

Insurance Institute for Highway Safety Crashworthiness Evaluation

Crash Test Report 1997 Kia Sephia (CF97013)

Vehicle identification number: KNAFA1254V5275108
Body style: Four-door sedan
Engine/transmission: Transverse 1.8-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)
- 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:	250 cm
Overall length:	436 cm
Overall width:	170 cm
Curb weight:	1,123 kg

Vehicle specifications (measured):

Front bumper to firewall:	107 cm
Curb weight:	1,172 kg
Test weight:	1,316 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:

July 16, 1997

Preocrash — 1997 Kia Sephia



Postcrash — 1997 Kia Sephia



Summary

A 1997 Kia Sephia was crash tested on July 16, 1997 into a fixed deformable barrier at 40.0 mi/h (64.4 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 the lower instrument panel in front of the dummy moved rearward 9-12 cm. A thin metal sheet underlying the left lower instrument panel was compressed forward 11 cm and contacted a steel pipe 4 cm in diameter and 0.64 cm thick. Resultant intrusion in the driver footwell measured 29 cm in the area where a footrest typically would be located and 28-35 cm at other places on the toepan. The upper end of the steering column moved upward 15 cm and rearward 5 cm. All doors remained closed during the crash. The driver door required tools to open after the crash. The right rear door required additional effort to open. The right front and left rear 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, an estimated 5 cm of webbing spooled off the retractor, and an additional 27 cm of slack webbing was added to the belt loop by tearing of the force-limiting stitching. As the dummy continued forward into the inflated airbag, its head, neck, and shoulders rolled leftward off the airbag. During rebound, the dummy leaned backward through the driver door frame so that most of its head and part of its left shoulder were outside the precrash location of the door. The back of the dummy's head then contacted the B-pillar and head restraint before the dummy settled into the seat.

The left leg had a maximum femur force of 11.2 kN. The left upper tibia A-P bending moment exceeded the data channel's programmed maximum of 409 Nm for 9 ms. The maximum left upper and lower tibia indices were 1.85 and 1.69, respectively. The right leg had maximum upper and lower tibia indices of 0.92 and 1.59, respectively.

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 toepan in the area where a footrest typically would be located.

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 (162 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 40 percent.

Structural Performance

All doors remained closed during the crash. The driver door aperture shortened 18 cm as measured at the lower edge of the window. The driver door required tools to open after the crash. The right rear door required additional effort to open. The right front and left rear doors opened with ease after the crash.

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.

