


Special issue: head protection in side impacts

STATUS REPORT

INSURANCE INSTITUTE
FOR HIGHWAY SAFETY

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You could
SURVIVE

a severe crash like
this because of
new technology —

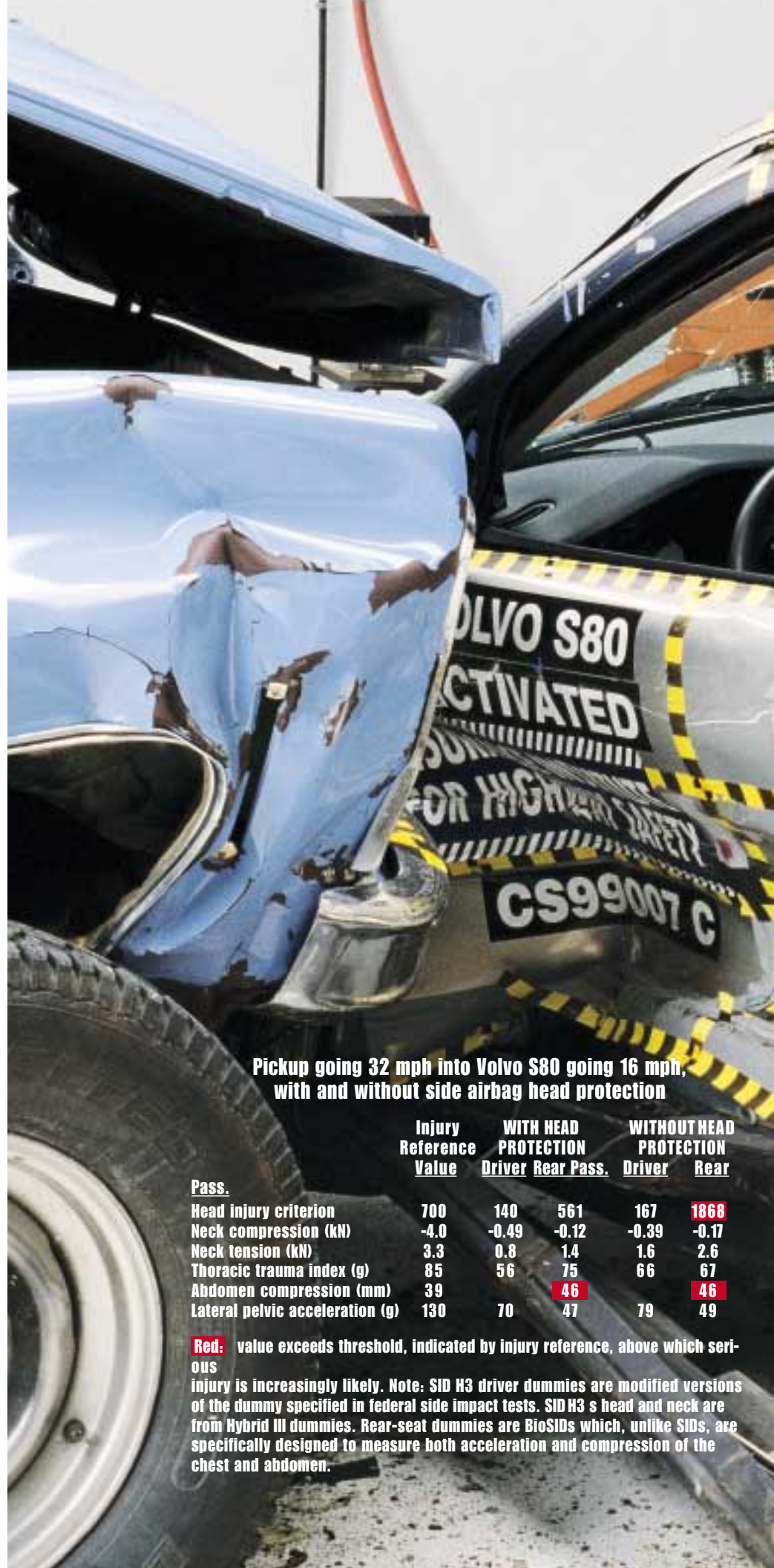
side airbag head protection. Many cars, including not only luxury models but also some popular and less expensive cars, are being equipped with side airbags designed to protect people's heads. New Institute crash tests of the BMW X5 and Volvo S80 — car-into-pole and vehicle-to-vehicle tests — demonstrate the important benefits afforded to occupants by these side airbag head protection systems.

