Insurance Institute for Highway Safety
Crashworthiness Evaluation

Crash Test Report
1998 Volkswagen Passat (CF98002)

Vehicle identification number: WVWMA63B8WE114404
Body style: Four-door sedan
Engine/transmission: Longitudinal 1.8-liter turbocharged 4-cylinder, 5-speed automatic, front-wheel drive

Standard crashworthiness features:

Driver and right front passenger front airbags
Driver and right front passenger seat-mounted side airbags
Dual-locking shoulder belts (front and rear outboard seating positions)
Shoulder belt upper anchorage height adjusters (front seating positions only)
Seat belt pretensioners (pyrotechnic, front and rear outboard seating positions)
Seat belt force-limiting mechanisms (front seating positions only)
Right front and both rear shoulder belt retractors are convertible from emergency to automatic locking for ease of child restraint use
Rear seat head restraints (outboard seating positions)

Other standard safety features:

Four-wheel antilock brakes

Vehicle specifications (provided by manufacturer):

Wheelbase:	271 cm
Overall length:	468 cm
Overall width:	174 cm
Curb weight:	1,415 kg

Vehicle specifications (measured):

Front bumper to firewall:	113 cm
Curb weight:	1,438 kg
Test weight:	1,576 kg
Overall width:	174 cm

Nominal test parameters:

40.0 mi/h (64.4 km/h), 40 percent overlap, deformable barrier face with slotted bumper

Crash test date:

January 22, 1998

Precrash — 1998 Volkswagen Passat

Postcrash — 1998 Volkswagen Passat

Summary

A 1998 Volkswagen Passat was crash tested on January 22, 1998 into a fixed deformable barrier at 40.2 mi/h (64.7 km/h) and a 38 percent overlap on the driver side. A Hybrid III 50th percentile male dummy was positioned in the driver seat with the lap/shoulder belt fastened.

Measures of intrusion taken after the crash indicate the lower instrument panel in front of the dummy moved rearward 7-8 cm. The knee bolster, which is supported by deformable lattice-shaped knee bars, was crushed forward 2 cm. This crush, however, is not reflected in the lower instrument panel measurements, which were made on the overlying and relatively undeformed trim panel. Resultant intrusion in the driver footwell measured 12 cm at the footrest and 10-16 cm at other places on the toepan. The upper end of the steering column moved upward 9 cm and rearward 2 cm. All doors remained closed during the crash. The driver and left rear doors required additional effort to open after the crash, but the right front and right rear doors opened with ease.

The driver dummy was restrained by a three-point lap/shoulder belt with pyrotechnic crash pretensioner and an airbag. During the crash, the belt pretensioner activated and pulled 8 cm of webbing into the retractor; the force limiter then released 4 cm of webbing. The deploying airbag contacted the dummy's head 14 ms before it was fully inflated. As the dummy loaded the fully inflated airbag, its head moved leftward and downward as the driver seat tipped forward and outboard. During rebound, the dummy's head contacted the head restraint before the dummy settled into the seat.

Measurements from the dummy's head, neck, chest, legs, and feet indicate significant injuries to these body regions would be unlikely.

Test Conditions

This vehicle had been tested previously in the Institute's Low-Speed Crash Test Program and subjected to an impact on the front corner of the passenger side at 5 mi/h (8 km/h) into a 30 degree angle barrier and a rear impact at 5 mi/h (8 km/h) into a flat barrier. All structural damage on the front was repaired prior to this test (see Appendix, Low-Speed Crash Test Damage Repair Estimate).

This test was conducted according to the procedures specified in the IIHS Offset Barrier Crash Test Protocol (Version IV). The Hybrid III dummy positioned in the driver seat was equipped with instrumented lower legs that included feet modified to include two accelerometers and to have a 45 degree dorsiflexion range with soft stops at all extremes of foot-ankle motion. All dummy seating parameters were set according to the procedures specified for Federal Motor Vehicle Safety Standard 208 compliance testing (49 *CFR* Part 571.208 § 11). The dummy's left foot was placed on the footrest.

Seat back, shoulder belt upper anchorage, and steering column adjustments were set according to the manufacturer's specifications for government crash testing. Other adjustments were set according to the procedure specified for Federal Motor Vehicle Safety Standard 208 compliance testing (49 *CFR* Part 571.208 § 7 and 8). After final positioning of the dummy, measurements from various parts of the dummy to a number of vehicle interior points were made. These measurements and the seat back, shoulder belt upper anchorage, and steering column adjustments are described in the Appendix, Dummy Clearance Measurements.

Vehicle acceleration measurements were made by a triaxial arrangement of accelerometers mounted on the vehicle's longitudinal centerline and 58 cm behind its center of gravity (174 cm behind the front axle). The vehicle speed recorded just prior to impact was 40.2 mi/h (64.7 km/h), and the actual overlap was 38 percent.

Structural Performance

All doors remained closed during the crash. The driver door aperture shortened 4 cm as measured at the lower edge of the window. The driver and left rear doors required additional effort to open after the crash, but the right front and right rear doors opened with ease.

No fuel system leaks were observed after the crash. In addition, no fuel system leaks were observed when the vehicle was rotated onto its right side to allow postcrash photography.

Figure 1 shows the overhead view of the crash deformation. Figure 2A illustrates the precrash and postcrash contour measures of the front bumper cover profile and the resulting permanent crush. Figure 2B illustrates the corresponding measures of both the front bumper reinforcement bar and the upper crossmember of the radiator support. Figure 3 shows the precrash and postcrash views from below. Figure 4 illustrates the deformation of the side rails, floor rails, and engine cradle, which are visible in Figure 3.

