

INSURANCE INSTITUTE FOR HIGHWAY SAFETY

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Jackie Glassman
Acting Administrator
National Highway Traffic Safety Administration
400 Seventh Street, S.W.
Washington, D.C. 20590

**Federal Motor Vehicle Safety Standards; Roof Crush Resistance;
Notice of Proposed Rulemaking; Docket No. NHTSA-2005-22143**

Dear Ms. Glassman:

The purpose of Federal Motor Vehicle Safety Standard (FMVSS) 216 is to reduce deaths and serious injuries when vehicle roofs crush into the occupant compartment during rollover crashes. According to the National Highway Traffic Safety Administration (NHTSA), approximately 10,000 vehicle occupants are killed in rollovers every year (Deutermann, 2002). Although it is impossible to determine the exact number of people who sustain serious and fatal injuries due to insufficient roof strength, preserving the integrity of the occupant compartment is a key factor in reducing the likelihood of injury in all types of crashes.

NHTSA has issued a Notice of Proposed Rulemaking (NPRM) for FMVSS 216, Roof Crush Resistance, asking for comments on the proposed changes. The Insurance Institute for Highway Safety agrees on the need to upgrade FMVSS 216 and concurs that raising the required test force to 2.5 times a vehicle's weight is feasible and justified because many vehicles already achieve this level of roof strength. We agree with the proposals to eliminate both the exemption for vehicles with gross vehicle weight ratings greater than 6,000 pounds and the 5,000-pound limit on the maximum force applied to the roofs of passenger cars. We also support the proposal to require occupant compartments to retain enough headroom to accommodate a 50th percentile male, regardless of the actual amount of roof crush, although we are concerned this aspect of the proposal could lead to the weakening of some roofs and might not be applied to vehicles with low rooflines. If these issues are addressed in the final rule, we believe the revision would lead to a modest improvement in occupant protection in rollover crashes.

At the same time, more could and should be done to improve occupant compartment integrity in the event of a rollover. A dynamic test ultimately will be needed, although good research is lacking to guide the specification of a dynamic test or to allow reasonably precise estimates of the real-world effectiveness of designing vehicles to meet such a test. In the meantime, testing roof crush strength at multiple load angles and testing with windshields removed would add to the meaningfulness of the quasi-static testing that NHTSA currently

requires. If the agency believes it cannot justify this additional testing in a rule at this time, it still should move forward by including such testing in a continuing research program on vehicle rollover protection. The agency should not consider this rulemaking the end of its activities on roof strength. These points are discussed in greater detail below.

Allowable Roof Crush

NHTSA has proposed changing the previous requirement that the test device travel 5 inches or less to a requirement that positive headroom is preserved for a 50th percentile Hybrid III male dummy in the front seating position under the side of the roof being tested. In the preliminary compliance tests released by the agency, tests of several vehicles showed 5 inches of ram travel before headroom was exhausted. This leaves open the possibility that some vehicles may meet the new standard (a force of 2.5 times vehicle weight with remaining headroom) but have weaker roofs than allowed under the current standard. That is, they would have failed the current requirement that a roof sustain a force of 1.5 times vehicle weight before 5 inches of travel. Ideally, all vehicles would meet the higher force requirement before headroom is exhausted and before the test device travels 5 inches. At the very least, the agency should modify the proposed rule to guarantee that all vehicles meeting the new standard also would meet the one being replaced. Such compliance would be easy to determine because force-displacement curves must continue to be recorded to monitor the loading rate and reaction force values.

A second concern relates to NHTSA's request for comments "on whether any additional or substitute requirements would be appropriate for low roofline vehicles in order to make the standard practicable." The agency has associated an increased injury risk in rollovers to reduced headroom (Austin et al., 2005) and yet, illogically, is open to considering alternative requirements for vehicles with the least initial headroom. NHTSA research suggests that vehicles with little initial headroom must limit crush more than other vehicles if their occupants are to be provided with the same level of protection. This means the new standard should not specify less stringent criteria for the very vehicles with the greatest need for stronger roofs.

