Insurance Institute for Highway Safety
Crashworthiness Evaluation

Crash Test Report
1997 Ford Escort (CF97016)

Vehicle identification number: 1FALP13P9VW254954
Body style: Four-door sedan
Engine/transmission: Transverse 2.0-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:

Integrated rear center seat child restraint
Four-wheel antilock brakes

Vehicle specifications (provided by manufacturer):

Wheelbase:	250 cm
Overall length:	443 cm
Overall width:	168 cm
Curb weight:	1,114 kg

Vehicle specifications (measured):

Front bumper to firewall:	108 cm
Curb weight:	1,151 kg
Test weight:	1,294 kg
Overall width:	171 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 6, 1997

Precrash — 1997 Ford Escort

Postcrash — 1997 Ford Escort

Summary

A 1997 Ford Escort was crash tested on August 6, 1997 into a fixed deformable barrier at 39.7 mi/h (63.9 km/h) and a 40 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 that lower instrument panel in front of the dummy moved rearward 4-8 cm. Resultant intrusion in the driver footwell measured 22 cm at the footrest and 18-26 cm at other places on the toepan. The upper end of the steering column moved upward 2 cm and rearward 2 cm. All doors remained closed during the crash. The driver door required additional effort to open, but all other doors opened with ease after the crash.

The driver dummy was restrained by a three-point lap/shoulder belt and an airbag. During the crash, 3 cm of webbing spooled off the retractor. The airbag briefly contacted the dummy's chin during deployment. During rebound, the dummy's head moved downward and outward. The head then moved upward and inward so that back of the head contacted the B-pillar and head restraint. The dummy then settled into the seat.

The dummy's head contact against the B-pillar produced a peak resultant head acceleration of 58 g. The right leg had a maximum upper tibia index of 1.42 and a maximum lower tibia axial force of 5.1 kN. Cracked plastic around the ignition switch and the undamaged ignition key and lock cylinder 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 62 cm behind its center of gravity (166 cm behind the front axle). The vehicle speed recorded just prior to impact was 39.7 mi/h (63.9 km/h), and the actual overlap was 40 percent.

Structural Performance

All doors remained closed during the crash. The driver door aperture shortened 6 cm as measured at the lower edge of the window. The driver door was driven rearward and shingled slightly beneath the left rear door. As a result, the door was jammed shut and required additional effort to open after the crash. The left rear door opened with ease after the crash, but interference with the driver door prevented it from opening fully until the driver door was pulled out of the way. The right front and right rear doors opened with ease after the crash.

There was extensive tearing of the welded seam between the driver door sill and adjacent floorpan.