Figure 1
Overhead View of Crash Deformation — 1998 Volkswagen Passat

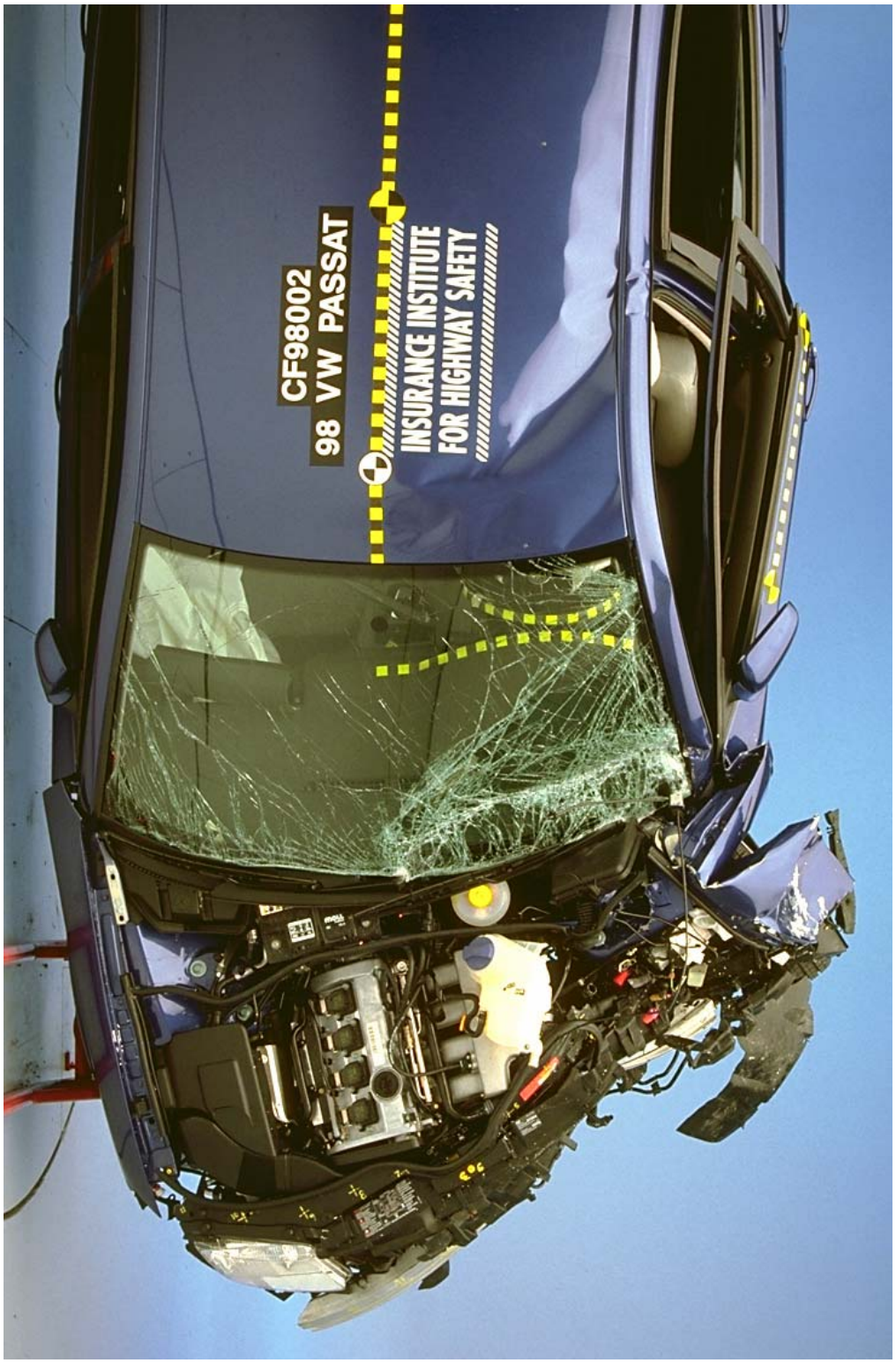
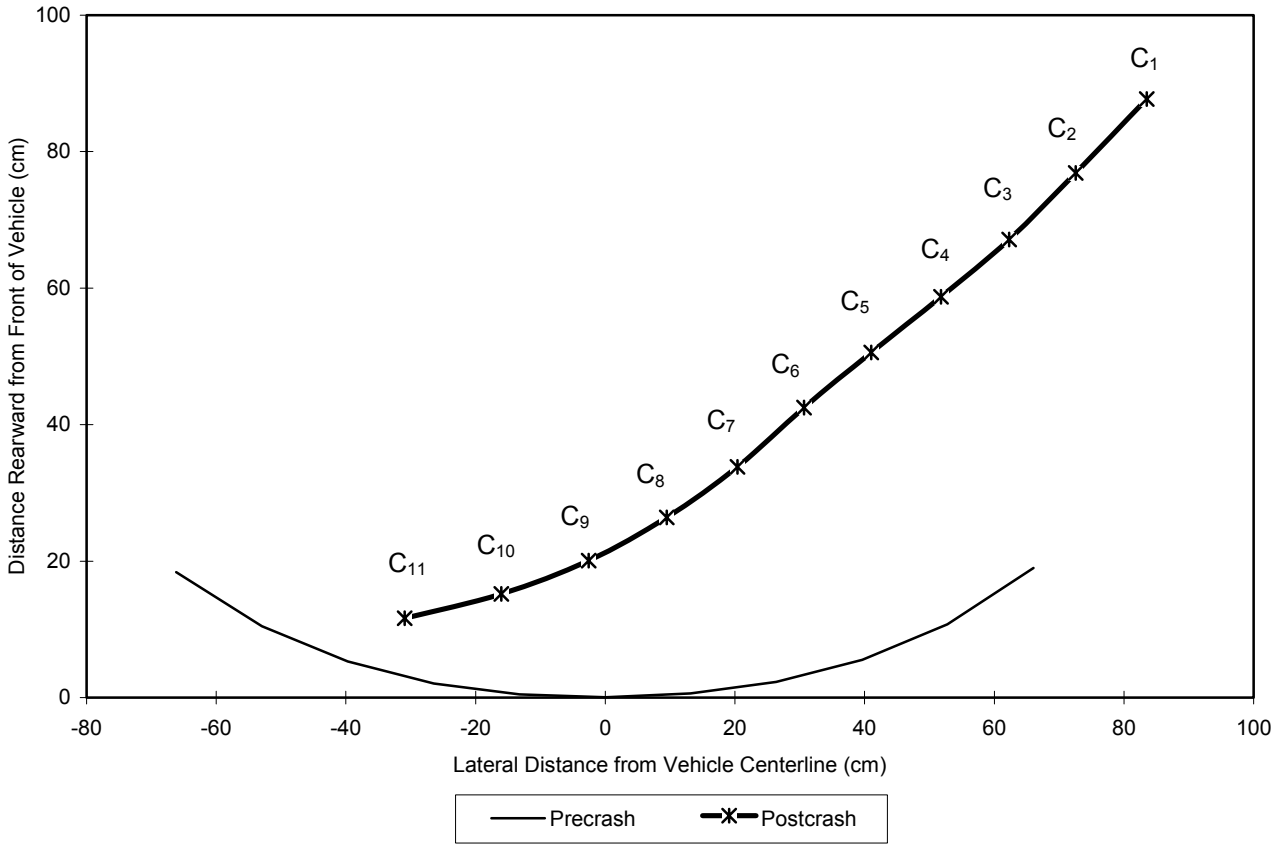


