Insurance Institute for Highway Safety
Crashworthiness Evaluation

Crash Test Report
1997 Mazda Protege (CF97017)

Vehicle identification number:	JM1BC1413V0103946
Body style:	Four-door sedan
Engine/transmission:	Transverse 1.5-liter 4-cylinder, 4-speed automatic, front-wheel drive

Standard crashworthiness features:

Driver and right front passenger front airbags
Dual-locking shoulder belts (front and rear outboard seating positions)
Shoulder belt upper anchorage height adjusters (front seating positions only)
Shoulder belt webbing grabbers (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

Optional safety features:

Four-wheel antilock brakes

Vehicle specifications (provided by manufacturer):

Wheelbase:	260 cm
Overall length:	444 cm
Overall width:	171 cm
Curb weight:	1,082 kg

Vehicle specifications (measured):

Front bumper to firewall:	104 cm
Curb weight:	1,133 kg
Test weight:	1,272 kg
Overall width:	170 cm

Nominal test parameters:

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

Crash test date:

August 14, 1997

Precrash — 1997 Mazda Protege

Postcrash — 1997 Mazda Protege

Summary

A 1997 Mazda Protege was crash tested on August 14, 1997 into a fixed deformable barrier at 40.0 mi/h (64.4 km/h) and a 41 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 indicated the lower instrument panel in front of the dummy moved rearward 2-6 cm. Resultant intrusion in the driver footwell measured 21 cm at the footrest and 19-29 cm at other places on the toepan. The upper end of the steering column moved upward 9 cm and forward 1 cm. All doors remained closed during the crash and opened with ease after the crash.

The driver dummy was restrained by a three-point lap/shoulder belt and an airbag. During the crash, 2 cm of webbing was pulled from the retractor, and 11 cm of webbing was released by tearing of the force-limiting stitching at the inboard seat belt mount. The airbag briefly contacted the dummy's head, neck, and shoulders during deployment. As the dummy's head rebounded rearward and leftward off the airbag, it passed through the plane of the driver door window then contacted the rear vertical support of the door window frame before the dummy settled into the seat.

The dummy's head contact against the door window frame produced a peak resultant head acceleration of 9 g. The right upper tibia had a maximum index of 1.18. Cracked plastic around the ignition switch and flat metal ignition key, which was bent by the dummy's knee, also represent possible sources of minor injuries to the right leg.

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 56 cm behind its center of gravity (167 cm behind the front axle). The vehicle speed recorded just prior to impact was 40.0 mi/h (64.4 km/h), and the actual overlap was 41 percent.

Structural Performance

All doors remained closed during the crash. The driver door aperture shortened 7 cm as measured at the lower edge of the window. The driver and left rear doors opened with ease after the crash, but minor interference with the driver door prevented the left rear door from opening fully without slight additional effort. The right front and right rear doors opened with ease after the crash.

The welded seam between the driver door sill and adjacent floorpan was separated for 41 cm extending rearward from the base of the A-pillar.

