Rollover revolution

Will rollover survival become less of a lottery when the legislation surrounding roof-crush testing is revised? **Byron Bloch** deliberates

■ If crash testing is to have validity, many argue that it must be relevant to what happens in real-world accidents. In the 1970s, the US fatality toll in rollovers was 1,000 a year, but has since risen to over 10,000 a year. So what is wrong with vehicle roofs, and why has the US safety standard seemingly failed to ensure that vehicles would have safe-roof structures? What, in turn, does this mean for auto makers? What standard should they adhere to in trying to design safe roofs?

The matrix of crash testing by some European manufacturers represents an effort to replicate what happens in real-world collisions. As stated by GM-Opel in 1993, 'Because test standards are often too theoretical, the test program for Opel models focuses on reality – on real accidents on European roads.' But in the US, each of the FMVSS safety standards typically uses only a single test as a minimum-compliance test that is often unrepresentative of what happens in real-world accidents.

For example, roof strength in rollovers is measured in a Federal Motor Vehicle Safety Standard 216 compliance test that only requires a 'slow push' downward on the front corner of the roof, up to 1.5 times the vehicle weight or 2268kg, whichever is less. There is no dynamic-rollover test of the vehicle, no test dummy to measure

Above: A crash dummy sits in a 2006 Buick Rainier at GMs rollover crash testing facility. The US$10 million facility will be used to study ways to reduce injuries and deaths in rollover crashes by developing sensors for air bags that can help protect occupants in a rollover and help keep them from being ejected from the vehicle

injury-related forces, and no evaluation of the seatbelt restraint.

It is fairly easy to pass this minimal compliance test, but it is no guarantee that the roof will not buckle and crush down in an accident. In the USA, the fatalities in rollover accidents attest to the fact that compliance with FMVSS 216 is no assurance of a safe roof. The upgrading of FMVSS 216 to a slow-push test at 2.5 times the vehicle weight is totally inadequate and far too minimal.

All other accident scenarios have US Safety Standards that require dynamic crash testing: frontal impact, side impact, and rear impact. So why is rollover the only accident scenario that is not matched to dynamic testing? After more than three decades of delay, there is now a controversy about finally upgrading FMVSS 216.

FMVSS 216 is only a 'minimum requirement' and when it was introduced back in 1973, it was supposed to be replaced with a dynamic-dolly rollover test by 1978. But that never happened. FMVSS 216 does not require any dynamic-rollover test, which would also evaluate effectiveness of seatbelt restraint devices, interior surfaces and any injury-mitigation padding, side-window glass breakage, and the effectiveness of inflatable side-curtain airbags.

FMVSS 216 does not measure intrusion into an occupant's survival space nor potential injury to an occupant's head and neck. However, the pending upgrade concerns roof contact with the head of a 50th-percentile average-size male test dummy, whereas the use of 95th-percentile size male test dummies would cover taller people who are closer to the roof. In a study of 25 rollover tests conducted by NHTSA in the 1990s, the instrumented-dummy neck loads were often in the range of 680 to 907kg.

From 2005 to 2007, the NHTSA conducted 35 tests in which the force was applied via an angled platen downward onto the driver's side of the roof. These were FMVSS 216-type tests, and the strength-to-weight ratio (SWR) was recorded. Force was applied until there was 127mm of travel, unless head contact occurred first. More than half the vehicles had a SWR ratio of three or less. And 11 of those vehicles would have failed the proposed NHTSA upgrade of FMVSS 216 at the proposed 2.5 SWR compliance-test level.