Figure 2
Crush Contour Measurements — 1998 Volkswagen Passat

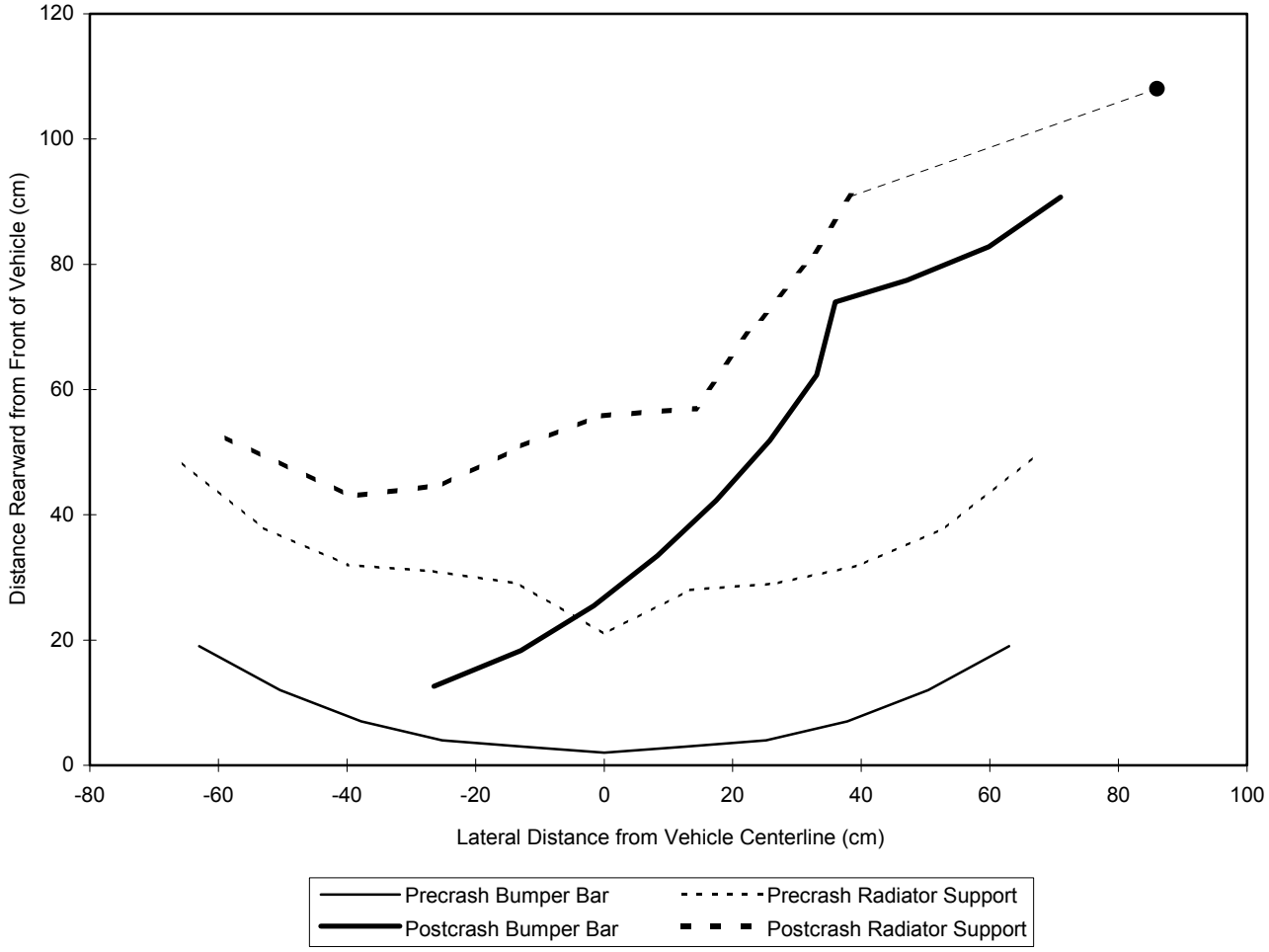
a) Exterior Crush Contour at Bumper Height