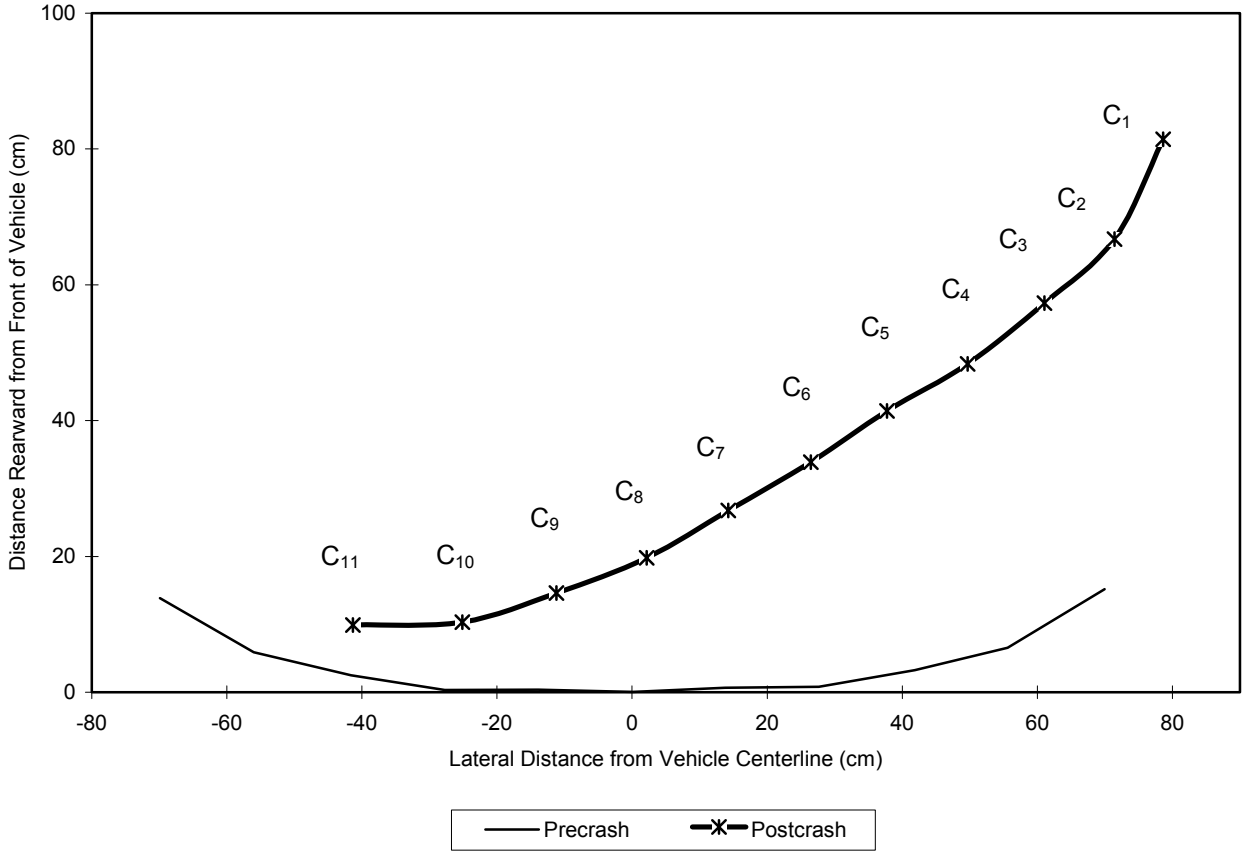
No fuel system leaks were observed after the crash. In addition, no fuel system leaks were observed when the vehicle was rotated onto its right side to allow postcrash photography.

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, floorpan stiffeners, and longitudinal and transverse members beneath the engine, which are visible in Figure 3.

Figure 1
Overhead View of Crash Deformation — 1997 Ford Escort

Figure 2
Crush Contour Measurement — 1997 Ford Escort

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)	81	67	57	48	41	34	27	20	15	10	10
Precrash Contour (cm)	15	7	3	1	1	0	0	0	2	6	14
Resulting Crush (cm)	66	60	54	47	40	34	27	20	13	4	-4

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 140 cm precrash and 120 cm postcrash.