However, 24 would have passed and, therefore, according to a NHTSA provision

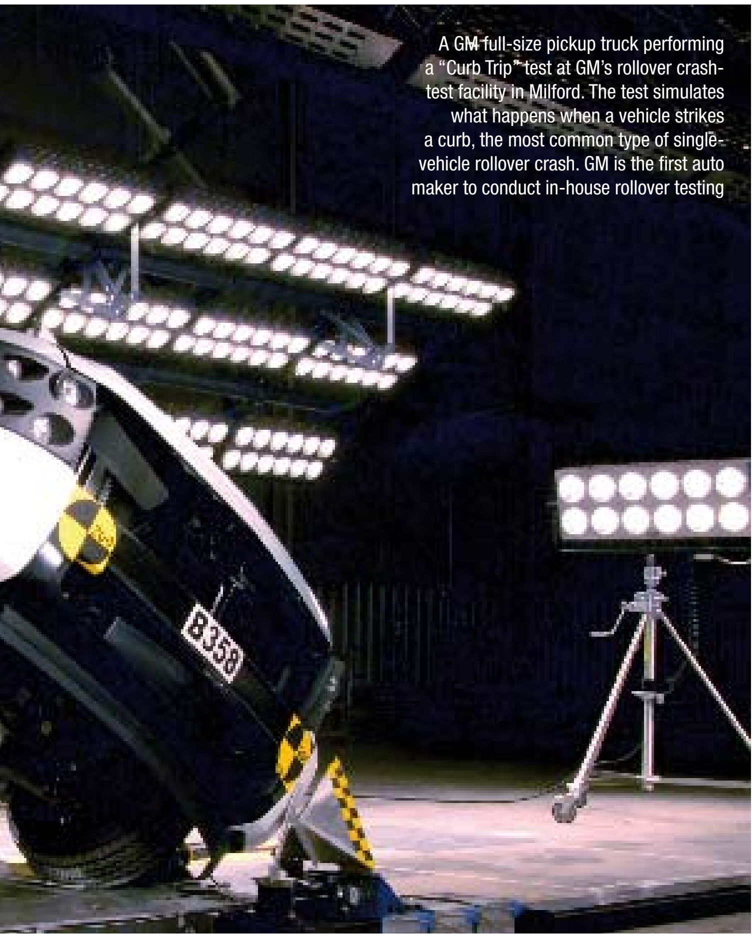
Rollover: Case A

This rollover accident occurred in 2002 in New Jersey. A 1999 Toyota RAV4 SUV was impacted in its side by an adjacent vehicle, causing the RAV4 to rollover.

The roof buckled and crushed downward into the survival space of the right-front passenger, causing fracture of his cervical vertebrae, rendering him a quadriplegic. The driver, seated where the roof did not buckle down, was not injured.

In the 2007 trial, I pointed out the roof's windshield header was a weak open-section design with large hole cutouts and structural discontinuities. I showed safer alternative designs, including a Toyota Camry's stronger closed-section header that would have helped reduce roof crush.

While the RAV4 roof complied with the FMVSS 216 slow-push test, its structure was inadequate and prone to collapse. The jury decided a verdict for the plaintiff.



A GM full-size pickup truck performing a "Curb Trip" test at GM's rollover crash-test facility in Milford. The test simulates what happens when a vehicle strikes a curb, the most common type of single-vehicle rollover crash. GM is the first auto maker to conduct in-house rollover testing

Rollover Case B

This rollover accident occurred in 1996, in Louisiana. A young man was driving a 1989 Ford Escort two-door hatchback when, to avoid another vehicle that had cut into his lane, the Escort left the road and rolled over at about 35mph on the grassy center median.

In the rollover, the Ford Escort's roof buckled and crushed downward into his survival space, causing forces that fractured his cervical vertebrae, rendering the seatbelted driver a quadriplegic. The right-front passenger, seated where the roof did not crush down, was only minimally injured.

In the 2007 trial, I testified that the roof was a defective design, including its weak open-section windshield header with large-hole cutouts, and A-pillar with minimal reinforcement of only the lower 30cm. I noted that although the vehicle complied with FMVSS 216, its roof structure was clearly inadequate. The jury decided a verdict for the plaintiff.

in the proposal, would be exempt from product-liability lawsuits alleging a defectively designed roof arising out of a rollover accident. The liability pre-emption would apply even if the roof had designed-in structural weaknesses, causing it to buckle and collapse and result in fatal/quadriplegic injuries. This proposed legal-liability pre-exemption among others is being challenged by the US Senate Judiciary Committee, which does not believe that the NHTSA has the legal authority to grant such pre-emption.

Importantly, there were eight vehicles with a SWR ratio between four and 5.1. The 2006 VW Jetta had a SWR of 5.1, the 2007 Toyota Scion tC had a SWR of 4.6, the 2006 Volvo XC90 was 4.6, and the 2006 Honda Civic, 4.5. There are production vehicles that clearly prove that notably stronger and safer roofs well above an SWR of four are technically feasible. NHTSA's analysis that an SWR of 2.5 or perhaps three would be sufficient is much too minimal to ensure safe performance. Going to a SWR of four or five is well justified as inexpensive current vehicles are already at that level.

A rating system for roof strength could be based on the tested SWR, so that prospective customers could select a vehicle with a stronger SWR of five over a competitive vehicle with a weaker SWR of only three. This would also help to stimulate the adoption of even stronger roofs in a greater number of vehicles.