	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}	C_{11}
Postcrash Contour (cm)	88	77	67	59	51	43	34	26	20	15	12
Precrash Contour (cm)	19	11	6	2	1	0	0	2	5	10	18
Resulting Crush (cm)	69	66	61	57	50	43	34	24	15	5	-6

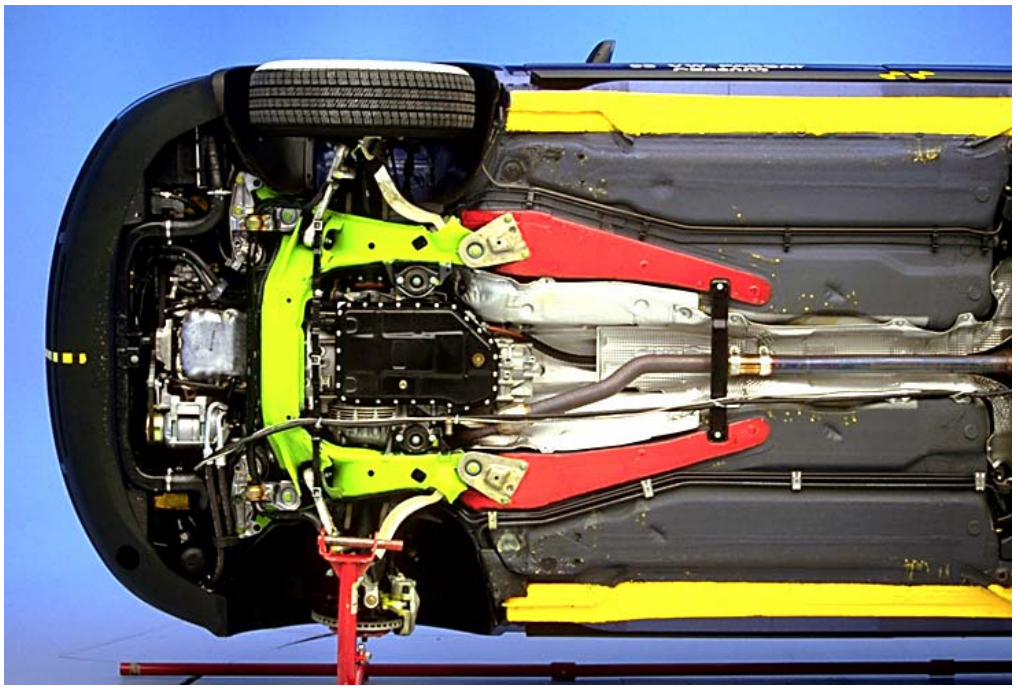
The bumper cover was torn completely off the vehicle during the crash. The postcrash contour represents the best attempt to fit the cover back onto the vehicle. The length of the reference line was 132 cm precrash and 114 cm postcrash.

b) Front Bumper Bar and Upper Radiator Support Crossmember Crush Contour



Upper radiator support crossmember (made of plastic) at driver side was broken off during the crash. Indicated endpoint represents junction of crossmember with fender.