Pickup truck into side of Volvo S80: The Institute conducted two crash tests in which the fronts of Chevrolet pickup trucks struck the sides of 1999 Volvo S80s. The S80 in one test included side airbag head protection, while in the other test the S80 didn't (both S80s had side airbags for torso protection). In each test, the pickup was going 32 mph, the S80 16 mph. Results show the head airbags provide very important protection in addition to what is afforded by the torso bags.

In the test without the head protection airbag, the heads of the driver and rear passenger dummies were struck by the hood of the pickup truck. The forces recorded on the rear-seat dummy's head were high — in fact, sufficient to cause fatal head injuries. The driver dummy's head contact didn't produce high forces, but the fact that the contact occurred means the head barely escaped severe impact. In contrast, in the test with the head protection airbag both dummies recorded low head forces because the inflatable curtain provided a cushion between the dummies' heads and the hood of the pickup truck.

Injury measures taken from the dummies' torsos were similar in the two Volvo S80s, with and without head protection. In both cars, these measures were low except for abdomen compression on the rear-seat dummies, which were at levels at which a person could sustain serious, though survivable, injuries to the spleen, kidney, or colon.

"These tests demonstrate that head airbags can make very serious vehicle-to-vehicle side impacts survivable by preventing the intruding vehicle structure from striking occupants' heads. Without head airbags, serious or fatal head injuries become more likely," says Institute president Brian O'Neill.



Pickup going 32 mph into Volvo S80 going 16 mph, with and without side airbag head protection

	Injury Reference Value	WITH HEAD PROTECTION		WITHOUT HEAD PROTECTION	
		Driver	Rear Pass.	Driver	Rear
Pass.					
Head injury criterion	700	140	561	167	1868
Neck compression (kN)	-4.0	-0.49	-0.12	-0.39	-0.17
Neck tension (kN)	3.3	0.8	1.4	1.6	2.6
Thoracic trauma index (g)	85	56	75	66	67
Abdomen compression (mm)	39		46		46
Lateral pelvic acceleration (g)	130	70	47	79	49

Red: value exceeds threshold, indicated by injury reference, above which serious injury is increasingly likely. Note: SID H3 driver dummies are modified versions of the dummy specified in federal side impact tests. SID H3's head and neck are from Hybrid III dummies. Rear-seat dummies are BioSIDs which, unlike SIDs, are specifically designed to measure both acceleration and compression of the chest and abdomen.



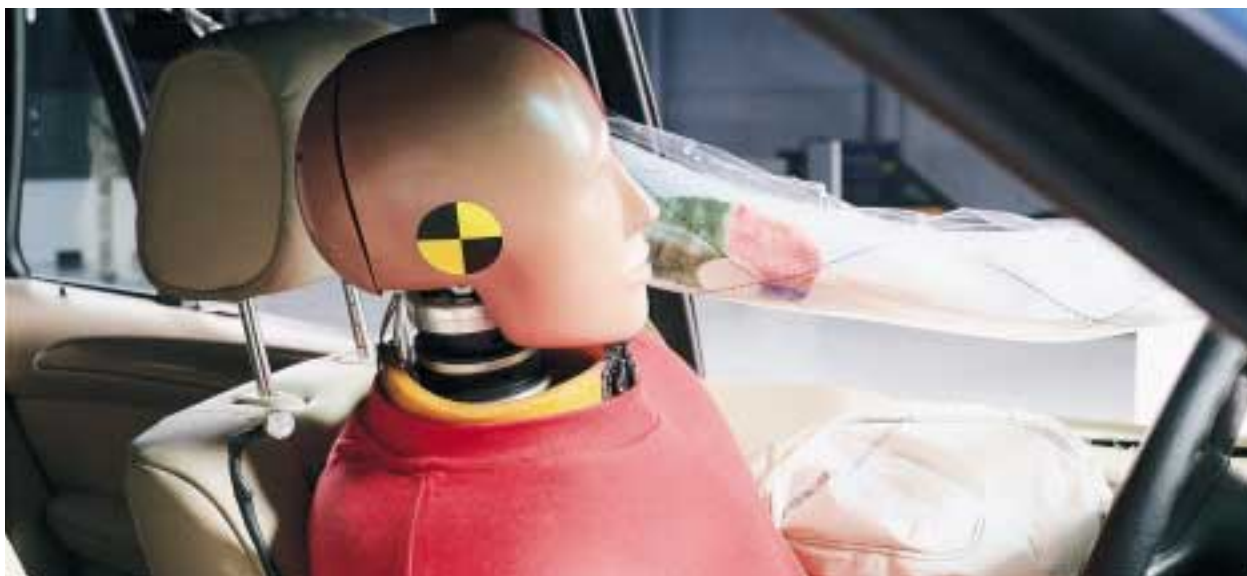
Car-into-pole crash tests: The Institute also conducted side-into-pole crash tests of a BMW X5 and Volvo S80, both equipped with side airbag head protection — an inflatable curtain in the Volvo and an inflatable tube-shaped airbag in the BMW. In each test, the vehicle was propelled sideways at 18 mph into a rigid pole.