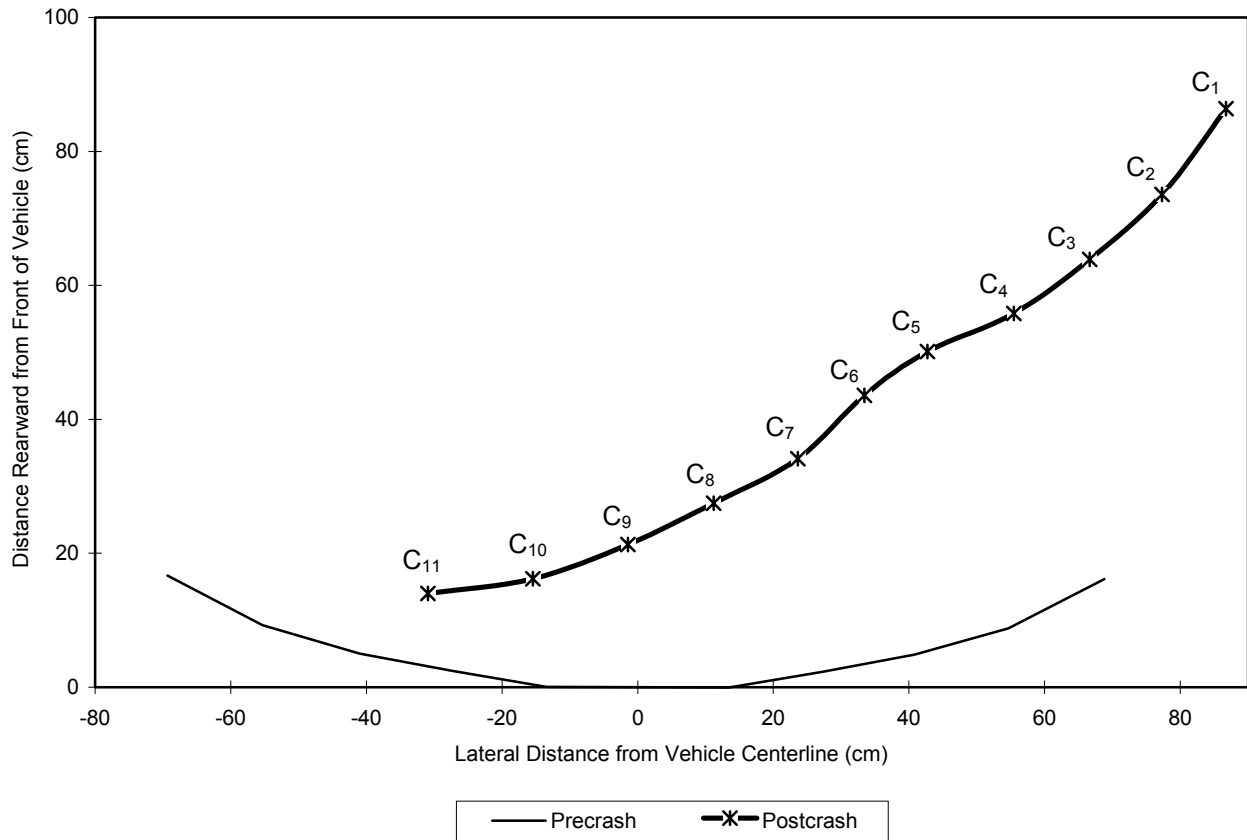
Figure 1 shows the overhead view of the crash deformation. Figure 2A illustrates the precrash and postcrash contour measures of the front bumper cover profile and the resulting permanent crush. Figure 2B illustrates the corresponding measures of both the front bumper reinforcement bar and the upper crossmember 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, lower radiator support, and crossmembers, which are visible in Figure 3.

Figure 1
Overhead View of Crash Deformation — 1997 Kia Sephia



Figure 2
Crush Contour Measurements — 1997 Kia Sephia

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)	86	74	64	56	50	44	34	27	21	16	14
Precrash Contour (cm)	16	9	5	2	0	0	0	2	5	9	17
Resulting Crush (cm)	70	65	59	54	50	44	34	25	16	7	-3

The length of the reference line was 138 cm precrash and 118 cm postcrash.