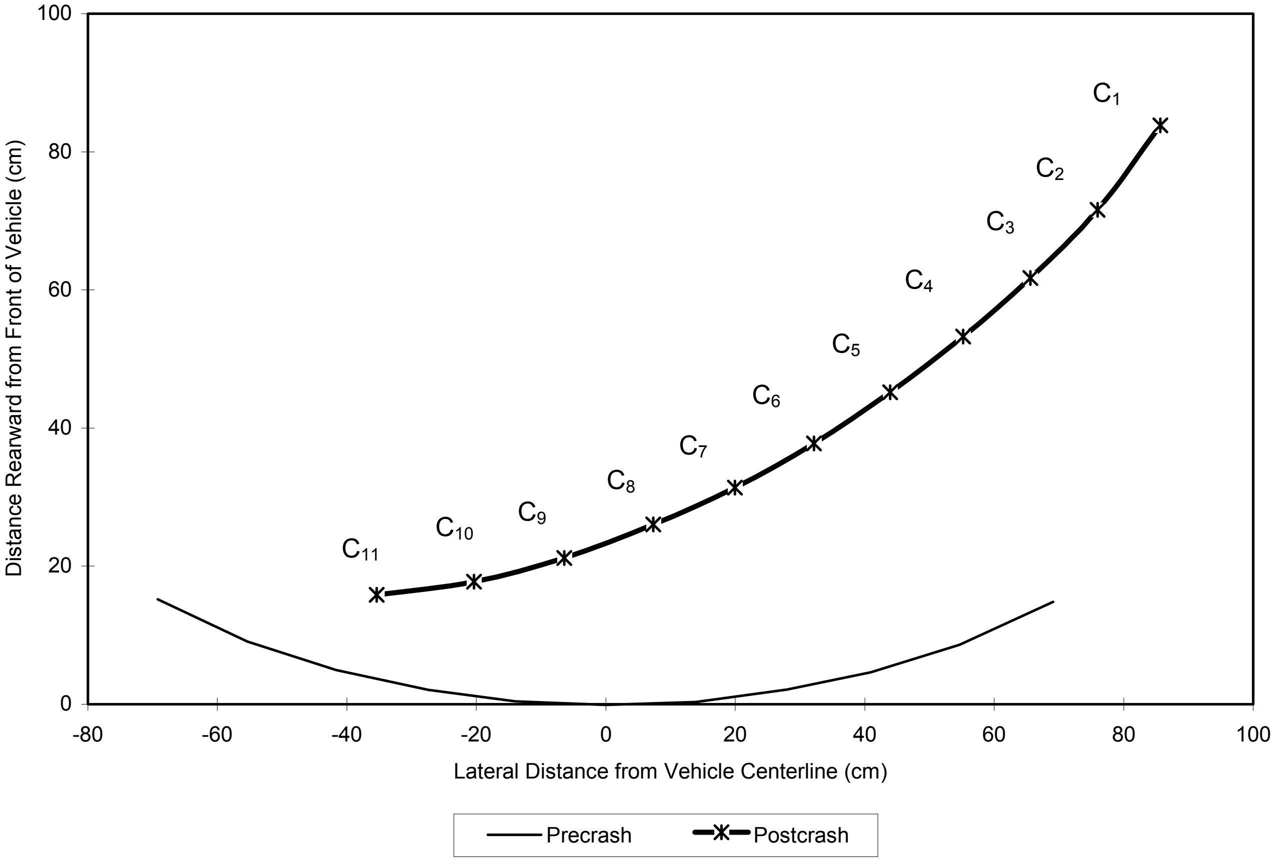
No fuel system leaks were observed after the crash. In addition, no fuel system leaks were observed when the vehicle was rotated onto its right side to allow postcrash photography.

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 frame rails, door sills, floor pan stiffeners, and longitudinal and transverse members beneath the engine, which are visible in Figure 3.

Figure 1
Overhead View of Crash Deformation — 1997 Mazda Protege

Figure 2
Crush Contour Measurements — 1997 Mazda Protege

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)	84	72	62	53	45	38	31	26	21	18	16
Precrash Contour (cm)	15	9	5	2	0	0	0	2	5	9	15
Resulting Crush (cm)	69	63	57	51	45	38	31	24	16	9	1

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 138 cm precrash and 121 cm postcrash.