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

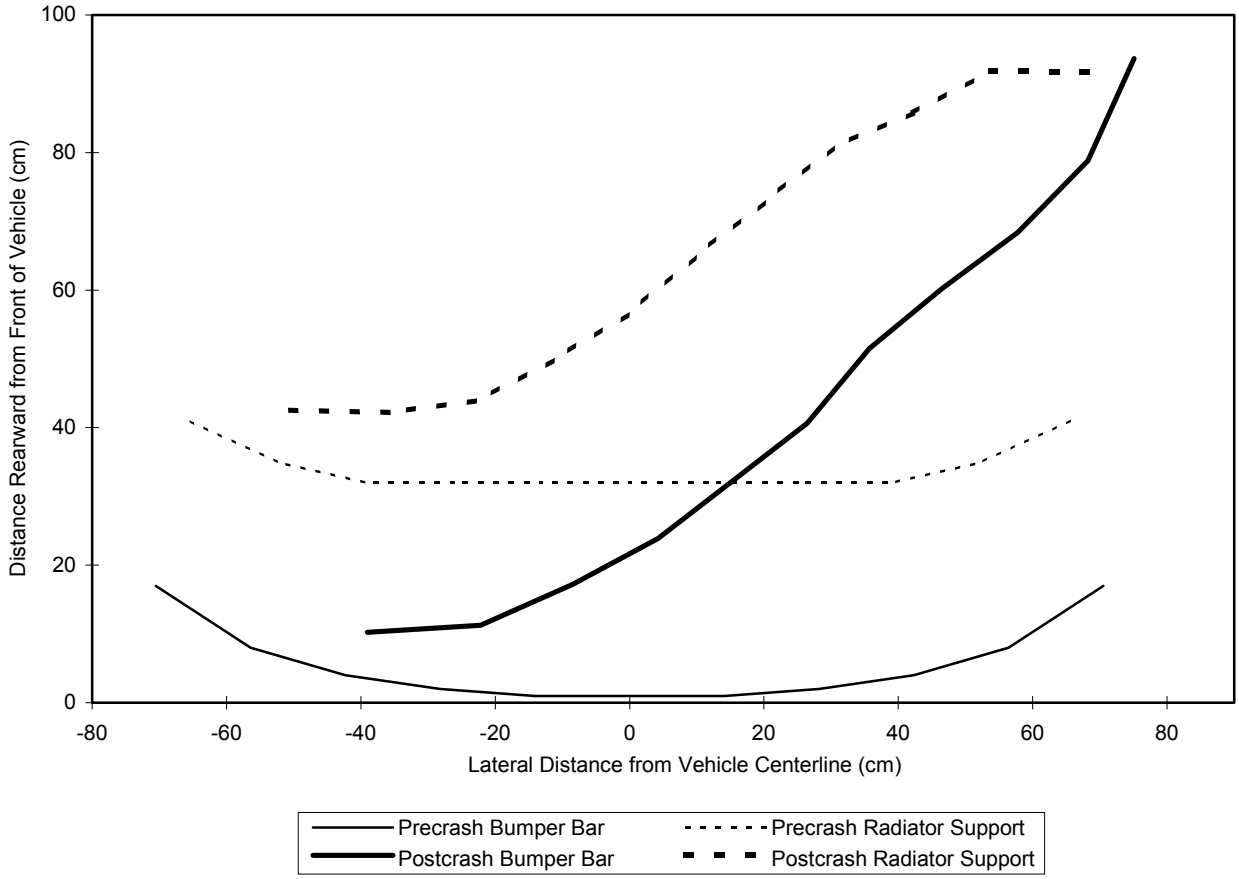
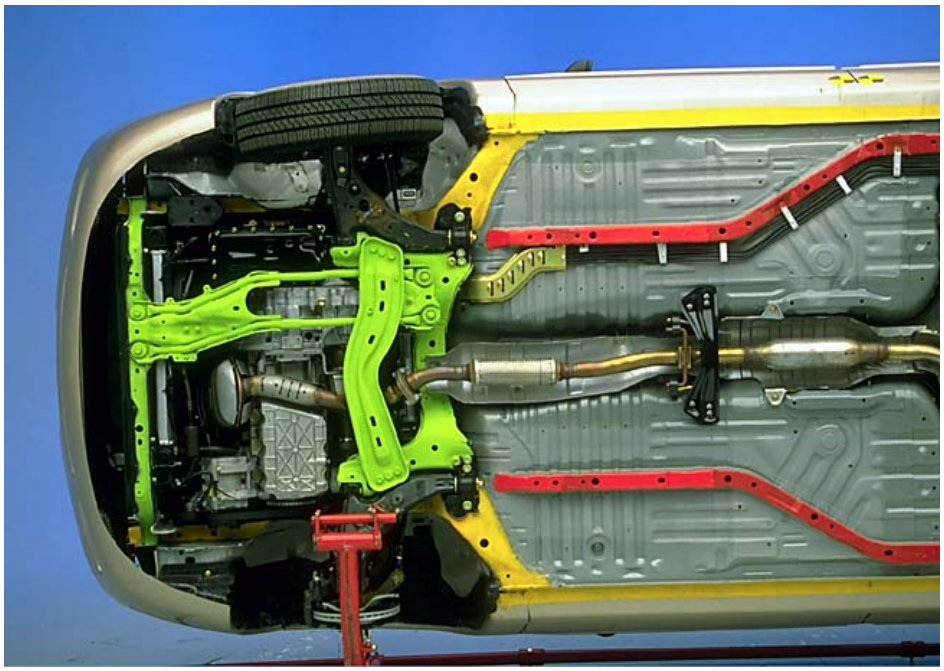