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

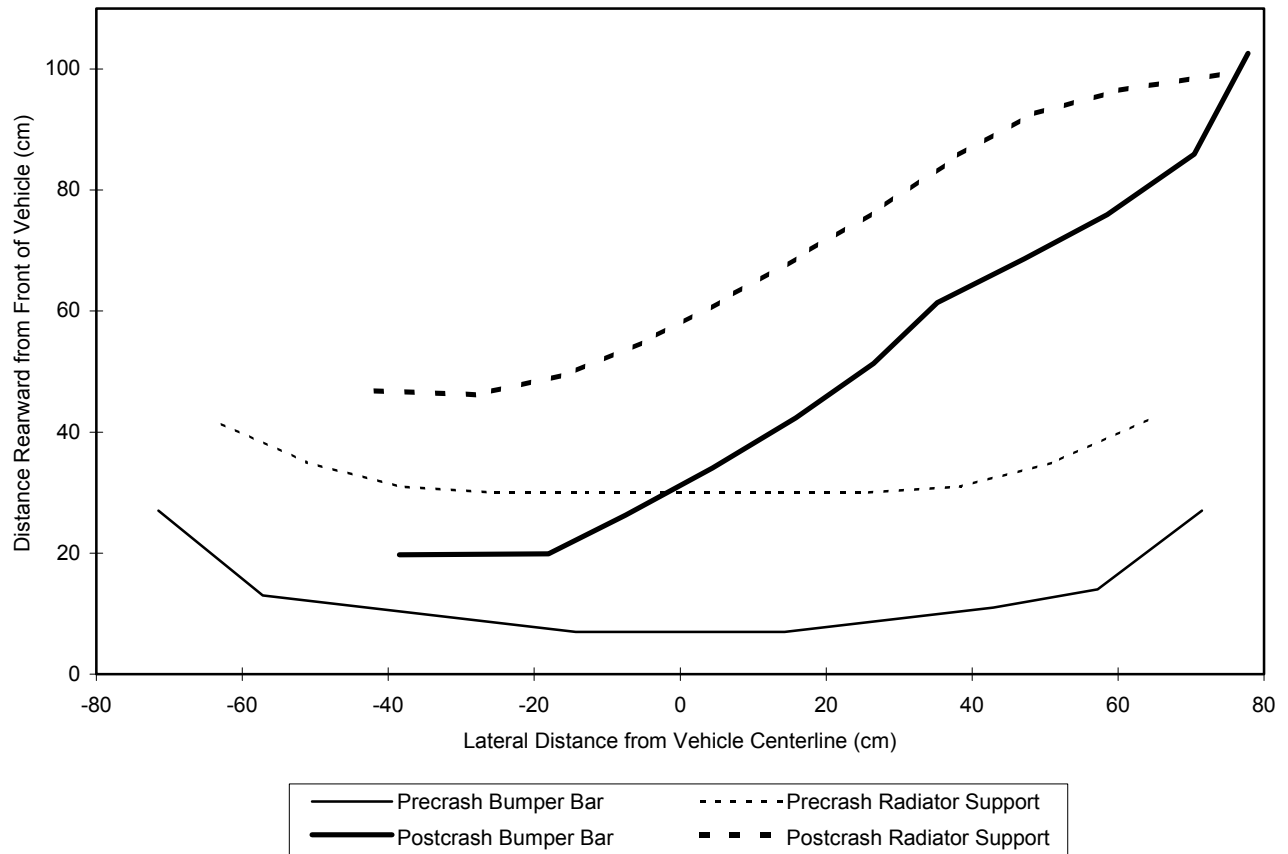
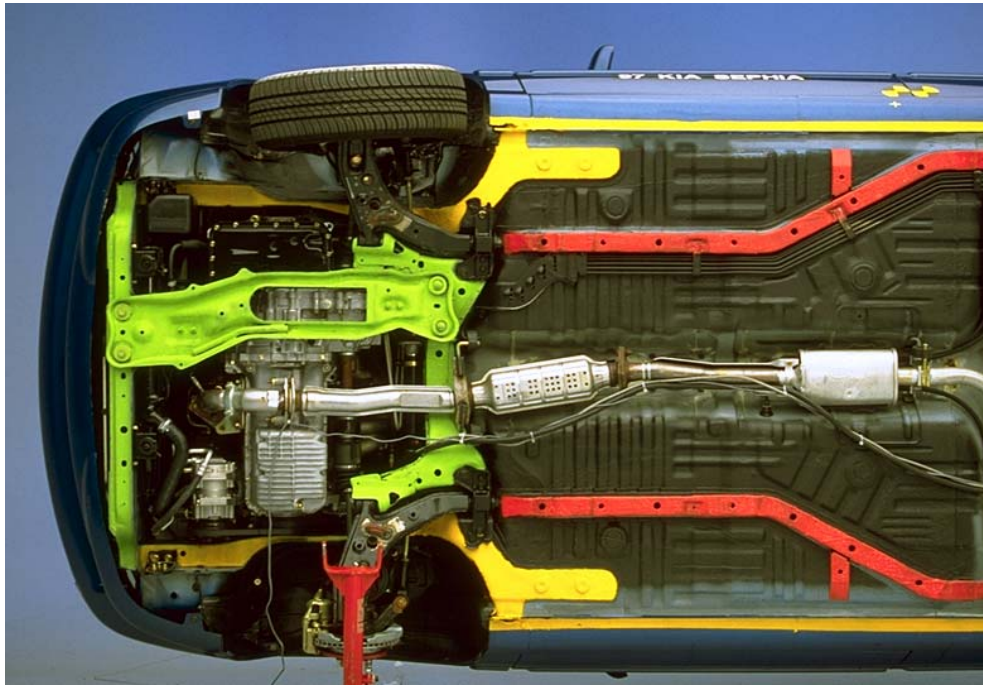