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

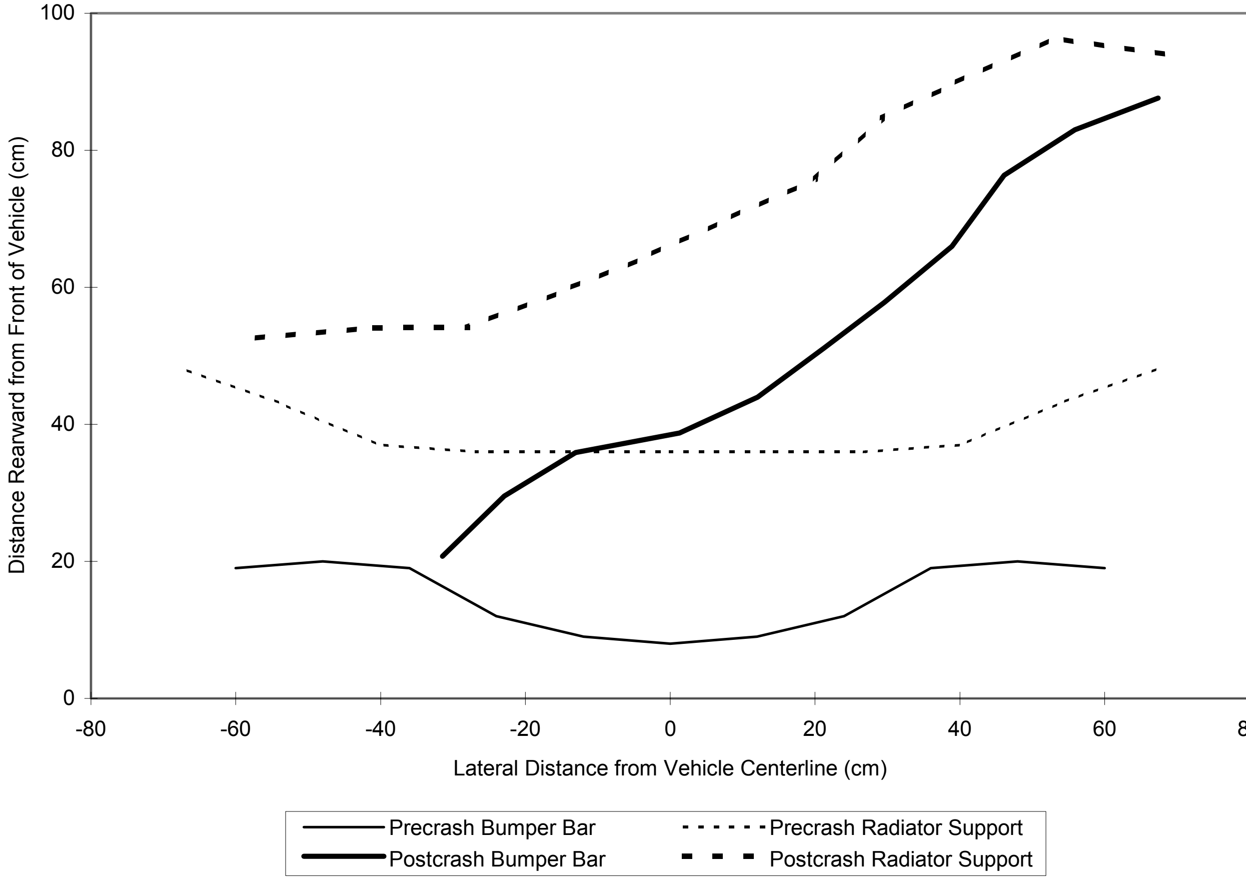
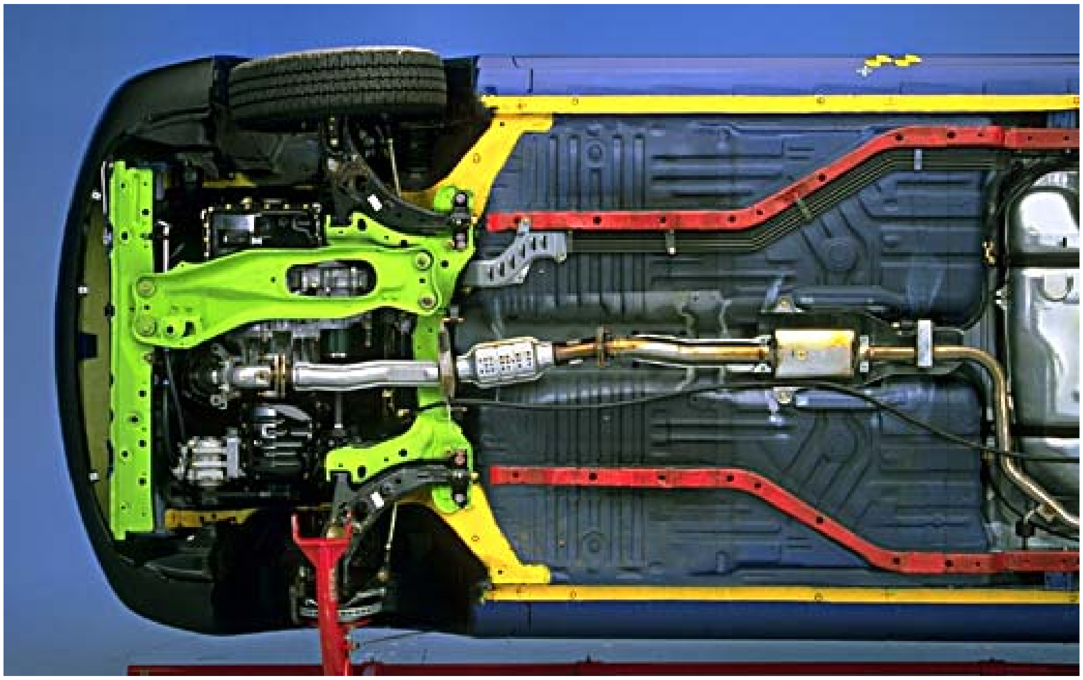