Figure 3
Precrash View from Below — 1997 Ford Escort



Postcrash View from Below — 1997 Ford Escort

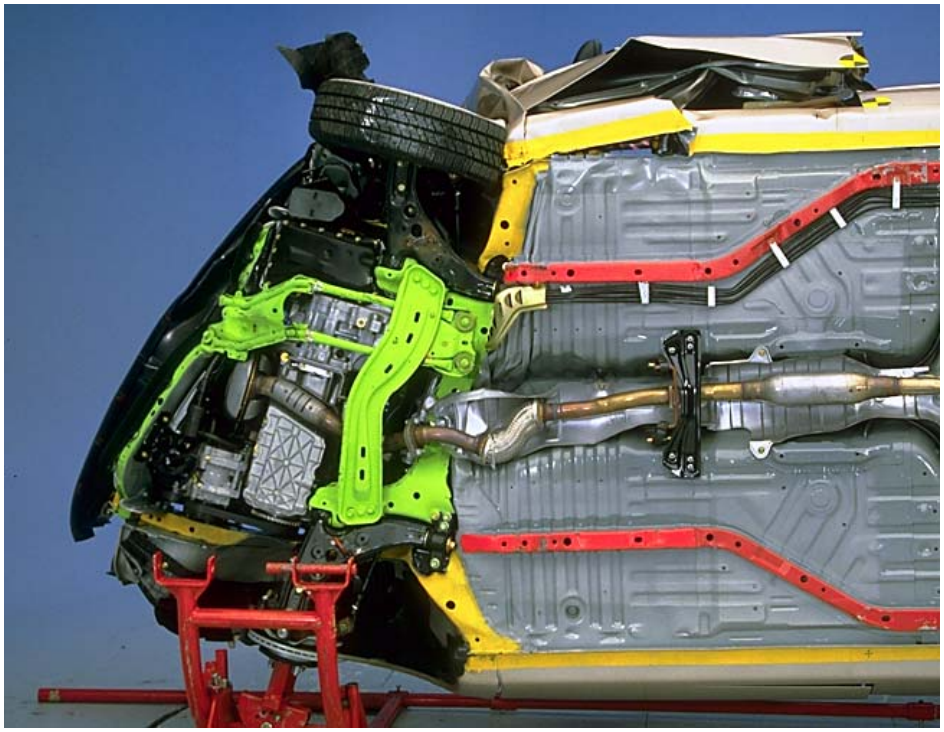
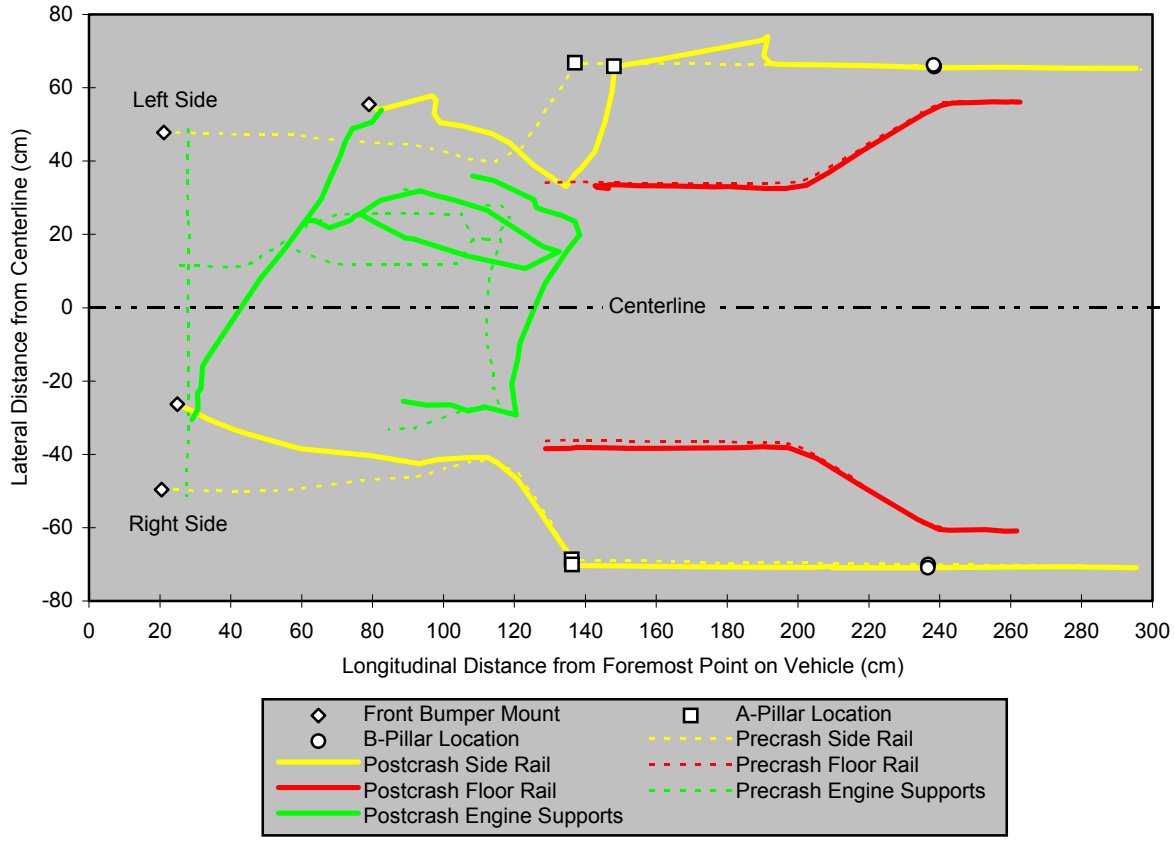
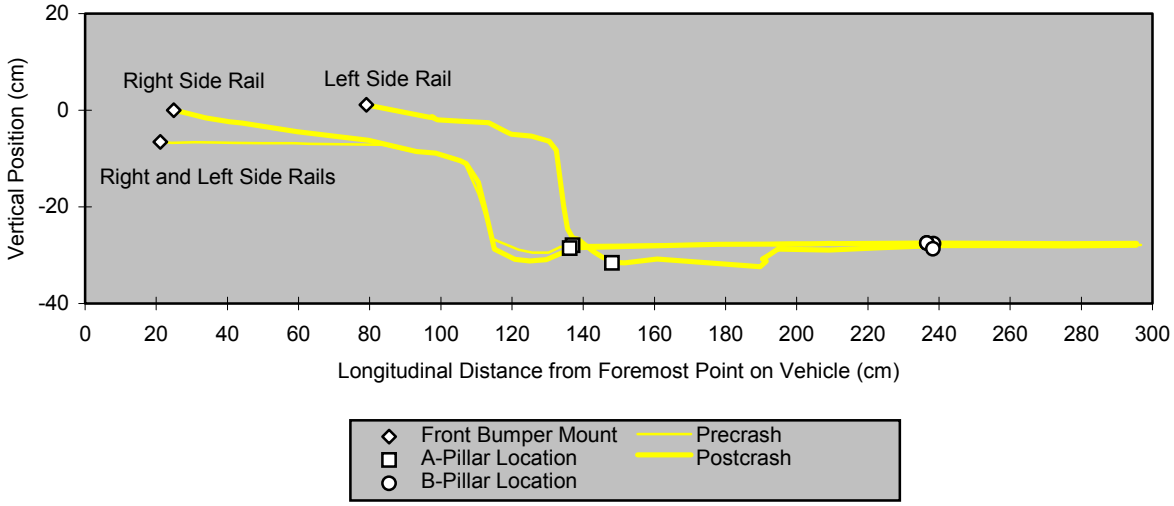