Figure 3
Precrash View from Below — 1998 Volkswagen Passat



Postcrash View from Below — 1998 Volkswagen Passat

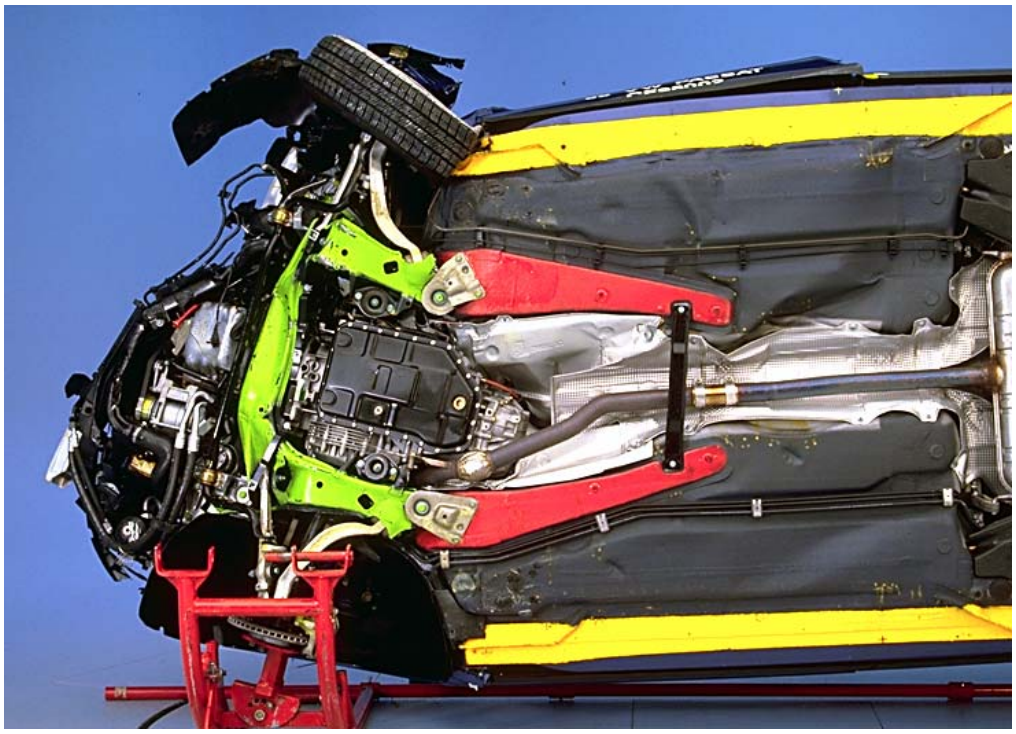
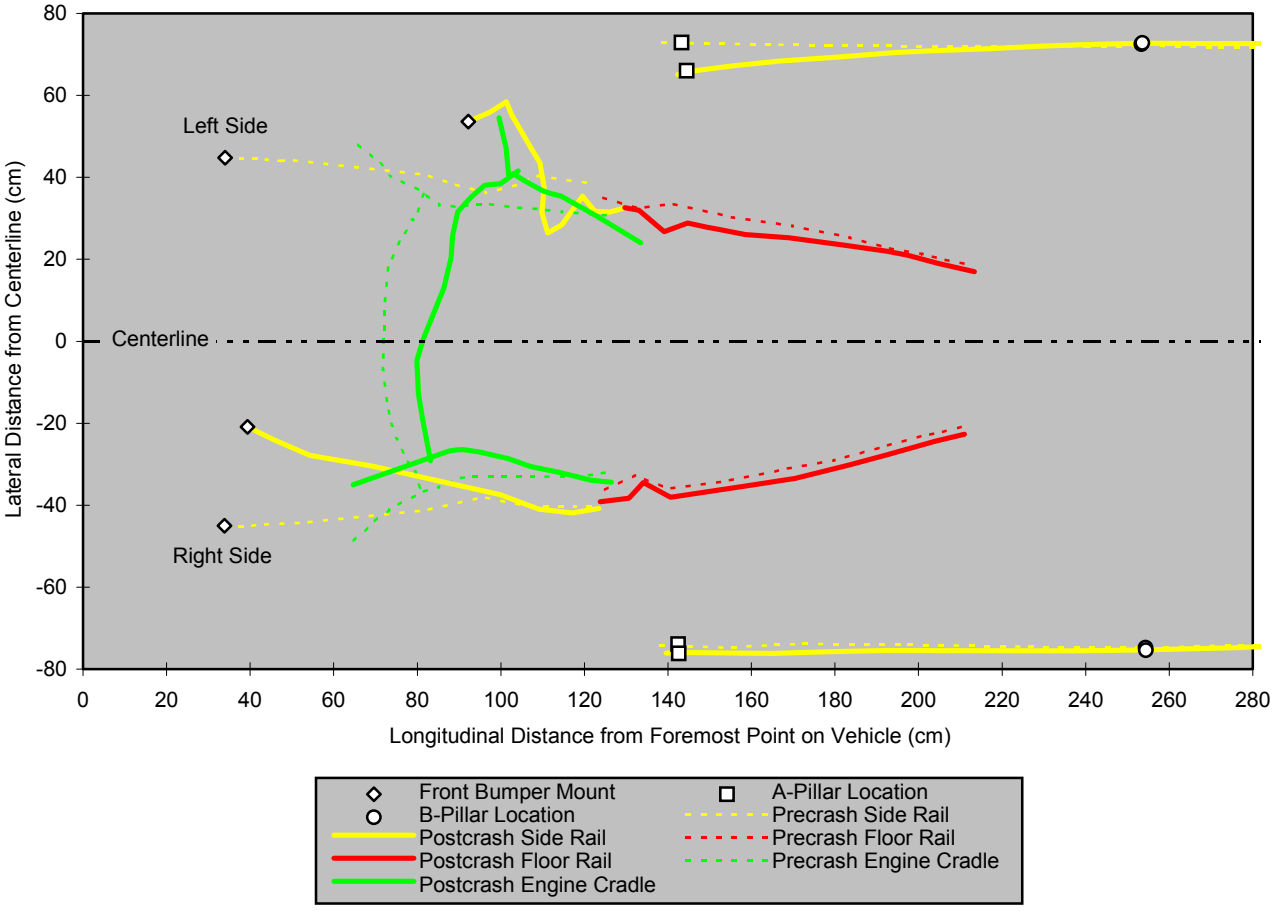
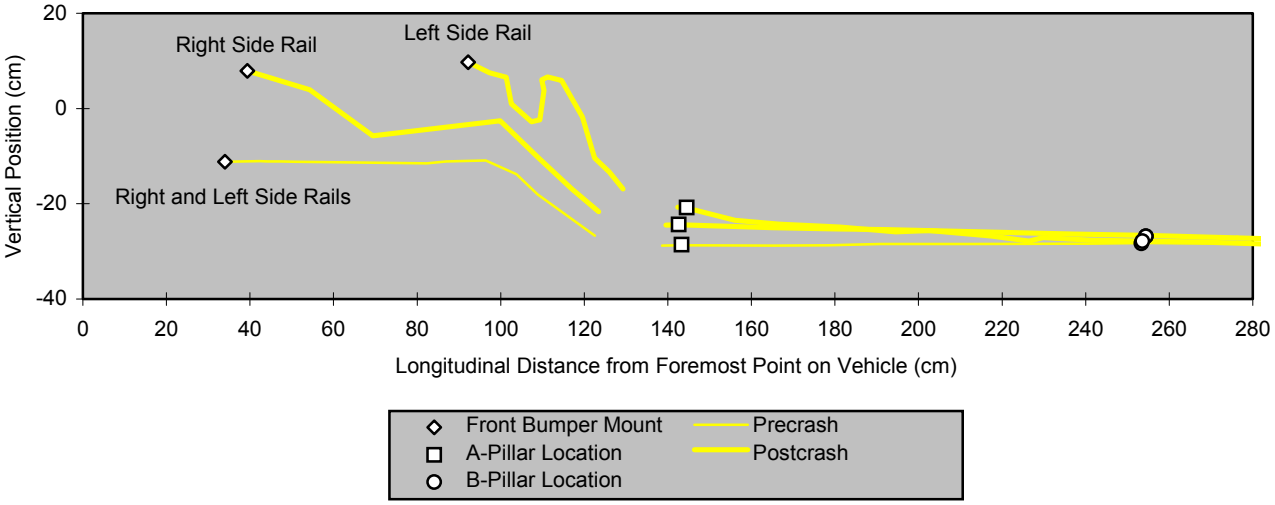