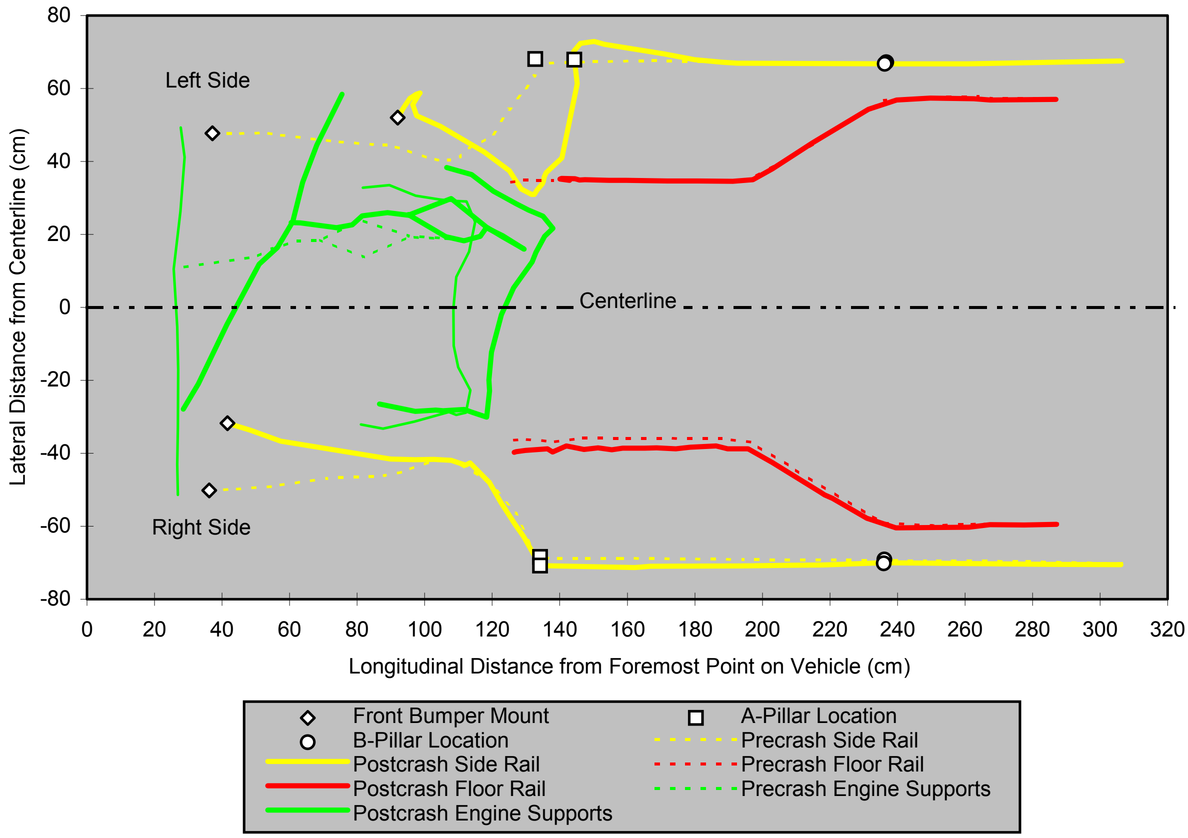
Figure 3
Precrash View from Below — 1997 Mazda Protege



