against the hood.

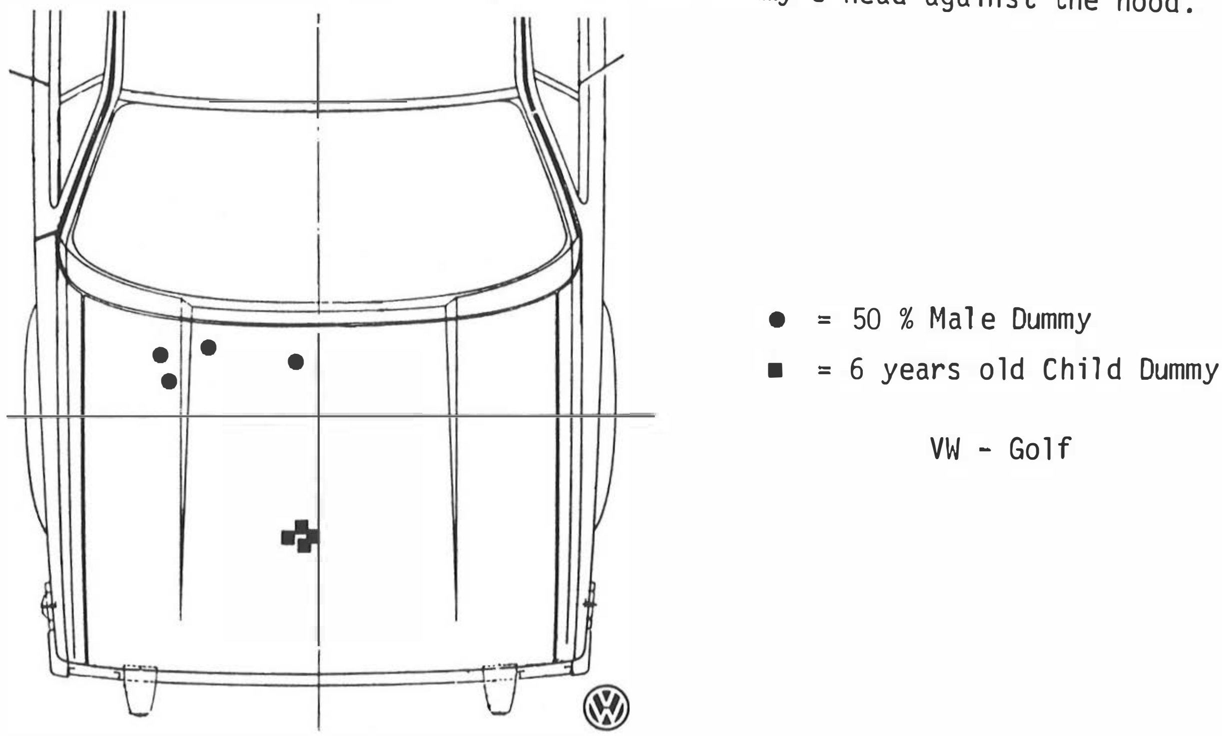


Fig. 9 Impact points of the dummy's head against the hood of the VW-Golf (Impact speed 35 km/h)

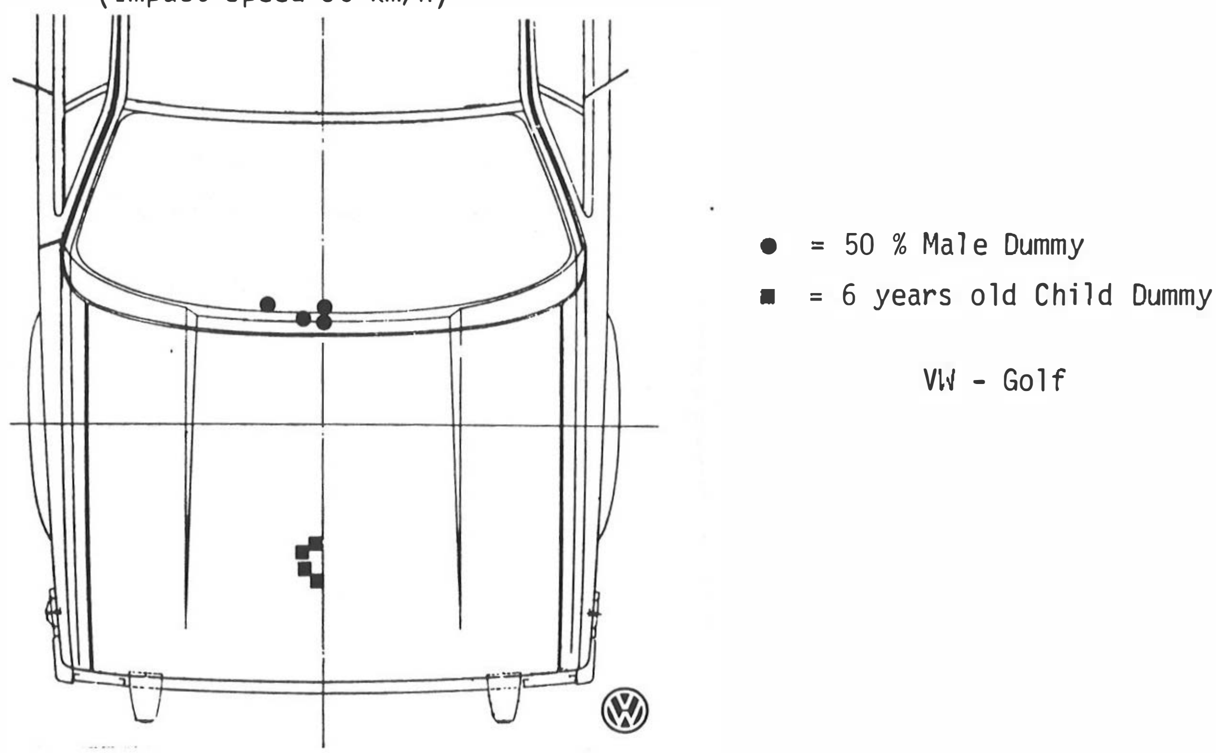
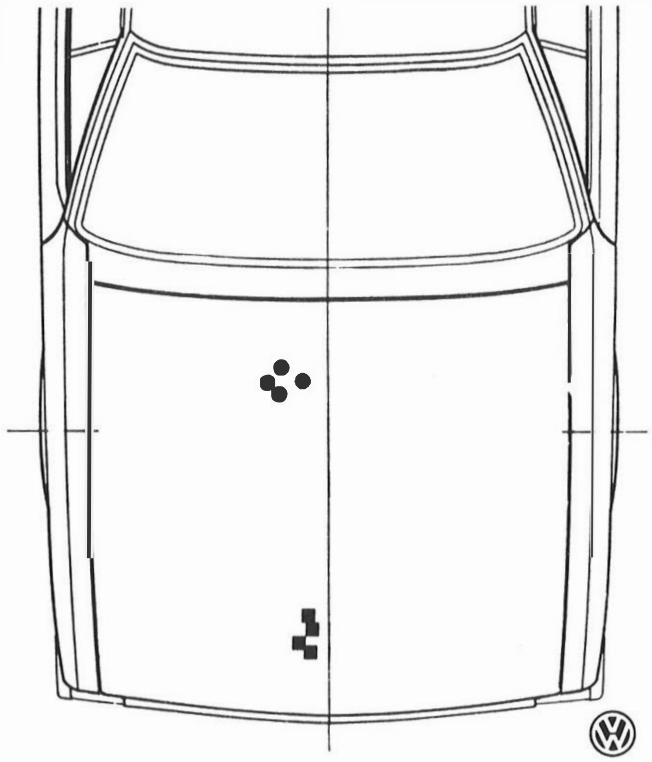