Figure 4
Frame Rail Deformation — 1998 Volkswagen Passat

a) View from Below



b) Side View



Various measures of intrusion were made after the crash. These residual measures of intrusion typically are less than the maximum deformation that occurs during the crash. The primary coordinate reference system for these measures is described in the IIHS Offset Barrier Crash Test Protocol (Version IV). The measures of deformation shown in Table 1 have been adjusted to better reflect the displacement of the various target locations relative to the driver. This was done by subtracting the average component displacements of the four seat-attachment bolts, which also were measured relative to the primary coordinate system, from the respective components of displacement for each of the target locations. The average displacement of the four seat-attachment bolts relative to the primary reference system also is shown in Table 1.

Table 1
Residual Measurements of Intrusion Relative to Driver Seat — 1998 Volkswagen Passat

Selected Locations*	Longitudinal	Lateral	Vertical	Resultant
Steering column (cm)	-2	-2	9	10
Left lower instrument panel (cm)	-8	-3	4	9
Right lower instrument panel (cm)	-7	-3	5	9
Brake pedal (cm)	-3	-2	2	4
Left toepan (cm)	-14	-5	5	16
Center toepan (cm)	-10	-5	7	13
Right toepan (cm)**	-9	-3	4	10
Footrest (cm)***	-8	-8	3	12
Average displacement of the four seat-attachment bolts from primary reference system (cm)****	-2	0	-4	—

* All measurements taken on driver side. From the driver's position, positive is forward, left, and up.
** The right toepan reference point was moved leftward 3 cm from the position specified in the Institute's protocol to allow this point to rest on the toepan rather than the side wall of the center console.
*** The footrest measurement was taken on the toepan directly underneath the footrest.
**** The front-seat bolt measurements were taken at the bolts that secure the central seat adjustment rail to the floor. The rear-seat bolt measurements were taken at positions along the rear adjustment rails that corresponded to the seat's precrash position.

Restraint System Performance

Airbags

Driver: The uninflated front airbag was 68 cm in diameter, and the excursion of its center when inflated was limited by three 25 cm-long tethers. The airbag was vented by one 40 mm-diameter hole at a position corresponding to 12 o'clock on the forward-facing surface of the airbag. Analysis of the high-speed film taken from camera positions B and D indicates the airbag deployed at 54 ms into the crash and appeared to be fully inflated at 74 ms. The seat-mounted side airbag did not deploy during the crash.

Passenger: The corner-mounted front airbag deployed rearward and was untethered. The cylinder-shaped airbag was vented by one 45 mm-diameter hole located at the top center. The airbag did not contribute to windshield damage during deployment. The seat-mounted side airbag did not deploy during the crash.

Seat Belts

This vehicle is equipped with dual-locking lap/shoulder belts with sliding latch plates at the outboard seating positions and adjustable upper anchorage points and force limiters at both front seating positions. The front inboard lower anchorage points are attached to and move with the seats. The front outboard lower anchorage points are bolted to the B-pillars. The front and rear outboard seating positions are equipped with pyrotechnic crash pretensioners that, when activated, remove slack from the shoulder belt webbing by pulling webbing back into the retractor. The driver belt pretensioner activated at 38 ms into the crash and pulled 8 cm of webbing into the retractor, as measured by film analysis of a marker on the belt. The torsion bar force limiter then released 4 cm of webbing, as estimated from postcrash deformation of the mechanism.

Seat

Postcrash examination of the driver seat rails indicates the left rear seat attachment moved forward 2 cm along the track during the crash. This movement likely was caused by deformation of the floor and right rear seat rail rather than failure of the latching mechanism, which was found secure in its precrash position after the crash. Deformation of the floor under the driver seat caused the seat to tip slightly outboard. Analysis of the high-speed film taken from camera position D indicates the driver seat back moved forward and then returned to a position slightly forward of its precrash position.

Steering Column

The upper end of the steering column moved upward 9 cm and rearward 2 cm relative to the driver seat. The lower end of the steering column is a tube-in-tube design and had a residual compression of 6 cm. There was no separation of the shear modules.

