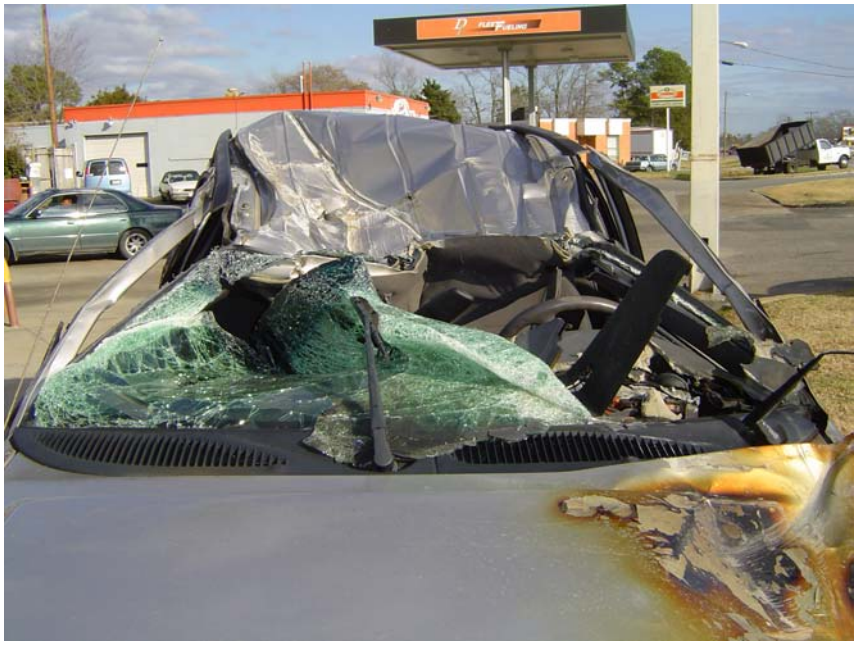
Safety Briefing on Roof Crush



How a Strong Federal Roof Crush Standard Can Save Many Lives
&
Why the Test Must Include Both Sides of the Roof

~ Public Citizen ~
www.citizen.org

The Importance of Far Side Safety in Rollover Crashes

- The current National Highway Traffic Safety Administration (NHTSA) test for roof strength is a static test that applies a platen on only one side of the vehicle.
- Yet a NHTSA study from July 2004 (Roof Crush Analysis Using 1997-2001 NASS Case Review) stated "[g]enerally, it was found that roof deformation was most severe on the side of the vehicle *opposite the side that makes first contact with the ground*."
- More than 26,000 people are seriously injured or killed in rollovers every year, including over 10,000 deaths. Yet NHTSA officials predict that only 50 lives would be saved by its new standard – **preventing just *one-half of one percent* of the rollover deaths each year.**
- As below, minimal changes to the agency's test would do little prevent the loss of life. A one-sided test does little to protect occupants because most severe injuries occur on the far side.

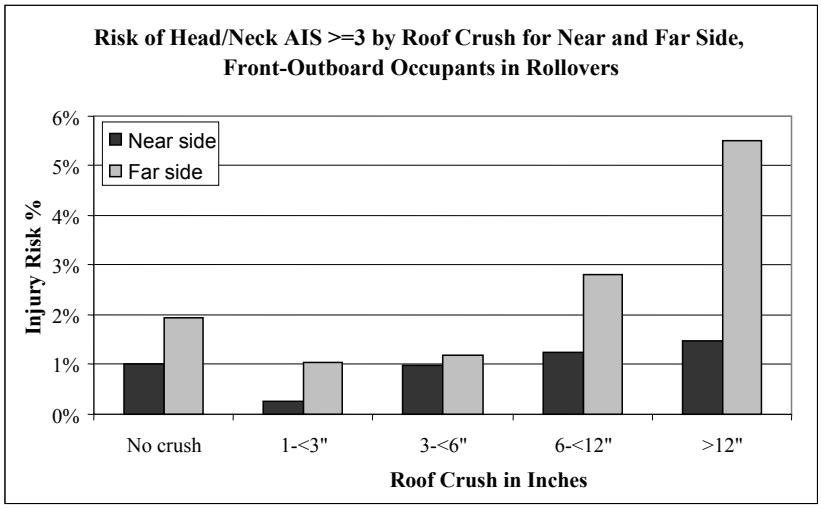
The Problem of Far Side Impacts:

In rollovers the roof is mainly crushed and people are seriously injured on the FAR side, opposite to the direction of roll (or NEAR side).