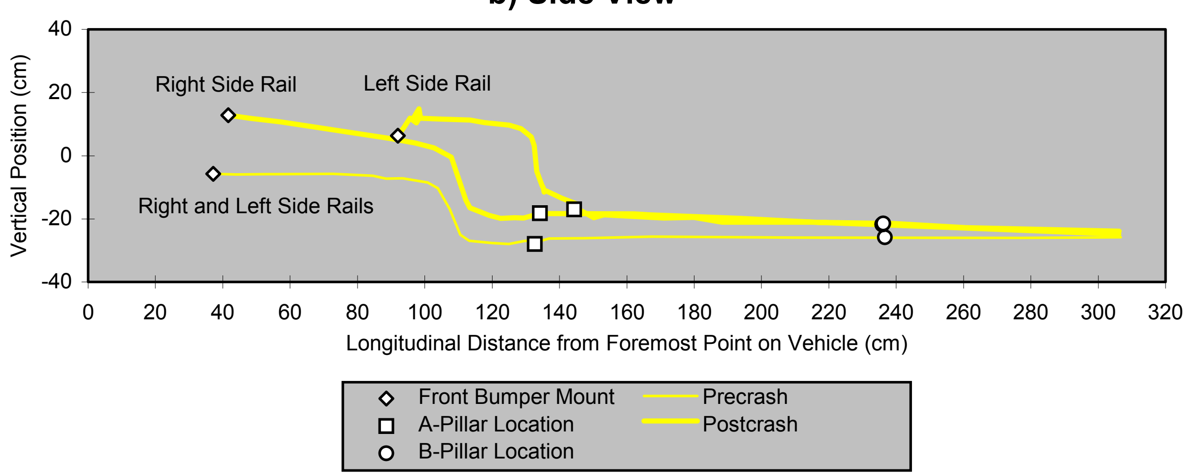
Postcrash View from Below — 1997 Mazda Protege

Figure 4
Frame Rail Deformation — 1997 Mazda Protege

a) View from Below



b) Side View



Various measures of intrusion were made after the crash. These residual measures of intrusion are typically 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 —
1997 Mazda Protege

Selected Locations*	Longitudinal	Lateral	Vertical	Resultant
Steering column (cm)	1	1	9	9
Left lower instrument panel (cm)	-6	-3	4	8
Right lower instrument panel (cm)	-2	-3	3	4
Brake pedal (cm)	-19	-2	6	20
Left toepan (cm)	-25	-8	7	28
Center toepan (cm)	-25	-12	9	29
Right toepan (cm)	-19	-4	3	19
Footrest (cm)	-20	-6	5	21
Average displacement of the four seat-attachment bolts from the primary reference system (cm)	-1	2	-2	—

* All measurements taken on the driver side. From the driver's position, positive is forward, left, and up.

Restraint System Performance

Airbags

Driver: The uninflated driver airbag was 65 cm in diameter and untethered. The airbag was vented by two 30 mm-diameter holes at positions corresponding to 10 and 2 o'clock on the forward-facing surface of the airbag. Analysis of the high-speed films taken from camera positions B and D indicated the airbag deployed at 30 ms into the crash and appeared to be fully inflated at 48 ms.

Passenger: The corner-mounted passenger airbag deployed rearward and was untethered. The cylinder-shaped airbag was vented by two 50 mm-diameter holes located at the lateral ends. The airbag did not appear to contribute to windshield damage during deployment.

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 at both front seating positions. The front inboard lower anchorage points are attached to and move with the seats. The outboard lower anchorage points are bolted to the B-pillars. Both front seat belts are equipped with webbing grabbers just above the retractors and force-limiting tear stitching on the webbing that attaches the buckle to the seats. During the crash, 2 cm of webbing was pulled from the retractor through the D-ring as measured by a pull-string mounted between the B-pillar trim and the webbing just below the D-ring. The buckle was pulled out 11 cm from its precrash position because of tearing of the force-limiting stitching.

Seat

Postcrash examination of the driver seat rails indicated no discernible movement of the seat in its tracks during the crash. The seat appeared to have been pitched forward slightly, which was confirmed by the residual measurements of intrusion.

Steering Column

The upper end of the steering column moved upward 9 cm and forward 1 cm relative to the driver seat. The steering column in front of the instrument panel inside the occupant compartment has two tube-in-tube mechanisms plus a universal joint. A residual collapse of 9 cm was measured along the upper tube above the universal joint. Another 2 cm of collapse was measured at the lower tube below the universal joint and just above the intruded toepan. Movement of the shear modules on the upper portion of the column measured 2 cm forward on the left side and zero on the right side.

Dummy Kinematics

Head, Neck, and Torso

Analysis of the high-speed films taken from camera positions D and E indicated the deploying airbag briefly contacted the dummy's head, neck, and shoulders at 36 ms into the crash and receded by 46 ms. The dummy's face began to load the airbag at 50 ms into the crash (2 ms after the airbag was fully inflated). Paint transferred from the dummy's face onto the airbag indicated the dummy's nose loaded the airbag 5 cm below and 7 cm to the right of its center. The dummy's head continued forward into the airbag and at 112 ms began to turn with the torso to face right. During rebound, the dummy's head moved leftward outside the plane of the driver window and rearward. Paint transfer indicated the upper right rear of the dummy's head contacted the rear vertical support of the door window frame, and the recorded head acceleration measures indicated this contact began at 278 ms. The dummy then settled back into the seat. Table 2 provides the timing and duration of these events.