Dummy Kinematics

Head, Neck, and Torso

Analysis of the high-speed film taken from camera position D indicates the deploying airbag contacted the dummy's face at 60 ms into the crash (14 ms before the airbag was fully inflated). The dummy's face began to load the airbag at 74 ms into the crash (at the time the airbag was fully inflated). Paint transferred from the dummy's face onto the airbag indicates the dummy's nose loaded the airbag 6 cm below and 1 cm to the right of its center. As the dummy moved forward and leftward into the airbag, its head moved down toward the window sill and faced right as the driver seat tipped forward. During rebound, the dummy's head contacted only the head restraint; recorded head acceleration measures indicate this contact began at 262 ms. The dummy then settled into the seat. Table 2 provides the timing and duration of these events.

Table 2
Restraint System Performance and Dummy Kinematics —
1998 Volkswagen Passat

Event	Time (ms)
Seat belt pretensioner activates	38
Deployment of airbag	54
Airbag contacts head during deployment	60
Airbag fully inflated; head begins to load airbag	74
Head begins to rotate right	114
Back of head in contact with head restraint	262-406

Legs and Feet

Left leg and foot: Paint transferred from the dummy's left knee indicates the knee contacted the knee bolster 3 cm below the left instrument panel intrusion reference point. The left knee also contacted the corner of the steering column trim. Paint transferred from the dummy's left shin indicates the shin contacted the knee bolster below and to the left of the left knee impact location.

The knee bolster, underlying the trim panel on which the lower instrument panel measurements were made, is supported by lattice-shaped knee bars extending rearward from the instrument panel support structure. The left knee bar was deformed such that the knee bolster was pushed forward 2 cm from its normal position (immediately forward of the trim panel). This crush, however, is not reflected in the lower instrument panel measurements listed in Table 1 because those measurements were made to points on the overlying and relatively undeformed trim panel.

The left foot was found fully dorsiflexed, everted, and rotated inward. The toes were angled approximately 60 degrees to the right of the neutral position, with the right side of the toes resting against the left side of the right foot. The back of the heel was pressed against the floormat, and the left side of the heel was pressed against the bottom of the footrest.

Right leg and foot: Paint transferred from the dummy's right knee indicates the knee contacted the steering column trim directly below the steering column. Paint transferred from the dummy's right shin indicates the shin contacted the knee bolster directly below the right knee impact location. The right foot was found fully dorsiflexed, inverted, and externally rotated. The toes were pointing 45 degrees to the right of the neutral position, and the back of the heel was pressed against the floormat. The right edge of the sole (at the ball of the foot) was resting on the lower edge of the accelerator pedal.

Dummy Injury Measures

Head

The maximum vector resultant head accelerations were recorded and the HICs were calculated during an interval that corresponds with the dummy's head excursion into the airbag. Contact between the back of the dummy's head and the head restraint at 262 ms produced a peak resultant head acceleration of 12 g at 268 ms. Table 3 provides a summary of the maximum head injury measurements recorded during the crash.

Table 3
Head Injury Measurements — 1998 Volkswagen Passat

Measure	Published Tolerance Threshold	Result	Time (ms)
Vector resultant acceleration (g)	80	44	91
Vector resultant acceleration — 3 ms clip (g)	80	43	90-93
Head Injury Criterion (HIC)	1000	271	79-115
Head Injury Criterion — 15 ms interval (HIC-15)*	700	160	88-103

* A proposed amendment to the Canadian Motor Vehicle Safety Regulations suggests calculating HIC during a 15 ms interval rather than the 36 ms interval specified by the U.S. standard. The Canadian proposal includes an injury threshold of 700 for front-seat occupants protected by airbags.

Neck

Table 4 provides a summary of the maximum neck injury measurements recorded during the crash.

Table 4
Neck Injury Measurements — 1998 Volkswagen Passat

Measure	Published Tolerance Threshold	Result	Time (ms)
A-P shear force (kN)	±3.1*	0.3	81
Axial compression force (kN)	4.0*	0.1	39
Axial tension force (kN)	3.3*	1.7	90
Flexion bending moment (Nm)	190**	12	75
Extension bending moment (Nm)	57**	10	46

* These values are for instantaneous loading. Neck loads are compared with magnitude-duration injury criteria in Figures A-12 to A-15.

** These published thresholds are recommended injury assessment reference values from Backaitis and Mertz (1994), but significant neck injury may occur at lower bending moments. Mertz and Patrick (1971) report that bending moments of 47 Nm in extension and 88 Nm in flexion would be non-injurious for occupants represented by the Hybrid III 50th percentile adult male dummy.

Chest

Table 5 provides a summary of the maximum chest injury measurements recorded during the crash.

Table 5
Chest Injury Measurements — 1998 Volkswagen Passat

Measure	Published Tolerance Threshold	Result	Time (ms)
Vector resultant spine acceleration — 3 ms clip (g)	60	36	103-106
Rib compression (mm)	50	28	92
Viscous criterion (m/s)	1.0	0.2	82

Legs and Feet

Table 6 provides a summary of the maximum leg and foot injury measurements recorded during the crash.