Figure 4
Frame Rail Deformation — 1997 Ford Escort

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 — 1997 Ford Escort

Selected Locations*	Longitudinal	Lateral	Vertical	Resultant
Steering column (cm)	-2	1	2	3
Left lower instrument panel (cm)	-8	-1	0	8
Right lower instrument panel (cm)	-4	0	-2	4
Brake pedal (cm)	-16	0	1	16
Left toepan (cm)	-25	-5	2	26
Center toepan (cm)	-26	-5	3	26
Right toepan (cm)	-18	-2	1	18
Footrest (cm)	-21	-3	0	22
Average displacement of the four seat-attachment bolts from the primary reference system (cm)	0	0	-1	—

* 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 67 cm in diameter, and the excursion of its center when inflated was limited by two 31 cm-long tethers. The airbag was vented by two 25 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, D, and E indicated the airbag deployed at 22 ms into the crash and appeared to be fully inflated at 44 ms.

Passenger: The corner-mounted passenger airbag deployed rearward and was untethered. The cylinder-shaped airbag was vented by two 40 mm-diameter holes located at the lateral ends. The steel-reinforced compartment cover contributed to windshield damage during deployment.

Seat Belts

This vehicle is equipped with dual-locking lap/shoulder belts with sliding latch plates 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 driver and right front passenger belts are equipped with webbing grabbers just above the retractors, but only the passenger belt has tear stitching on the webbing inside the buckle housing. During the crash, 3 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.

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 pitched forward slightly, which was confirmed by the residual measurements of intrusion.

Steering Column

The upper end of the steering column moved upward 2 cm and rearward 2 cm relative to the driver seat. The portion of the steering column between the instrument panel and firewall uses two tube-in-tubes plus a universal joint. A residual collapse of 9 cm was measured along the upper tube, above the universal joint. Another 5 cm of collapse was measured along 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 1 cm forward on left side and zero on the right.