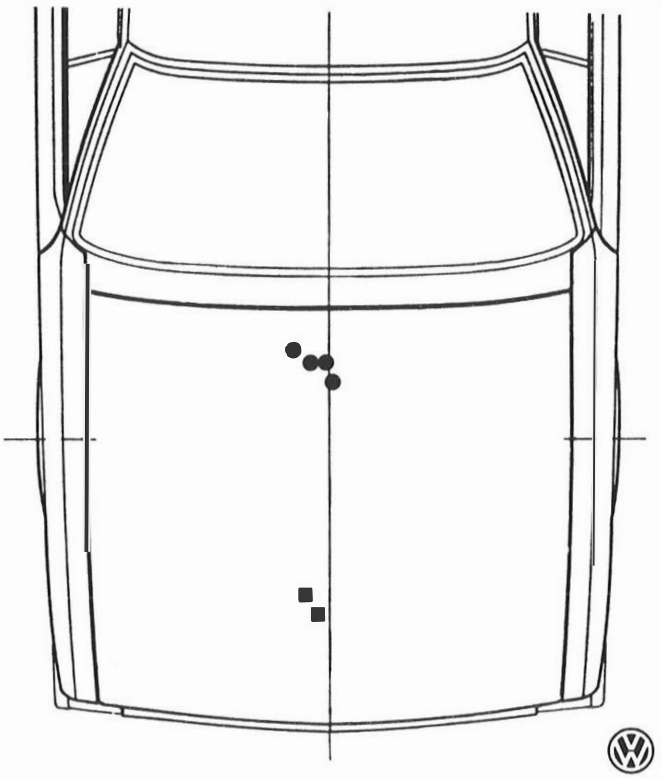
Fig. 10 Impact points of the dummy's head against the hood of the VW-Golf (Impact speed 50 km/h)



● = 50 % Male Dummy
■ = 6 years old Child Dummy

VW - Passat

Fig. 11 Impact points of the dummy's head against the hood of the VW-Passat
(Impact speed 35 km/h)



● = 50 % Male Dummy
■ = 6 years old Child Dummy

VW - Passat

Fig. 12 Impact points of the dummy's head against the hood of the VW-Passat
(Impact speed 50 km/h)

5. Conclusion

The purpose of this investigation was, to demonstrate the differences of the behaviour of the two types of dummy - 50 % male dummy and 6 years old child dummy - during a simulated car-to-pedestrian collision.

It has to be stated that the tests were made under very special conditions and consequently up to now a correlation of the dummy test results to the real accident situation is impossible for mainly three reasons:

- Limitation of test parameters in comparison to the real accident situation,
- insufficient simulation of the pedestrian by the dummy and
- insufficient protection criteria for the impacted pedestrian.

Nevertheless significant tendencies can be seen if one compares the results of the tests with the two types of dummy:

- no significant differences between the head loadings,
- the chest loadings are higher for the impacted child dummy especially for the impact speed of 50 km/h,
- the pelvis loadings are higher for the impacted child dummy than for the adult and
- the impact points of the head against the hood differ extremely between the adult and the child dummy - as can be seen clearly in figures 9 to 12.

The results of this study may help to underline that any car related measure has to be protective for both groups of pedestrians children and adults.

The results clearly show, that loadings and kinematics are of significant difference for these two groups of pedestrians under similar accident conditions. Consequently all pedestrian - protection measures have to be proven to be beneficial for children and adults. Furthermore pedestrian protection requirements have to take into account this situation and it has to be assured that they will not affect requirements concerning active safety, occupant protection and the energy situation.

6. References

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