Table 6
Leg and Foot Measurements — 1998 Volkswagen Passat

Measure	Published Tolerance Threshold	Left	Time (ms)	Right	Time (ms)
Axial femur force (kN)	9.1*	3.7	89	1.8	86
Tibia-femur displacement (mm)	15	5	80	4	98
Upper Tibia					
L-M moment (Nm)	±225	43	71	70	75
A-P moment (Nm)	±225	-48	79	-70	91
Vector resultant moment (Nm)	225	50	79	83	82
Index	1.00	0.23	71	0.37	82
Lower Tibia					
L-M moment (Nm)	±225**	76	68	132	75
A-P moment (Nm)	±225**	54	103	53	84
Vector resultant moment (Nm)	225**	79	70	133	75
Axial force (kN)	8.0**	0.8	40	2.2	109
Index	1.00	0.37	70	0.60	75
Foot					
A-P foot acceleration (g)	±150	-24	79	-52	62
I-S foot acceleration (g)	±150	48	80	-53	72
Vector resultant foot acceleration (g)	150	50	80	70	72

* This critical value is for instantaneous loading. Femur loads are compared with magnitude-duration injury criteria in Figures A-23 and A-34.

** These published thresholds are for fractures of the tibia. Ankle and foot injuries have been associated with bending moments as low as 50-100 Nm, and heel fractures have been associated with axial forces as low as 6.0 kN.

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Appendix

Low-Speed Crash Test Damage Repair Estimate

Dummy Clearance Measurements

Graph Index — index to graphs of time plots of dummy and vehicle data

Manufacturer's window sticker

Low-Speed Crash Test Damage Repair Estimate

1998 Volkswagen Passat Four-Door Sedan: 5 mi/h Front into Angle Barrier

Test number: LA97021
VIN: WVWMA63B8WE114404
Mileage: 224
Features: Driver and passenger frontal airbags, driver and right front passenger side impact airbags, four-wheel antilock brakes, air conditioning, automatic transmission, heated power mirrors, keyless entry system, power door locks, power windows, heated back glass, tilt and telescoping steering wheel, cruise control, two-stage paint.

	Part		Labor	
Description	**Mfg. No**	**Price**	**Operation**	**Hours**
Bumper cover, front	New Part	$310.00	Replace	1.0
Bumper cover, front			Refinish	3.0
Bumper absorber, front			Repair/align*	0.5
Radiator support			Repair/align*	1.0
Headlamps			Aim	0.5
Paint and materials		48.00		
Total Parts		$358.00		
Total Labor		186.00		6.0
Grand Total		$544.00		

* This item was repaired as indicated before the 40 mi/h frontal offset barrier test.

Dummy Clearance Measurements

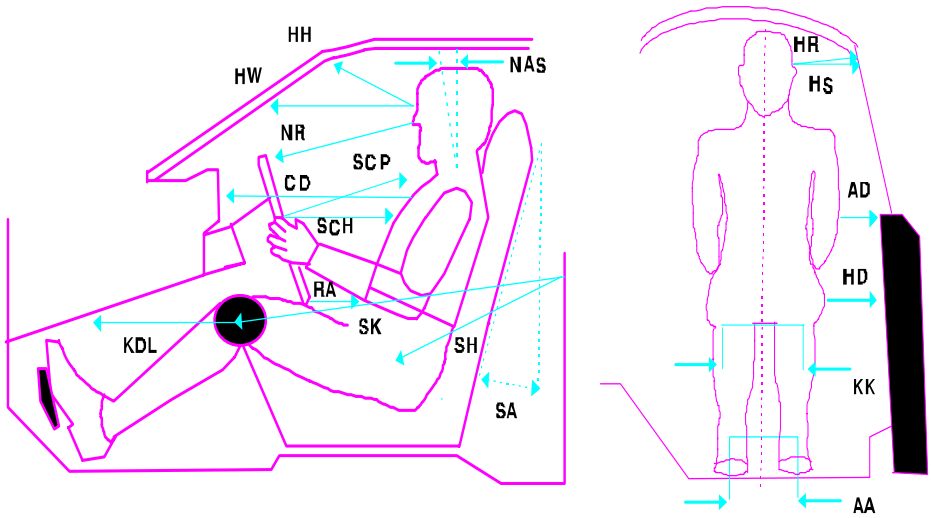
Test Number: CF98002
Vehicle Make: Volkswagen Passat
Vehicle Model Year: 1998
Seat Type: Manual adjustment

Manufacturer's Specifications
Seat Back Information: Reclined to 9.6 degrees from vertical as measured from head restraint supports (19 degrees with H-point machine)

Upper Belt Anchorage: Adjusted to third position from top
Steering Column Adjustment: Vertical adjustment set to 67.3 degrees from horizontal; longitudinal adjustment set to 2.15 cm rearward of forwardmost position

Location	Code	Measurement	Location	Code	Measurement
Head to header	HH	370	Neck angle, torso 90	NAT90	21.3°
Head to windshield	HW	640	Neck angle, seated	NAS	5.6°
Nose to rim	NR	405	Torso angle (NAT90 – NAS)	TA	15.7°
Chest to dash	CD	731	Striker to knee**	SK	660
Rim to abdomen	RA	210	Striker to knee angle**	SKA	9.5°
Knee to dash, left	KDL	170	Striker to H-point, horizontal	SHH	228
Knee to dash, right	KDR	185	Striker to H-point, vertical	SHV	221
Steering wheel to chest, horizontal	SCH	332	Ankle to ankle	AA	345
Steering wheel to chest, perpendicular	SCP	389	Knee to knee	KK	300
Steering wheel to chest, reference	SCR	388	Arm to door	AD	120
Hub to chest, minimum	HCM	278	H-point to door	HD	155
Pelvic angle	PA	24.1°	Head to A-pillar	HA	575
Seat back angle*	SA	11.7°	Head to roof	HR	215
			Head to side window	HS	240

All distance measurements are in mm.
* This measurement was made on the head restraint support posts.
** These measurements are made in a vertical plane containing the striker and parallel to the driver door sill.



Graph Index