It is clear that sole reliance on a slow-push test at a 2.5 or 3 SWR will not be sufficient to ensure safe-roof performance in real-world rollover accidents. The auto industry has already shown that it is entirely feasible and economical to have roofs with a SWR of at least 4.5 to 5 as in the current VW

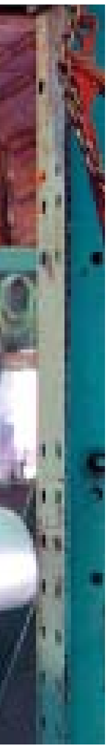
This Toyota Camry had "full load" applied, which means 4.3 times the vehicle weight, therefore a strength-to-weight ratio (SWR) of 4.3, well above the level of 2.5 to three that the NHTSA is currently considering

GM's rollover history

In the 1950s, GM showed how its cars could survive dynamic rollover tests at 50mph with only minimal roof deformation. GM called this the supreme test, as validation of their strong turret-top roof-structure design. But then GM did very little rollover testing in the USA between 1970 and 2000. In that same era, GM-Opel in Europe began conducting dynamic rollover tests for improving safety in their European vehicles.

After decades of not conducting dynamic rollover tests in the USA, in 2006 GM opened a US$10 million state-of-the-art rollover crash test facility at its proving ground in Milford, Michigan. When the facility was launched, NHTSA administrator Nicole Nason was quoted as saying, "The work at this facility will contribute to fewer deaths and injuries from rollover crashes."

For its new facility, GM announced that multiple types of dynamic rollover tests will



Jetta, Toyota Scion tC, Volvo XC90, and the Honda Civic, among others.

As well as North American manufacturers such as GM (see GM's rollover history), European automotive manufacturers have also been conducting valid and repeatable dynamic-rollover tests for over 30 years. These have typically been lateral-dolly rollover tests in the 48km/h-plus range. NHTSA likes to point to a series of unusual rollover tests that it conducted with an elevated-dolly rollover apparatus as not ensuring sufficient repeatability; and then proceeds to dismiss all dynamic rollover testing altogether.

Such dynamic rollover tests are much needed to ensure effective performance of the total system of side-curtain airbags, seatbelts with pre-tensioners, windshield and side-window glass integrity, interior padding, and other crashworthy measures.

If a specific slow-push test is included in an upgraded FMVSS 216, it must be a sequential two-sided test that ensures a SWR of at least four, with no intrusion into the survival space of a seated 95th-percentile male test dummy. The vehicle being tested should be the heaviest version of that specific model.

The SWR of the tested vehicle should be posted on the data sheet affixed to the vehicle's window, and also be available from NHTSA and the auto makers. A publicly available ranking list of SWR for each model vehicle would enable the public to compare the relative roof strengths of competitive vehicles, thereby stimulating the auto makers to make continuous improvements.

A lateral-dolly rollover at 64km/h should be required to demonstrate validation of the total performance of the roof, seatbelt system with pre-tensioners, windshield integrity and retention, side-window glass integrity and retention, interior padding, and other measures for occupant protection. Anthropomorphic test dummies (95th percentile adult males) should be seatbelted in each designated seat position.

There is no legal or ethical basis for NHTSA, as a regulatory agency, to include pre-emption for any roof that complies with its minimal and unrealistic slow-push test that requires a strength-to-weight ratio of only 2.5 or three, or for any other test. An injured citizen's right to seek justice through the courts is an inherent constitutional right in most civilized societies. An administrative regulatory agency is not empowered to rescind those rights.

Vehicle manufacturers worldwide should adopt the roof SWR of at least four, plus dynamic rollover testing at 64km/h. After a reasonable phase-in of three to five years, the requirements should then be increased to a SWR of five, and dynamic rollovers at 80km/h. The goal is to eliminate deaths and severe injuries in rollover accidents. If some nations opt for lesser safety requirements, such vehicles should be barred from being marketed in nations with higher safety standards.

be conducted, including: trip over – the most frequent type of rollover; ditch fall-over – simulating a driver driving off the side of a road; corkscrew ramp flip-over – simulating a driver striking a rigid object at high-speed; and dolly rollover – used in rollover research for more than 35 years and conducted with the vehicle being pulled sideways on a platform at a 23° angle.

GM intends to conduct dynamic rollover tests of 150 to 200 vehicles each year. While commendable, the key will be how rapidly and effectively the test knowledge is transferred into GM's mass-produced vehicles with stronger roof structures, more effective side-curtain airbags, safer side-window glazing, more effective seatbelt restraints, and interior energy-absorbing padding. In short, a more crashworthy vehicle to protect occupants better in rollover accidents.