Table 2 Analysis of Restraint System Performance and Dummy Kinematics — 1997 Mazda Protege	
Event	**Time (ms)**
Deployment of airbag	30
Airbag contacts dummy's head, neck, and shoulders	36
Airbag fully inflated	48
Head begins to load airbag	50
Head begins to move toward the left, still in contact with airbag	112
Head contacts vertical support of door window frame	278

Legs and Feet

Left leg and foot: Paint transferred from the dummy's left knee indicated the knee contacted the knee bolster 5 cm above and 2 cm to the right of the left instrument panel intrusion measurement point. The medial aspect of the left knee also transferred a light mark to the lower left side of the steering column trim. Paint transferred from the dummy's left shin indicated the shin contacted the knee bolster directly below the left knee impact location. The left foot was found with the ball of its sole pressed against the intruded toepan to the right of the footrest and the back of its heel resting against the carpet on the floorpan. The foot was dorsiflexed to the stop and slightly everted.

Right leg and foot: Paint transferred from the top of the dummy's right knee indicated the knee contacted and broke the lower right corner of the plastic steering column trim just to the right of the ignition switch. The jagged edges of the broken plastic represent a possible source of laceration injury. The lower portion of the knee contacted the top of the bolster about 8 cm above and 3 cm to the right of the right instrument panel intrusion measurement point. Paint from the right knee also was found on the forward surface of the flat metal ignition key, which was bent rearward and might cause minor knee injuries under some circumstances. Paint transferred from the top of the dummy's right shin indicated the shin contacted the knee bolster directly below the right knee impact location on the bolster. The right foot was found on the accelerator pedal, which was pressed against the intruded toepan. The back of the heel was suspended above the carpet and floormat. The right edge of the foot was pressed firmly against the left side of the exhaust system tunnel forward of the center console. The foot was somewhat dorsiflexed but neither inverted or everted.

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. The airbag's contact with the dummy's head during deployment produced a peak resultant head acceleration of 16 g at 39 ms. The dummy's head contact against the vertical support of the driver door window frame produced a peak resultant head acceleration of 9 g at 284 ms. Table 3 provides a summary of the maximum head injury measurements recorded during the crash.

Table 3
Head Injury Measurements — 1997 Mazda Protege

Measure	Published Tolerance Threshold	Result	Time (ms)
Vector resultant acceleration (g)	80	59	105
Vector resultant acceleration — 3 ms clip (g)	80	58	104-107
Head Injury Criterion (HIC)	1000	448	86-118
Head Injury Criterion — 15 ms interval (HIC-15)*	700	324	97-112

* 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 — 1997 Mazda Protege**			
Measure	**Published Tolerance Threshold**	**Result**	**Time (ms)**
A-P shear force (kN)	±3.1*	0.3	39
Axial compression force (kN)	4.0*	0.3	138
Axial tension force (kN)	3.3*	1.6	105
Flexion bending moment (Nm)	190**	14	182
Extension bending moment (Nm)	57**	22	283

* 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 — 1997 Mazda Protege**			
Measure	**Published Tolerance Threshold**	**Result**	**Time (ms)**
Vector resultant spine acceleration — 3 ms clip (g)	60	48	101-104
Rib compression (mm)	50	30	93
Viscous criterion (m/s)	1.0	0.2	90

Legs and Feet

Left leg and foot: None of the injury measures approached the reference values.

Right leg and foot: The right upper tibia had a maximum L-M bending moment of 261 Nm at 97 ms, which contributed to the maximum upper tibia index of 1.18.