The 18 mph speed of this test “might not sound like one at which a crash could be serious,” O’Neill says, “but impacts into rigid objects such as poles or trees at 18 mph are, in fact, very severe.” The intrusion into the X5 and S80 indicates the severity. The pole is relatively narrow, so there was major penetration into the side of each car. Yet the forces recorded on the dummies’ heads in these tests were low.

This isn’t the first time the Institute has tested a BMW with head protection airbags (see *Status Report*, Dec. 27, 1997).

“All of these tests demonstrate that people can survive serious side impact crashes in the real world because head airbags prevent their heads from striking rigid objects,” O’Neill says. He adds that “side airbags with head protection represent a very important safety development that will save lives and prevent major head trauma in a range of serious side impact crashes.”

All four recent crash tests involving Volvos and a BMW were conducted in cooperation with the automakers.



2001 BMW X5 with side airbag head protection, 18 mph
Head injury criterion
Neck compression (kN)
Neck tension (kN)
Thoracic trauma index
Abdomen compression
Lateral pelvic acceleration

1999 Volvo S80 with side airbag head protection, 18 mph
Head injury criterion
Neck compression (kN)
Neck tension (kN)
Thoracic trauma index
Abdomen compression
Lateral pelvic acceleration
Note: test dummy (SID H)



Side impacts with fatal head injuries when intruding vehicles struck occupants heads; crashes show need for side airbags with head protection

Almost 10,000 occupant deaths occur each year in side impact crashes, and head injuries cause more than half of these deaths. Head injuries are the cause of death in 51-74 percent of single-vehicle side impacts and 41-64 percent of multiple-vehicle side impacts. Thirty-eight percent of single-vehicle side impact crash deaths occur when vehicles strike trees or poles on the dead occupants' side of the vehicle. In two-vehicle side impact crashes, 38 percent of car occupant deaths occur when a pickup or sport utility vehicle strikes the car.

Passenger vehicle occupant deaths in side impact crashes

Crash type	Single-vehicle	Multiple-vehicle	Total
All	14,733	17,210	31,943
Side impact	2,957	6,700	9,657
Side impact with fatal head injury	1,500-2,200	2,700-4,300	4,200-6,500

Source: FARS (1999), NASS/CDS (1995-99)



Three fatal side impacts in which intruding vehicles hit the heads of people in struck vehicles:

1993 Pontiac Grand Am was struck by a 1972 GMC full-size pickup truck. The Grand Am's 29-year-old female driver died from massive injuries to her head, neck, chest, and abdomen. A 72-year-old passenger in the rear seat also was killed.



1991 Chevrolet Geo was struck by a 1997 Ford pickup truck. The Geo's 23-year-old male driver was killed. His injuries included chest trauma plus fatal injuries when the hood of the intruding pickup struck his head.



1997 Plymouth Breeze was struck by a 1985 Chevrolet Blazer. The Breeze's 30-year-old female driver was killed. Her injuries included head trauma when the intruding Blazer's hood struck her head.

Chart reproduced on page 9 of this PDF file

Side airbag Intrusion into pole	Injury Reference Value	Test Result
	700	439
	-4.0	-0.47
	3.3	1.5
(g)	85	51
(mm)		
Acceleration (g)	130	43
Side airbag Intrusion into pole		
	700	265
	-4.0	-0.16
	3.3	1.0
(g)	85	37
(mm)		
Acceleration (g)	130	43

(3) doesn't record abdomen compression

New crash test barrier is key to improving side impact protection

A lineup of Mercury Grand Marquis sedans, each with major crash damage on the driver side, is one sign of the new side impact research going on at the Institute's Vehicle Research Center.

The Institute has been developing alternative side impact test procedures. This work is intended to lead to a consumer information program to rate vehicles on side impact protection. The effort is similar to the Institute's frontal offset test program, which informs consumers and encourages automakers to improve vehicle designs for frontal crashworthiness. The test program also may form the basis for future changes to side impact requirements under Federal Motor Vehicle Safety Standard (FMVSS) 214.