By addressing these issues, NHTSA will ensure that the new standard is applied correctly to all vehicles. The Institute supports the proposal with the modifications we have set out and believes it may improve occupant protection in certain cases. Still, the introduction of the new rule is unlikely to decrease the problem of roof crush in many real-world rollover crashes. The agency estimates that nearly 70 percent of all vehicles with gross vehicle weight ratings less than 10,000 pounds already meet the proposal. This may be an overestimation

because it does not account for the number of vehicles that appear to meet the new requirement by a small amount but will need to be redesigned in order to maintain an acceptable margin of compliance. Nevertheless, the estimate does question the likelihood that the new standard will significantly improve roof designs. It suggests that the increase in maximum test force from 1.5 to 2.5 times the unloaded vehicle weight simply will update the standard to the current status of many vehicles. Substantially reducing deaths and injuries in rollovers requires a comprehensive solution that does more than maintain the status quo of any aspect of the problem, including roof strength.

Need for Better Real-World Data

Any type of vehicle evaluation should be assessed based on its ability to encourage design changes that make meaningful differences in real-world crashes. NHTSA's New Car Assessment Program's frontal test was a good example during its early years. In response to this test, automakers began installing new restraint systems that improved test scores and reduced the likelihood of serious occupant injuries in frontal crashes (Kahane et al., 1994). As NHTSA has indicated in a previous report, the same criterion should apply to a roof crush test: "static results are far more useful if they can be used to qualitatively predict the dynamic performance of the roof strength. Once a test procedure has been developed, it will be necessary to compare baseline testing data against the NASS investigated accident data in order to evaluate the effectiveness of the test procedure" (Summers et al., 1996).

With respect to the roof crush standard, there is a surprising lack of evidence demonstrating the ability of the test configuration used in the standard to produce changes that make a difference in real-world rollover crashes. For its part, NHTSA has not conducted the analysis Summers et al. recommended in 1996, saying only that broad "damage patterns" produced in extended 216 tests "are generally consistent with the observations" from a selected number of NASS cases (Pack et al., 2004). Only one major published study has compared roof damage in real-world rollovers among various vehicle models based on their performance in the FMVSS 216 test (Moffatt and Padmanaban, 1995). The authors found "no relationship between the roof strength-to-weight ratio [as measured under the FMVSS 216 test configuration] and the likelihood of severe roof damage for vehicles involved in rollovers." However, a separate analysis in this study found that severe injury rates in rollovers were more than 2.5 times higher for belted occupants in convertibles than for belted occupants in hardtop versions of the same vehicles. A similar Institute review of 55 convertible/hardtop pairs showed an increased risk of serious and fatal injuries for the drivers of the convertibles (Appendix).

Together these data demonstrate that roof strength is important in reducing injury risk in rollover crashes but suggest that the FMVSS 216 method of measuring roof strength may be inadequate. In a 1998 technical report, NHTSA researchers Rains and Van Voorhis stated, "it has yet to be shown that the static test procedure represents real-world rollover forces on the roof." Therefore, it is important to consider the proposed rule a first step toward improving occupant protection in rollovers. NHTSA must monitor the effects of the rule to assess its relevance and determine what subsequent action is appropriate.

Rollovers are complicated events. Many factors influence the magnitudes, directions, and areas over which forces are applied. The experience of a roof when loaded at a predetermined point by a large plate, oriented at a specific angle and pushed at a slow rate, may not be correlated to its performance in a rollover crash where all of these conditions may be different. Future test procedures should be judged according to whether they address this problem.

Potential Improvements to the Quasi-Static Test Procedure

Below are two types of changes with the potential to increase the relevance of a new roof crush standard. These suggestions do not require modifying the test fixture.