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

Table 6
Leg and Foot Measurements — 1997 Mazda Protege

Measure	Published Tolerance Threshold	Left Leg		Right Leg	
		Result	Time (ms)	Result	Time (ms)
Axial femur force (kN)	9.1*	3.3	84	2.9	87
Tibia-femur displacement (mm)	15	9	105	7	95
Upper Tibia					
L-M moment (Nm)	±225	107	103	261	97
A-P moment (Nm)	±225	-66	83	121	66
Vector resultant moment (Nm)	225	113	103	261	97
Index	1.00	0.50	103	1.18	97
Lower Tibia					
L-M moment (Nm)	±225**	-67	70	152	54
A-P moment (Nm)***	±225**	151	81	70	70
Vector resultant moment (Nm)	225**	163	81	152	54
Axial force (kN)	8.0**	1.1	69	3.9	54
Index	1.00	0.75	81	0.78	54
Foot					
A-P foot acceleration (g)	±150	-32	73	-91	52
I-S foot acceleration (g)	±150	51	72	90	53
Vector resultant foot acceleration (g)	150	59	72	124	54

* 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.

References

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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

1997 Mazda Protege Four-Door Sedan: 5 mi/h Front into Angle Barrier

Test number: LA97012
VIN: JM1BC1413V0103946
Mileage: 65
Features: Driver and passenger airbags, air conditioning, automatic transmission, power steering, power mirrors, power door locks, power windows, heated back glass, tilt steering wheel, cruise control, two-stage paint.

	Part		Labor	
Description	**Mfg. No**	**Price**	**Operation**	**Hours**
Bumper cover, front			Repair/align	2.0
Bumper cover, front			Refinish	3.6
Bumper reinforcement plate, right front	BC1M-50-A80A	$32.80	Replace*	
Bumper absorber, front	BC1M-50-111B	43.20	Replace	3.0
Sidemember assembly, right front			Repair/align*	1.5
Sidemember assembly, right front			Refinish	0.3
Paint and materials		62.40		
Total Parts		$138.40		
Total Labor		322.40		10.4
Grand Total		$460.80		

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

Dummy Clearance Measurements

Test Number: CF97017
Vehicle Make: Mazda Protege
Vehicle Model Year: 1997
Seat Type: Manual adjustment (both fore/aft and seat back angle)

Manufacturer's Specifications

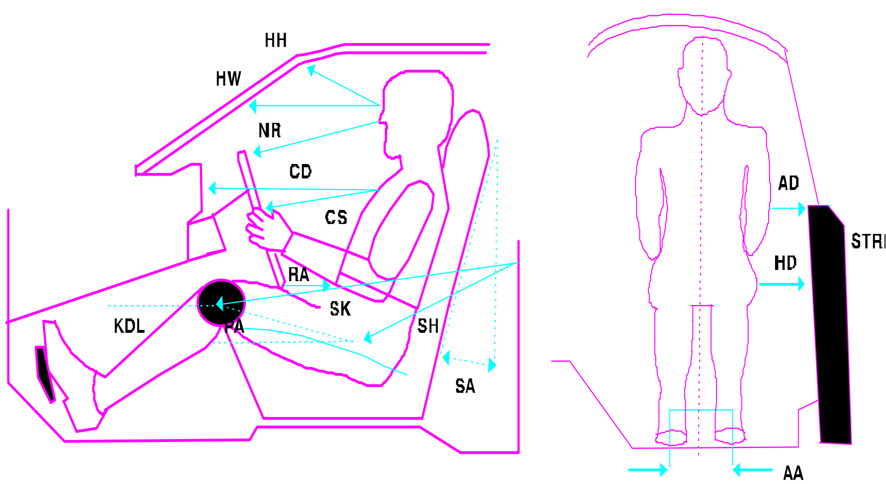
Seat Back Information: Reclined rearward to sixth position (first locking position is most upright), or nominal 21 degrees from vertical as measured on lower rear of seat back frame

Upper Belt Anchorage: Adjusted to first position below uppermost setting

Steering Column Adjustment: Midpoint

Location	Code	Measurement	Location	Code	Measurement
Head to header	HH	315	Torso angle	TA	16.5°
Head to windshield	HW	515	Striker to knee*	SK	625
Nose to rim	NR	400	Striker to knee angle*	SKA	0.2°
Chest to dash	CD	545	Striker to H-point horizontal	SHH	223
Chest to steering wheel	CS	380	Striker to H-point vertical	SHV	-93
Rim to abdomen	RA	180	Arm to door	AD	95
Pelvic angle	PA	24.7°	H-point to door	HD	205
Knee to dash left	KDL	160	Seat back angle	SA	21.1°
Knee to dash right	KDR	160	Ankle to ankle	AA	280
Chest to airbag module	ABM	255	Knee to knee	KK	325

All distance measurements are in mm.
* These measurements are made in a vertical plane containing the striker and parallel to the driver door sill.



Graph Index