Figure 3
Preocrash View from Below — 1997 Kia Sephia

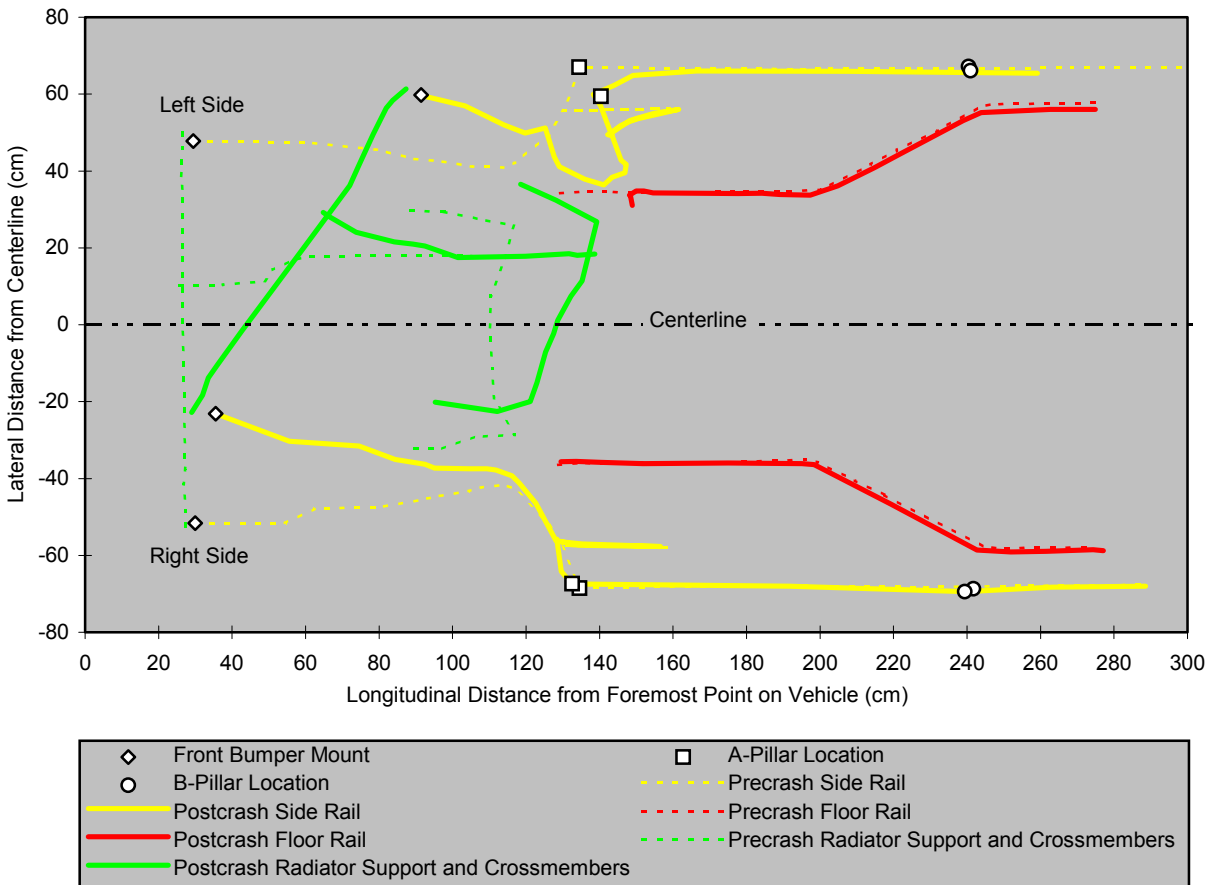


Postcrash View from Below — 1997 Kia Sephia

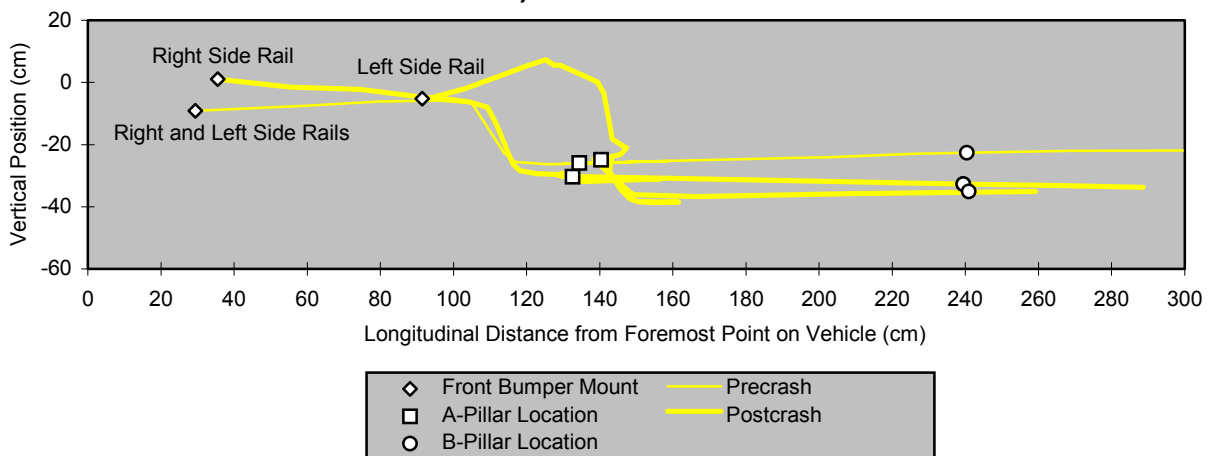


Figure 4
Frame Rail Deformation — 1997 Kia Sephia

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 Kia Sephia				
Selected Locations*	Longitudinal	Lateral	Vertical	Resultant
Steering column (cm)	-5	3	15	16
Left lower instrument panel (cm)	-12	-2	11	16
Right lower instrument panel (cm)	-9	-2	7	12
Brake pedal (cm)	-23	-3	11	25
Left toepan (cm)	-34	-2	10	35
Center toepan (cm)	-33	-3	11	35
Right toepan (cm)	-26	0	9	28
Footrest (cm)	-28	-1	7	29
Average displacement of the four seat attachment bolts from primary reference system (cm)	-3	2	-6	—

* 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 62 cm in diameter, and the excursion of its center when inflated was limited by four 29 cm-long tethers. The airbag was vented by two 20 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 film taken from camera position D indicated the airbag deployed at 16 ms into the crash and appeared to be fully inflated at 36 ms.

Passenger: The mid-mounted passenger airbag deployed horizontally and was restrained by one 57 cm-long tether. The cylinder-shaped airbag was vented by two 38 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 front outboard lower anchorage points are bolted to the B-pillars. During the crash, the amount of seat belt webbing pulled through the retractor usually is measured using a pull-string stitched to the belt webbing just outside the retractor housing. The free end of the string is pulled taut and taped against the retractor housing. The precrash position of the string relative to the tape is marked with a knot located at the upper edge of the tape. After the crash, the position of the string relative to the tape is marked, and the maximum spool-out is measured. In this crash, the spool-out could not be measured using the method stated above. The driver seat tilted to the left and pushed the retractor housing 6 cm rearward, thus increasing the amount of string pulled through the tape. A spool-out measurement of 5 cm was determined using the known precrash position of the webbing and the loading mark left by the D-ring during the crash. After the crash, the belt was positioned to its precrash location, and the location of the D-ring relative to the webbing was marked. The difference between this precrash mark and the loading mark made by the D-ring during the crash was 5 cm. In addition, the force-limiting stitching tore, adding 27 cm of additional slack webbing to the belt loop.