Dummy Kinematics

Head, Neck, and Torso

Analysis of the high-speed film taken from camera positions D and E indicated the deploying airbag contacted the dummy's chin at 32 ms into the crash and receded by 36 ms. The dummy's face began to load the airbag at 60 ms into the crash (16 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 1 cm to the right of its center. As the dummy's head continued forward, it began to move leftward at 108 ms. During rebound, the dummy's head moved leftward and downward, then upward and rightward. Beginning at 214 ms, the upper left rear portion of the dummy's head contacted the B-pillar, and the right rear portion of the head contacted the outboard edge of the head restraint, as indicated by recorded head acceleration measures. The plastic trim on the B-pillar was cracked by this impact. 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 Ford Escort	
Event	**Time (ms)**
Deployment of airbag	22
Airbag contacts chin during deployment	32
Airbag fully inflated	44
Head begins to load airbag	60
Head begins to move leftward, still in contact with airbag	108
Head contacts B-pillar and head restraint	214

Legs and Feet

Left leg and foot: Paint transferred from the dummy's left knee indicated the knee contacted the knee bolster 6 cm above the left instrument panel intrusion measurement point, to the left of the steering column. The left knee also contacted the turn signal stalk and transferred a light mark onto the 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, but no paint was transferred to the hood release handle at the same location. The left foot was found with the sole of both the heel and toe pressed against the intruded toepan. The back of the heel was suspended above the floorpan. The foot was dorsiflexed to the stop and slightly everted.

Right leg and foot: Paint transferred from the dummy's right knee indicated the knee contacted the knee bolster just to the right of the steering column about 7 cm above and 6 cm to the left of the right instrument panel intrusion measurement point. This impact broke the lower right corner of the steering column plastic trim just below the ignition switch. The right knee also contacted the metal ignition lock cylinder and the lower edge of the ignition key. The jagged edges of the broken plastic and the undamaged lock cylinder and key represent possible sources of minor injury to the knee. Paint transferred from the dummy's right shin indicated the shin contacted the knee bolster directly below the right knee impact locations on the bolster and steering column. The shin impact also produced faint transfer and scuff marks that extended rightward across the bolster and onto the left side of the padded border around the radio/climate control panel. The right foot was found on the accelerator pedal with its entire sole pressed against the intruded toepan. The back of the heel was in a downward buckle in the floorpan, and the right edge of the foot was against the broken side trim of the center console. The foot was slightly dorsiflexed and slightly inverted.

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 dummy's head contact against the B-pillar produced a peak resultant head acceleration of 58 g at 222 ms. Table 3 provides a summary of the maximum head injury measurements recorded during the crash.

Table 3
Head Injury Measurements — 1997 Ford Escort

Measure	Published Tolerance Threshold	Result	Time (ms)
Vector resultant acceleration (g)	80	66	102
Vector resultant acceleration — 3 ms clip (g)	80	65	100-103
Head Injury Criterion (HIC)	1000	678	80-116
Head Injury Criterion — 15 ms interval (HIC-15)*	700	457	94-109

* 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 Ford Escort

Measure	Published Tolerance Threshold	Result	Time (ms)
A-P shear force (kN)	±3.1*	0.2	81
Axial compression force (kN)	4.0*	0.5	222
Axial tension force (kN)	3.3*	1.6	94
Flexion bending moment (Nm)	190**	11	82
Extension bending moment (Nm)	57**	19	232

* 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 Ford Escort

Measure	Published Tolerance Threshold	Result	Time (ms)
Vector resultant spine acceleration — 3 ms clip (g)	60	49	102-105
Rib compression (mm)	50	42	103
Viscous criterion (m/s)	1.0	0.2	68

Legs and Feet

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

Right leg and foot: The maximum right upper tibia A-P bending moment was 264 Nm at 67 ms. The maximum right upper tibia index was 1.42 at 67 ms. The maximum right lower tibia axial force was 5.1 kN at 67 ms.