Passenger (far side) injury

Driver (far side) injury

Far Side Occupants at Much Higher Risk from Roof Crush than Near Side

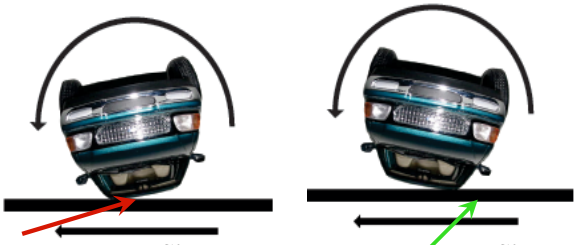


1992 to 2002 NASS/CDS Data

- The second, or far side, impact in a rollover crash has a different, more severe pitch angle and greater roll angle than the first impact, subjecting the roof to greater friction from sliding, or lateral, contact with the roadway. The strength added by the windshield and its bonding is gone when both break after the first impact, substantially weakening the roof.

Road Contact Resultant Roof Forces

are similar in pitch but more lateral on the far side than on the near side



Far Side **Near Side**

Far side roof strength is reduced as much as 30 percent by near side windshield breaks, plus an additional 40 percent by the more lateral loading. [11]

- A test of only one side of the roof ignores a major cause of injury in rollovers because far side roof strength is much more important than on the near side. **Vehicles which pass the NHTSA near side test often cannot even support the vehicle's weight on the far side.** The far side of the roof collapses in actual rollover crashes, inflicting massive injuries on people sitting there.
- A strong roof also prevents the windows from breaking, keeping occupants in the vehicle. Dynamic tests confirm that when the roof crushes less than 4 inches, safety glass in side window glazing is preserved, limiting ejection. In video images of an SUV with a strong roof , a Volvo XC90, in a multiple roll dynamic test available on the Public Citizen Web site (www.citizen.org), the windows remain totally intact and unbroken even after multiple rolls.
- NHTSA's test does not measure roof crush on the far side. In the crashes below, far side passengers were the ones killed or seriously injured, and crush patterns show the roll direction.

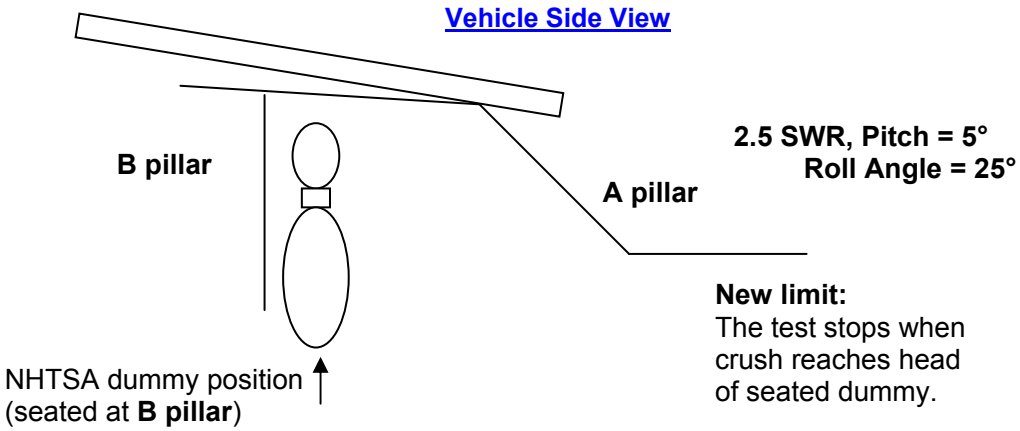
Fatal or Serious Injury Rollover Crashes with **Passenger Side as the Far Side**

Fatal or Serious Injury Rollovers with the **Driver Side as Far Side**

The Importance of A-Pillar Strength in Rollover Crashes

- The current National Highway Traffic Safety Administration (NHTSA) static test applies a large platen on only one side of the vehicle's roof at **a pitch angle of 5°**, and **a roll angle of 25°**. The roof must be strong enough to resist with a force of **1.5 times** the vehicle's weight before crushing more than 5 inches. The 1.5 times figure is called the Strength-to-Weight Ratio, or SWR.