Seat

Postcrash examination of the driver seat rails indicated no discernible movement of the seat in its tracks during the crash. Analysis of the high-speed film taken from camera position D indicated the driver seat back maintained its position throughout the crash. Deformation of the floor under the driver seat caused the seat to tip outboard so that it contacted the B-pillar.

Steering Column

The upper end of the steering column moved upward 15 cm and rearward 5 cm relative to the driver seat. The telescoping steering column compressed 4 cm. The left shear module compressed 2 cm, but the right shear module did not compress.

Dummy Kinematics

Head, Neck, and Torso

Analysis of the high-speed film taken from camera position D indicated the dummy's face began to load the airbag at 58 ms into the crash (22 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 above its center. As the dummy's head continued forward, it rolled leftward and downward off the airbag so that the dummy's face was turned upward. During rebound, the dummy leaned backward through the door frame. At the time of its furthest lateral excursion, most of the dummy's head and part of its left shoulder were outside the precrash position of the driver door. As the dummy returned to an upright position, the back of its head moved near the

rear vertical portion of the window frame. As the car settled, the back of the dummy's head contacted the

B-pillar at 480 ms and then the head restraint at 890 ms, as indicated by film analysis and paint transfers. The dummy then settled onto the left side of the seat, with the dummy's left side resting against the B-pillar. Table 2 provides the timing and duration of these events.

Table 2 Analysis of Restraint System Performance and Dummy Kinematics — 1997 Kia Sephia	
Event	Time (ms)
Deployment of airbag	16
Airbag fully inflated	36
Head begins to load airbag	58
Head begins to rotate leftward	110
Head contacts B-pillar	480
Head contacts head restraint	890

Legs and Feet

Left leg and foot: Paint transferred from the dummy's left knee indicated the knee contacted the knee bolster 1 cm above and 5 cm to the left of the left instrument panel intrusion measurement point. This impact broke the plastic face of the bolster and compressed the underlying metal structure forward 11 cm so that the structure contacted a 4 cm-diameter, 0.6 cm-thick steel pipe running laterally underneath the instrument panel. Paint transferred from the dummy's left shin indicated the shin contacted the knee bolster directly below the left knee impact location and contributed to the damage of the bolster face. The left foot was found with the area from the ball to the toe pressed against the toepan and the rest of the foot suspended. The foot was fully dorsiflexed and slightly everted.

Right leg and foot: Paint transferred from the dummy's right knee indicated the knee contacted the knee bolster 4 cm above and 6 cm to the left of the right instrument panel intrusion measurement point and the lower right corner of the steering column trim below the ignition key. This impact cracked the steering column trim. Paint transferred from the dummy's right shin indicated the shin contacted the knee bolster below and to the right of the right knee impact location. The right knee and shin deformed the steel bracket underneath the knee bolster. The right foot was found with its sole against the toepan and accelerator pedal. The right side of the right shoe was torn by a rigid steel bracket used to mount an interior trim piece to the drive shaft tunnel. The right foot bent this bracket rearward during the crash. The right side of the foot was pressed firmly against the drive shaft tunnel. The foot was fully 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 contacts against the B-pillar and head restraint occurred after data collection ended. Table 3 provides a summary of the maximum head injury measurements recorded during the crash.

Table 3 Head Injury Measurements — 1997 Kia Sephia			
Measure	Published Tolerance Threshold	Result	Time (ms)
Vector resultant acceleration (g)	80	59	102
Vector resultant acceleration — 3 ms clip (g)	80	58	100-103
Head Injury Criterion (HIC)	1000	595	78-114
Head Injury Criterion — 15 ms interval (HIC-15)*	700	374	89-104

* 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 Kia Sephia			
Measure	Published Tolerance Threshold	Result	Time (ms)
A-P shear force (kN)	±3.1*	-0.5	111
Axial compression force (kN)	4.0*	0.2	163
Axial tension force (kN)	3.3*	2.2	103
Flexion bending moment (Nm)	190**	34	90
Extension bending moment (Nm)	57**	20	142