New side impact tests are needed in part because neither FMVSS 214 nor the government's consumer test program, the Lateral Impact New Car Assessment Program, addresses occupant head protection. In fact, the side impact dummies, or SIDs, used in these tests don't record head forces.

Plus the barrier used for both test programs is outdated. Mounted on a movable cart, the FMVSS 214 barrier hits the side of

another vehicle to simulate an intersection-type crash. But the size of the barrier is based on cars of the late 1970s, which aren't typical of today's fleet with its proliferation of heavy, high-riding sport utility vehicles.

In the government tests, there's no chance that the SIDs in the struck vehicle will be hit by the intruding barrier. "Yet in serious real-world side impacts people's heads often are struck by intruding vehicles," Institute president Brian O'Neill points out. "Head injuries are especially likely when a relatively high vehicle like an SUV hits the side of a car."

Side impacts involving high-riding vehicles striking cars are classic examples of crashes in which side airbags for people's heads can provide effective protection.

"Today's tests should recognize the protection possible with side impact head airbags. This technology wasn't even a concept when FMVSS 214 was under consideration. But now it's in cars, and the extra protection should be reflected in tests to provide consumers with safety information. Testing with a barrier higher than the one used for FMVSS 214 is a necessary first step," O'Neill adds.

The new prototype barrier being used in side impact tests conducted by the Institute is based on the FMVSS 214 barrier, but it stands about 12 inches taller in part because it's raised higher off the ground like SUVs and

pickups. It's also contoured to resemble the fronts of late-model SUVs. Like the FMVSS 214 barrier, its face is deformable to represent the crushable front end of a striking vehicle.

So far, the Institute has conducted four tests with the new barrier. Each test simulates an intersection crash in which a striking vehicle moving at 30 mph, represented by the barrier, hits the driver side of a vehicle going 15 mph. Injury measures are recorded on a dummy in the driver seat and another in the left rear seat.

SIDs used in government crash tests aren't very sophisticated dummies. This is why the Institute and others are considering more advanced alternative dummies including EuroSID2 and SID-IIs (see *Status Report*, Sept. 28, 1996).

SID-IIs is a small (5th percentile) female, while the others represent 50th percentile males. Shorter women may be more likely to be struck in the head by an intruding vehicle in a side impact, which is one argument for using SID-IIs. However, it's not yet clear which dummy ultimately will be selected for use in the new side impact tests.

Transport Canada is working with the Institute on tests using the new barrier and SID-IIs. The Institute also will share progress reports on this program with the National Highway Traffic Safety Administration, automakers, and other groups.



2001 models with side airbag head protection

The designs of side airbag head protection systems in BMWs and Volvos (see cover story) aren't the same. The BMW design is a tube-shaped airbag that inflates from the roof to protect occupants' heads. Volvo's side airbags are curtain designs that deploy from the roof. Other side airbags in 2001 models deploy from the vehicle seat, inflating forward and upward to cushion an occupant's head and chest.