- Based on agency officials' statements and reports it appears NHTSA is planning a minimal change to the standard, **increasing the Strength-to-Weight-Ratio (SWR) to about 2.5** and permitting the roof to crush until it contacts a dummy's head. The pitch angle and roll angle would not change, and the test would also still be performed on only one side of the roof.

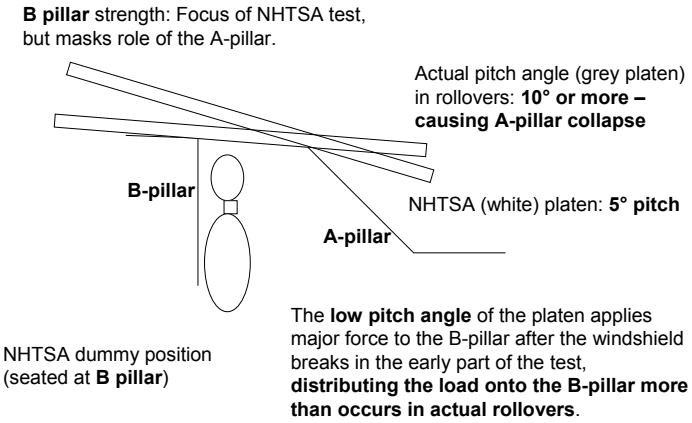


- NHTSA officials have said that **only a small number of lives – 50** – would be saved by the new standard, although roof crush in rollover kills 6,000 to 7,000 people a year, and **27,000 people annually are killed or seriously injured in rollover crashes.** This type of NHTSA rule would save few lives, in part because **data show the average roof strength of on-road vehicles is already 2.3 SWR**, and that most vehicles now made can meet the anticipated NHTSA proposal. NHTSA found in 2003 that 8 of 10 vehicles would pass the anticipated new standard.

- In addition, vehicles with a very weak A-pillar (supports beside the windshield) can pass the anticipated test. Yet a strong A-pillar is needed to protect occupants in rollovers.
- **In addition to testing only the near side of the vehicle, the NHTSA test is unrealistic when compared to actual rollovers for three critical reasons:**

1) **It uses the wrong pitch angle: 5°**. SUVs and pickups are front-heavy and pitch forward during a rollover to an angle of 10° or more. In the test, the low pitch angle for the platen allows the B-pillar (the support beside a front-seat occupant shoulder) to take up the load. In an actual rollover, however, force is concentrated on the more forward A-pillar.

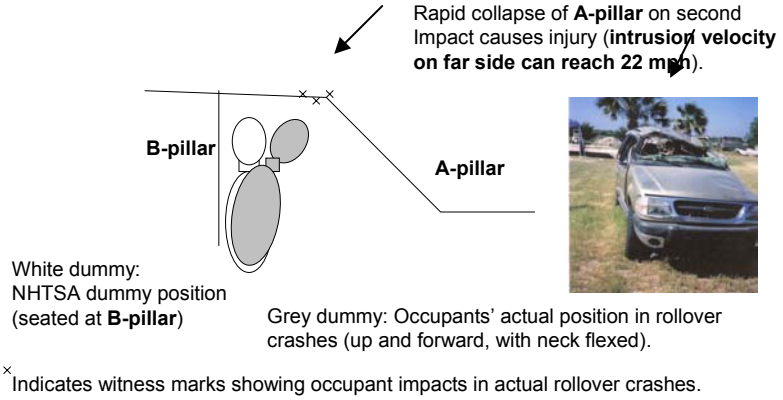
Load Placed on B-Pillar in Test Conceals A-Pillar Failure



2) **The dummy's head position is not realistic.** In the NHTSA test, the test dummy's head is straight up, whereas in actual rollover crashes the occupant's head is thrown forward, under the collapsing A-pillar section of the roof.