* 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 Kia Sephia			
Measure	Published Tolerance Threshold	Result	Time (ms)
Vector resultant spine acceleration — 3 ms clip (g)	60	53	104-107
Rib compression (mm)	50	40	91
Viscous criterion (m/s)	1.0	0.4	100

Legs and Feet

Left leg and foot: The left femur reached a maximum force of 11.2 kN and exceeded the magnitude-duration corridor with a force that exceeded 8.8 kN for slightly more than 2 ms. The actual maximum values for the upper tibia A-P bending moment, resultant bending moment, and index are greater than those indicated in Table 6 because the A-P bending moment exceeded the data channel's programmed maximum of 409 Nm for 9 ms. The left lower tibia had a maximum index of 1.69.

Right Leg and Foot. The right upper tibia had a maximum index of 0.92. The right lower tibia had a maximum index of 1.59.

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

Table 6 Leg and Foot Measurements — 1997 Kia Sephia					
Measure	Published Tolerance Threshold	Left Leg		Right Leg	
		Result	Time (ms)	Result	Time (ms)
Axial femur force (kN)	9.1*	11.2	92	3.8	77
Tibia-femur displacement (mm)	15	2	79	8	105
Upper Tibia					
L-M moment (Nm)	±225	48	135	114	65
A-P moment (Nm)	±225	409***	103	158	60
Vector resultant moment (Nm)	225	410	103	182	64
Index	1.00	1.85	112	0.92	64
Lower Tibia					
L-M moment (Nm)	±225**	-31	69	78	65
A-P moment (Nm)	±225**	372	78	336	75
Vector resultant moment (Nm)	225**	372	78	336	75
Axial force (kN)	8.0**	2.0	71	3.9	64
Index	1.00	1.69	78	1.59	75
Foot					
A-P foot acceleration (g)	±150	-56	69	-89	58
I-S foot acceleration (g)	±150	94	70	119	59
Vector resultant foot acceleration (g)	150	102	70	149	59

* This critical value is for instantaneous loading. Femur loads are compared to 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.

*** A-P moment exceeded the data channel's programmed maximum of 409 Nm at 103-112 ms.

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 Kia Sephia Four-Door Sedan: 5 mi/h Front into Angle Barrier

Test Number: LR97005

VIN: KNAFA1254V5275108

Mileage: 28

Features: Driver and passenger airbags, air conditioning, automatic transmission, power steering, heated back glass, two-stage paint.

Description	Part		Labor	
	Mfg. No	Price	Operation	Hours
Bumper reinforcement, front	0K24A 50 070F	\$213.05	Replace*	1.9
Bumper cover, front			Repair/align	1.0
Bumper cover, front			Refinish	3.2
Bumper absorber, front			Repair/align	0.5
Bumper mounting bracket, right front		Included**	Replace*	
Headlamps			Aim	0.5
Lens and housing, turn signal lamp, right front	0K240 51 061	\$33.30	Replace	
Radiator support			Repair/align*	1.5
Radiator support			Refinish	0.5
Inner fender panel, right front			Repair/align*	1.0
Sidemember, left front			Repair/align*	0.5
Sidemember, right front			Repair/align*	2.5
Fender, right front			Repair/align*	0.5
Paint and materials		59.20		
Total Parts		\$305.55		
Total Labor		421.60		13.6
Grand Total		\$727.15		

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

** Part included with front bumper reinforcement bar.

Dummy Clearance Measurements

Test Number: CF97013
Vehicle Make: Kia Sephia
Vehicle Model Year: 1997
Seat Type: Manual adjustment