Just as restraint systems "tuned" to produce desirable characteristics in a given crash test may not be as effective in other situations, it is possible that some vehicles that pass the current or proposed roof crush standard do not perform well under other loading conditions. A roof crush test with more than one specific loading direction would encourage roof and pillar designs that remain intact in more rollover crashes. Therefore, an improvement to the standard would be to specify a range of roll and pitch angles for the load plate under which a roof would have to sustain the required force. This would be similar to FMVSS 208's frontal test requirements, under which vehicles must meet the performance criteria when tested at any angle between perpendicular and 30 degrees. In the absence of a range of plate angles, any distinct test angle choices should be supported by evidence that such angles are representative of a significant percentage of real-world rollovers.

Another improvement to the proposed standard would be to test vehicles without their windshields in place. NHTSA says "examination of real-world rollover crashes indicates that the windshield rarely separates from the vehicle, and therefore, does provide some crush resistance" (NHTSA, 2005). The agency has declined to propose testing without the windshield because a "vehicle should be tested with all structural components that would be present in a real-world rollover crash." It

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is unclear how often windshields stay in place in real-world rollovers or how much load bearing a windshield typically has, but it is apparent that windshield integrity often is compromised in rollovers whether or not there is complete separation from the vehicle. Little can be done to ensure that a windshield will remain in place in a rollover crash, so roof designs that rely on the strength of the glazing to meet the FMVSS 216 test requirement will provide less protection than those that do not. By testing without windshields, NHTSA would stimulate the most robust safety cage designs.

The Institute suggests these two changes would improve the proposed standard, though it is not possible, based on current research, to estimate the degree of improvement. At a minimum the agency should launch an evaluation program to obtain comparative information about roof designs currently on the market. Although all vehicles will have met FMVSS 216 requirements, it would be valuable to know the range of protection offered by various models. Specifically, it would be useful to assess whether vehicles that perform well at various load angles or without their windshields have lower injury rates in rollover crashes. This would be the kind of information that could contribute to a future upgrade of FMVSS 216.

Dynamic Test Still Needed

Whatever the outcome of this rulemaking process, NHTSA should continue to develop a dynamic test procedure. A repeatable dynamic rollover test will be difficult to develop, but it is needed to adequately evaluate vehicle rollover safety. As in any type of crash, the injury risks in rollovers are determined by the overall interaction of vehicle structure, restraint system components, and occupant kinematics. This interaction can be observed and evaluated most comprehensively through dynamic testing. NHTSA should focus resources on developing a test procedure that will generate innovative design improvements to benefit occupants in real-world rollover crashes.

Sincerely,



Adrian K. Lund, Ph.D.
Chief Operating Officer

cc: Docket Clerk, Docket No. NHTSA-2005-22143

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APPENDIX
Analysis of Serious and Fatal Driver Injuries
in Rollovers of Convertibles versus Hardtops

The importance of vehicle roofs in preventing occupant injuries in rollover crashes is illustrated by the relative risks of serious and fatal injuries for drivers in vehicles with and without roofs. The Insurance Institute for Highway Safety identified 55 pairs of convertible/hardtop vehicle models. Comparing the percentages of deaths of belted drivers in rollovers, Institute researchers estimated the fatality risk in rollovers for drivers of vehicles with roofs relative to drivers of vehicles without roofs. A 95 percent confidence interval was calculated for the estimate of relative risk.

	Driver deaths	Driver deaths in rollovers	Percentage of driver deaths in rollovers
Convertibles	385	106	28
Hardtops	2,682	542	20

Mantel-Haenszel estimate of relative risk: 0.72

95% confidence interval for relative risk: (0.60-0.87)

Source of fatality data: 1993-2002 Fatality Analysis Reporting System

The researchers conducted another analysis of the same vehicle pairs, using police data files from Florida for calendar years 1993-2001. The rates of serious and fatal injuries (coded K or A) for drivers involved in rollover crashes were used to estimate risk for drivers of vehicles with roofs relative to drivers of vehicles without roofs.

	Drivers involved in rollovers	Drivers seriously injured	Percentage of drivers seriously injured
Convertibles	155	45	29
Hardtops	1,109	239	22

Mantel-Haenszel estimate of relative risk: 0.65

95% confidence interval for relative risk: (0.48-0.89)