3) **The test ignores the speed of the roof's intrusion.** When a weak A-pillar buckles, it caves into the occupant's survival space at speeds up to 22 mph, inflicting severe injury.

NHTSA Dummy Position Focuses Incorrectly on B-Pillar Strength, Ignores Intrusion Velocity



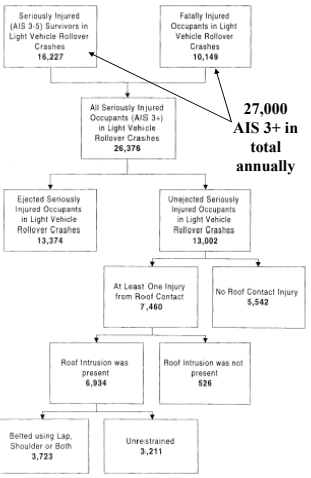
- A weak A-pillar also allows side window glass to break, **allowing even belted occupants' bodies, heads and arms to be ejected through the side openings**, with devastating results.
- The NHTSA test cannot predict the performance of vehicles in real world rollover crashes. **To prevent thousands of rollover deaths, we need a dynamic test that simulates actual rollovers.**

Roof Strength is Critical to Ejection Risk in Rollovers

- **Ejection is the most dangerous consequence of a rollover.** Between 1992 and 2002, half of the people killed in rollovers – more than 13,00 per year – were partially or fully ejected, and 20 percent of these victims were belted. There is no current standard for belt performance in rollovers.
- **NHTSA is ignoring the link between roof-strength and ejection.** NHTSA's roof crush benefit analysis excludes ejection risks. Yet NHTSA data shows *45 percent of partially or fully ejected occupants contacted the inside of vehicle, including the roof, prior to ejection.*

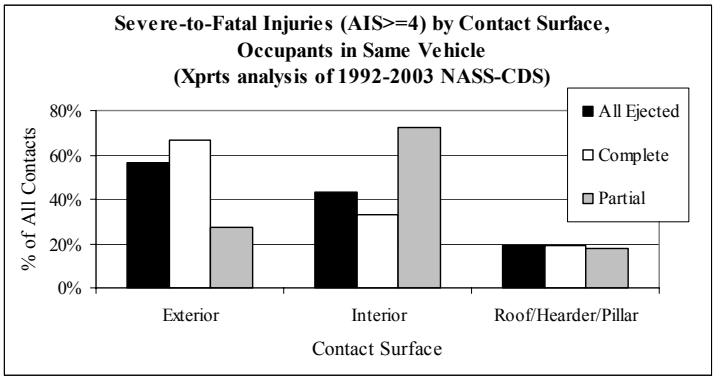
Roof Strength/ Ejection Relationship Ignored

NHTSA Underestimates Roof Strength Benefits:
Serious Injuries Analysis
(from Request for Comments)



27,000 AIS 3+ in total annually

NHTSA excludes ejected occupants, and assumes that occupants **were not injured by roof crush prior to ejection**.



- **Roof strength is critical to reducing ejection risk in a rollover:** When a weak roof collapses, the supporting pillars deform, warping and shattering the windshield and side windows and sometimes unlatching the doors. This opens many portals for occupant ejection.
- **Centrifugal forces exacerbate risk:** The centrifugal forces of the roll pull occupants toward the outside of the vehicle. Without rollover pretensioners, belts are too slack to hold people in place.
- **Industry data proves the ejection-roof strength relationship:** In a 1982 study by General Motors of rollover ejection, GM engineer Ivar Arums found the roof lost one-third of its strength when the bonded windshield broke. Arums concluded a stronger roof would reduce ejections by 23 percent, even with tempered window glass. *GM did not tell NHTSA about these results.*

LABORATORY SIMULATION
OF OCCUPANT EJECTION THROUGH WINDOWS

* THE DESIGN OF A TEST FACILITY OR TESTING METHOD FOR OCCUPANT EJECTION THROUGH WINDOWS SHOULD SIMULATE THE PERTINENT PORTIONS OF THE ACCIDENT. IT SHOULD DEFINE HOW TO TEST AND YET BE INDEPENDENT OF VEHICLE DESIGN.