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

Table 6
Leg and Foot Measurements — 1997 Ford Escort

Measure	Published Tolerance Threshold	Left Leg		Right Leg	
		Result	Time (ms)	Result	Time (ms)
Axial femur force (kN)	9.1*	3.2	92	3.5	67
Tibia-femur displacement (mm)	15	0	—	0	—
Upper Tibia					
L-M moment (Nm)	±225	32	51	114	66
A-P moment (Nm)	±225	67	109	264	67
Vector resultant moment (Nm)	225	70	113	287	67
Index	1.00	0.31	113	1.42	67
Lower Tibia					
L-M moment (Nm)	±225**	-46	66	-94	81
A-P moment (Nm)***	±225**	46	95	59	80
Vector resultant moment (Nm)	225**	46	66	108	81
Axial force (kN)	8.0**	1.4	48	5.1	67
Index	1.00	0.24	66	0.53	81
Foot					
A-P foot acceleration (g)	±150	-36	64	-67	65
I-S foot acceleration (g)	±150	52	92	83	63
Vector resultant foot acceleration (g)	150	54	89	101	63

* 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

1997 Ford Escort Four-Door Sedan: 5 mi/h Front into Angle Barrier

Test Number: LA97004
VIN: 1FALP13P9VW254954
Mileage: 167
Features: Driver and passenger airbags, air conditioning, automatic transmission, power steering, heated back glass, two-stage paint.

	Part		Labor	
Description	**Mfg. No**	**Price**	**Operation**	**Hours**
Bumper cover, front			Remove/reinstall	1.9
Bumper cover, front			Repair/align	1.0
Bumper cover, front			Refinish	3.7
Bumper reinforcement, front	F7CZ17C947AA	$166.85	Replace*	
Headlamps			Aim	0.5
Radiator support			Repair/align*	0.5
Panel assembly, right inner fender			Repair/align*	1.5
Panel assembly, right inner fender			Refinish	0.5
Fender, right front			Repair/align*	2.5
Fender, right front			Refinish	2.8
Paint and materials		112.00		
Total Parts		$278.85		
Total Labor		461.90		14.9
Grand Total		$740.75		

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

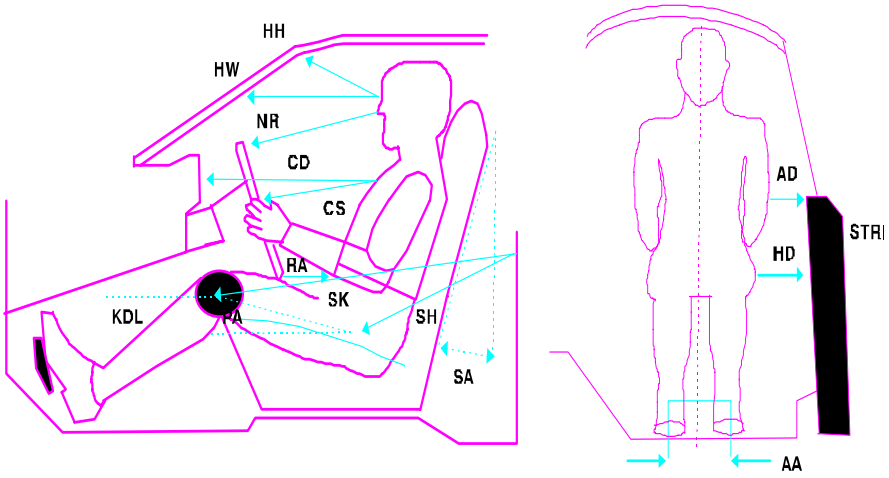
Dummy Clearance Measurements

Test Number: CF97016
Vehicle Make: Ford Escort
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 20 degrees from vertical as measured on lower rear of seat back frame
Upper Belt Anchorage: Adjusted to lowest position
Steering Column Adjustment: Midpoint of continuously adjustable range for tilt (test car has nonadjustable column)

Location	Code	Measurement	Location	Code	Measurement
Head to header	HH	320	Torso angle	TA	17.4°
Head to windshield	HW	550	Striker to knee*	SK	595
Nose to rim	NR	405	Striker to knee angle*	SKA	0.3°
Chest to dash	CD	590	Striker to H-point horizontal	SHH	185
Chest to steering wheel	CS	395	Striker to H-point vertical	SHV	-105
Rim to abdomen	RA	200	Arm to door	AD	90
Pelvic angle	PA	24.9°	H-point to door	HD	130
Knee to dash left	KDL	210	Seat back angle**	SA	21.6°
Knee to dash right	KDR	160	Ankle to ankle	AA	345

All distance measurements are in mm.
* These measurements are made in a vertical plane containing the striker and parallel to the driver door sill.
** Measured after seat back was reclined rearward to the sixth position, which is the primary determinant for this adjustment.



Graph Index