Make	std or opt	type	Make	std or opt	type
AUDI			LINCOLN		
A4	standard	inflatable curtain	Continental	standard	dual-chamber thorax bag
A6	standard	inflatable curtain	LS	standard	dual-chamber thorax bag
A8	standard	inflatable curtain	Navigator	standard	dual-chamber thorax bag
allroad	standard	inflatable curtain	Town Car	standard	dual-chamber thorax bag
TT	standard	dual-chamber thorax bag	MAZDA		
S4	standard	inflatable curtain	626	optional	dual-chamber thorax bag
BMW			Millenia	standard	dual-chamber thorax bag
3 series (except convertible)	standard	inflatable tubular structure	MPV	optional	dual-chamber thorax bag
5 series	standard	inflatable tubular structure	Protege	optional	dual-chamber thorax bag
7 series	standard	inflatable tubular structure	Tribute	optional	dual-chamber thorax bag
X5	standard	inflatable tubular structure	MERCEDES		
BUICK			CL class	standard	inflatable curtain
Century	optional	dual-chamber thorax bag	C class	standard	inflatable curtain
Regal	optional	dual-chamber thorax bag	E class	standard	inflatable curtain
CADILLAC			S class	standard	inflatable curtain
Seville	standard	dual-chamber thorax bag	MERCURY		
CHEVROLET			Cougar	optional	dual-chamber thorax bag
Impala	optional	dual-chamber thorax bag	Mountaineer	optional	dual-chamber thorax bag
Monte Carlo	optional	dual-chamber thorax bag	Sable	optional	dual-chamber thorax bag
Venture	standard	dual-chamber thorax bag	NISSAN		
CHRYSLER			Altima	optional	dual-chamber thorax bag
300M	optional	dual-chamber thorax bag	Maxima	optional	dual-chamber thorax bag
Concorde	optional	dual-chamber thorax bag	Pathfinder	optional	dual-chamber thorax bag
LHS	optional	dual-chamber thorax bag	Sentra	optional	dual-chamber thorax bag
PT Cruiser	optional	dual-chamber thorax bag	OLDSMOBILE		
Sebring 4-door	optional	inflatable curtain	Silhouette	standard	dual-chamber thorax bag
Town & Country	optional	dual-chamber thorax bag	PLYMOUTH		
Voyager	optional	dual-chamber thorax bag	Neon	optional	dual-chamber thorax bag
DODGE			PONTIAC		
Caravan/Grand Caravan	optional	dual-chamber thorax bag	Montana	standard	dual-chamber thorax bag
Intrepid	optional	dual-chamber thorax bag	PORSCHE		
Neon	optional	dual-chamber thorax bag	911	standard	dual-chamber thorax bag
Stratus 4-door	optional	inflatable curtain	Boxster	standard	dual-chamber thorax bag
FORD			SAAB		
Escape	optional	dual-chamber thorax bag	9-3	standard	dual-chamber thorax bag
Expedition	optional	dual-chamber thorax bag	9-5	standard	dual-chamber thorax bag
Explorer	optional	dual-chamber thorax bag	SATURN		
Focus	optional	dual-chamber thorax bag	L series	optional	inflatable curtain
Taurus	optional	dual-chamber thorax bag	S series	optional	inflatable curtain
Windstar	optional	dual-chamber thorax bag	TOYOTA		
HYUNDAI			Sequoia	optional	inflatable curtain
Elantra	standard	dual-chamber thorax bag	VOLKSWAGEN		
Sonata	standard	dual-chamber thorax bag	Cabrio	standard	dual-chamber thorax bag
XG300	standard	dual-chamber thorax bag	Golf	standard	inflatable curtain
INFINITI			Jetta	standard	inflatable curtain
G20	standard	dual-chamber thorax bag	Passat	standard	inflatable curtain
I30	standard	dual-chamber thorax bag	VOLVO		
Q45	standard	dual-chamber thorax bag	C70	standard	dual-chamber thorax bag
QX4	standard	dual-chamber thorax bag	S40	standard	inflatable curtain
JAGUAR			V40	standard	inflatable curtain
S type	standard	dual-chamber thorax bag	S60	standard	inflatable curtain
XK	standard	dual-chamber thorax bag	S80	standard	inflatable curtain
LEXUS			V70	standard	inflatable curtain
LS 430	standard	inflatable curtain			
GS 300/430	standard	inflatable curtain			

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This special issue focuses on head protection in side impact crashes. Recent special issues have focused on the following subjects:

State traffic safety laws	35:10 (2000)
Driver death rates	35:7 (2000)
Federal airbag rule	35:6 (2000)
Cosmetic repair parts	35:2 (2000)
Graduated licensing	34:10 (1999)
Vehicle compatibility in crashes	34:9 (1999)
Child safety	34:8 (1999)
Neck injuries	34:5 (1999)
Vehicle safety advancements	34:4 (1999)
Pedestrian deaths, injuries	34:3 (1999)
Truck safety	33:8 (1998)
Urban crashes	33:4 (1998)
Crash compatibility	33:1 (1998)



kill almost 10,000 vehicle occupants per year

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Warrior Insurance Group
Yasuda Fire & Marine of America
Zurich U.S.

Chart from pages 4-5

<u>2001 BMW X5 with side airbag head protection, 18 mph into pole</u>	<u>Injury Reference Value</u>	<u>Test Result</u>
Head injury criterion	700	439
Neck compression (kN)	-4.0	-0.47
Neck tension (kN)	3.3	1.5
Thoracic trauma index (g)	85	51
Abdomen compression (mm)		
Lateral pelvic acceleration (g)	130	43

<u>1999 Volvo S80 with side airbag head protection, 18 mph into pole</u>		
Head injury criterion	700	265
Neck compression (kN)	-4.0	-0.16
Neck tension (kN)	3.3	1.0
Thoracic trauma index (g)	85	37
Abdomen compression (mm)		
Lateral pelvic acceleration (g)	130	43

Note: test dummy (SID H3) doesn't record abdomen compression