THE EJECTION PHENOMENON APPEARS TO HAVE TWO ASSOCIATED COMPONENTS WHICH NEED TO BE ADDRESSED IN ANY TEST PROGRAM:

VEHICLE STRUCTURAL DEFORMATION	OCCUPANT EXIT AREA
* NONE	* ADJACENT WINDOW (near side)
* ABOVE WINDOW	* OPPOSITE WINDOW (far side)
* BELOW WINDOW	* NON-SIDE WINDOW (backlight)
* CORNER OF WINDOW	* NON-WINDOW (door)

** ALTHOUGH IT MAY BE TECHNICALLY CHALLENGING TO MITIGATE EJECTION BY DEVELOPING ALTERNATIVES TO GLAZING MATERIALS IT SHOULD BE KEPT IN MIND THAT PARTIAL EJECTION REDUCTION AND POST ACCIDENT EGRESS/ACCESS ARE SIGNIFICANT ASPECTS OF VEHICLE DESIGN.

** THEREFORE IT IS NECESSARY TO TEST THE STRUCTURE AVAILABLE TO RETAIN THE GLAZING AS WELL AS TESTING THE OCCUPANT RETENTION CAPABILITIES OF THE GLAZING .

IT IS WITH THESE TWO POINTS IN MIND THAT THE FOLLOWING TESTS ARE PROPOSED TO ENABLE DEVELOPING AND TESTING ALTERNATIVE GLAZING SYSTEMS DESIGNED TO MITIGATE EJECTIONS.

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- **Dynamic tests show that adequate roof strength prevents window breakage and occupant ejection:** Tests using a dynamic rollover testing device, the Jordan Rollover System (JRS), show that if the roof does not distort more than 3 or 4 inches, the roof impacts will not break the windows, and occupants cannot be ejected.

Summary: Roof Strength is "Backbone" of Rollover Safety, Dynamic Tests Would Reveal Actual Rollover Risks

- **Far Side Occupant Risks Ignored by NHTSA:** In rollover crashes, the roof is mainly crushed – and people are seriously injured – on the far side. The far side impact occurs at a more severe pitch and roll angle, after the roof has been substantially weakened by windshield breakage from the first impact. NHTSA's current static test ensures only that the roof will survive the first impact, *and fails to measure roof crush or occupant risk on the far side.*

- **Weak A-Pillars Ignored by NHTSA:** NHTSA's test can be passed by vehicles with very weak A-pillars. Most cars, SUVs and pickups will pitch forward during a rollover crash to an angle of 10° or more. The 5° pitch angle in FMVSS 216 allows the B-pillar to take up the load, whereas in an actual rollover the force is concentrated on the A-pillar. In NHTSA's test, the dummy's head is located near the B-pillar, whereas in an actual rollover crash, an occupant's head is thrown toward the collapsing A pillar. NHTSA's static test also ignores the speed of the A-pillar collapse which can be up to 22 mph – fast enough to injure or kill an occupant.

- **The Relationship Between Ejection and Roof Strength Ignored by NHTSA:** A vehicle's roof strength is closely tied to the risk of ejection during a rollover. If the roof is too weak, the supporting pillars deform and collapse when the vehicle's roof strikes the ground in a rollover, warping and shattering the windshield and side windows and even unlatching the doors. This opens many potential portals through which occupants can be ejected.

- **An effective roof strength standard would prevent thousands of deaths and serious injuries.** A standard that limits crush to about 4 inches in a dynamic test, such as the dolly rollover test (currently an optional part of Federal Motor Vehicle Safety Standard 208), would reduce ejections by at least 50 percent – preventing at least 6,500 deaths and serious injuries, or 125 per week. Roof intrusion injury would also be greatly reduced, preventing another 100 deaths and serious injuries each week and bringing the total number to 10,000 each year. In order to minimize rollover deaths, a vehicle needs a strong roof, in addition to advanced window glazing and rollover-triggered belt and airbag systems — all available on Volvo's XC-90 SUV.

- **NHTSA should make the now-voluntary FMVSS 208 dolly rollover test mandatory**. At a minimum, a two-sided test with greater pitch and roll angles, verified by dynamic testing, should be required at the earliest possible date by the Federal government.