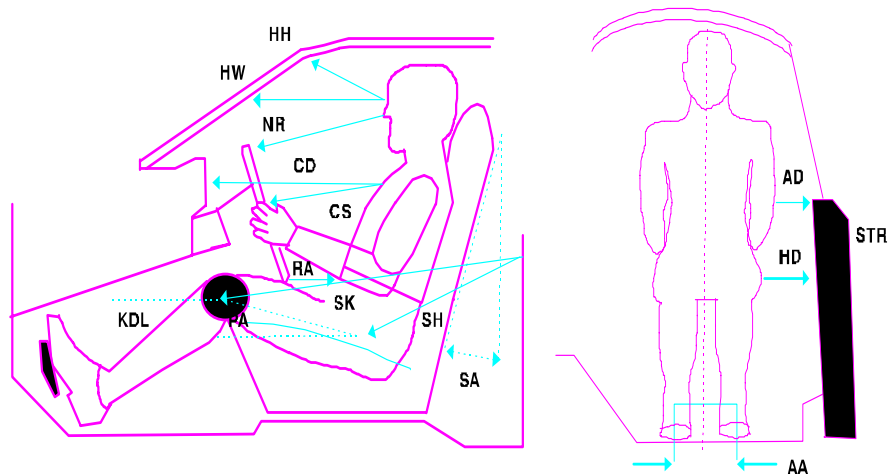
Manufacturer's Specifications

Seat Back Information: Reclined to fifth notch rearward from full vertical position
Upper Belt Anchorage: Adjusted to uppermost position
Steering Column Adjustment: Not adjustable

Location	Code	Measurement	Location	Code	Measurement
Head to header	HH	300	Torso angle	TA	14.3°
Head to windshield	HW	485	Striker to knee*	SK	590
Nose to rim	NR	415	Striker to knee angle*	SKA	2.8°
Chest to dash	CD	590	Striker to H-point	SHH	170
			horizontal		
Chest to steering wheel	CS	380	Striker to H-point	SHV	-110
			vertical		
Rim to abdomen	RA	210	Arm to door	AD	90
Pelvic angle	PA	24.7°	H-point to door	HD	160
Knee to dash left	KDL	220	Seat back angle	SA	19.5°
Knee to dash right	KDR	195	Ankle to ankle	AA	350
Chest to airbag module	ABM	265	Knee to knee	KK	370

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

A-1	Vehicle longitudinal acceleration (X)
A-2	Vehicle lateral acceleration (Y)
A-3	Vehicle vertical acceleration (Z)
A-4	Vehicle vector resultant acceleration
A-5	Head A-P acceleration (X)
A-6	Head lateral acceleration (Y)
A-7	Head I-S acceleration (Z)
A-8	Head vector resultant acceleration
A-9	Neck A-P force (X)
A-10	Neck axial force
A-11	Neck occipital A-P bending moment
A-12	Neck tension — force by duration analysis
A-13	Neck compression — force by duration analysis
A-14	Neck shear (positive) — force by duration analysis
A-15	Neck shear (negative) — force by duration analysis
A-16	Chest compression
A-17	Chest A-P acceleration (X)
A-18	Chest lateral acceleration (Y)
A-19	Chest I-S acceleration (Z)
A-20	Chest vector resultant acceleration
A-21	Chest Viscous Criterion
A-22	Left femur axial force
A-23	Left femur — force by duration analysis
A-24	Left tibia-femur displacement
A-25	Left upper tibia L-M bending moment
A-26	Left upper tibia A-P bending moment
A-27	Left upper vector resultant moment
A-28	Left lower tibia L-M bending moment
A-29	Left lower tibia A-P bending moment
A-30	Left lower vector resultant moment
A-31	Left lower tibia axial force
A-32	Left foot vector acceleration
A-32a	Left foot A-P acceleration
A-32b	Left foot I-S acceleration
A-33	Right femur axial force
A-34	Right femur — force by duration analysis
A-35	Right tibia-femur displacement
A-36	Right upper tibia L-M bending moment
A-37	Right upper tibia A-P bending moment
A-38	Right upper vector resultant moment
A-39	Right lower tibia L-M bending moment
A-40	Right lower tibia A-P bending moment
A-41	Right lower vector resultant moment
A-42	Right lower tibia axial force
A-43	Right foot vector acceleration
A-43a	Right foot A-P acceleration
A-43b	Right foot I-S acceleration