A shattering saga

Byron Bloch studies the latest crash test evidence and discovers how one simple change to side window glazing in vehicles can greatly improve the overall safety of passengers in rollover accidents.

In side impact and rollover accidents, it is imperative that occupants are kept safely within the protective structures of the vehicle. It is critical that seat-belted occupants are not partially ejected beyond the periphery of the vehicle and its side window glass. It is also critical that all unbelted occupants be prevented from being partially or fully ejected.

The latest NHTSA data shows that 35% of all vehicle fatalities in the USA occur in rollovers, and about half of those occur when the occupants are fully ejected. Even for seat-belted occupants, severe to fatal injuries still occur when the person is partially ejected through the adjacent window opening after the glass has shattered. There is clearly a major problem with the window glazing – and that applies predominantly to side windows, but also to rear hatch windows and sun roofs.

The proposed United States Federal Motor Vehicle Safety Standard FMVSS 226, currently in the final rule-making process, establishes a new safety standard with the intent to reduce the partial and complete ejection of vehicle occupants through side windows in crashes, particularly rollovers. This new standard would apply to the side windows next to the first three rows of seats in motor vehicles with a gross vehicle weight rating (GVWR) of 4,536kg or less. Compliance will be phased into production vehicles, for an increasing portion of each auto maker’s fleet, beginning with 20% in September 2014, to 100% by September 2017.

NHTSA anticipates that vehicle manufacturers would meet the standard by using upgraded designs of side-curtain airbags and possibly supplementing them with enhanced protective glazing (EPG).
such as laminated sandwich designs made up of three layers - glass-plastic-glass. The laminated glass would provide further support for the inflated side-curtain airbags and would also serve as a protective 'life net' ensuring that no occupants are partially or completely ejected.

Side-curtain airbags would probably be made larger to cover more area of the window opening, and would stay inflated for an extended time period (e.g. about six to eight seconds) to ensure continuous protection as the vehicle tumbled multiple times in rollover accidents. Inertial sensors would prompt side airbag inflation when the vehicle was initiating a lateral rollover would prompt side airbag inflation when the vehicle was initiating a lateral rollover accident. This is remarkably demonstrative of what happened in Case A (see page 8), in which a young girl was ejected out onto the road and severely injured.

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The proposed FMVSS 226 does not include any dynamic testing of the vehicle to validate that the occupants would be safely contained in a rollover accident. What is needed instead is a dynamic rollover test, such as the lateral dolly rollover test described in FMVSS 208, so that the total system is evaluated. This includes injury criteria for the occupants and the evaluation of the roof structure, the door structure, the door latches, the window glazing, the window retention, the seatbelt, the side torso airbag, the side-curtain airbag, interior surfaces and edges, and other factors that may increase or mitigate injury severity.

The entire vehicle would be tested as to whether or not it performs safely in preventing and reducing injury to the occupant’s head, neck and torso. Instrumentation on the dummies would record the levels of multi-axis forces generated during the rollover sequence. I believe the compliance rollover test should be initially conducted at 40mph, then (after four years) elevated to 50mph, then later to 60mph.

European auto makers (VW, Audi, Mercedes, BMW, Peugeot, Volvo and Saab) have been conducting such dynamic rollover tests since the mid-1970s. Their vehicles
In rollover accidents, close to achieving the level of zero deaths and side window glass integrity in rollovers. This must change if we are to ever get close to achieving the level of zero deaths in rollover accidents.

GM’s rollover tests in the 50s

General Motors conducted dynamic rollover tests at 50mph (80km/h) in the mid-1950s to show the strength of the roof structure of its production cars, which were also equipped with laminated side window glass. Now, some 60 years later, US safety standards still do not require any dynamic rollover tests to demonstrate roof strength and side window glass integrity in rollovers. This must change if we are to ever get close to achieving the level of zero deaths in rollover accidents.

Quick link

It is important to encourage the adoption of laminated side window glass and also improved side-curtain airbags that stay inflated longer. But we must also ensure that doors will stay shut, that stronger roofs won’t buckle and crush down, that seatbelts will tighten and that interior surfaces are padded, so that all occupants are better protected during side impacts and rollover accidents.

“Automakers must treat the vehicle in total… and make sure their development process includes dynamic rollover testing”

Complete ejection: Case A

Bethany, aged 11, was seat-belted on the second-row seat of a Chevy Suburban SUV. In a moderate collision, the seatbelt came unbuckled and she was ejected through the adjacent large side window opening as the tempered glass easily shattered. Bethany impacted her head on the road, incurring severe trauma to her face, skull and brain. If that large side window had been laminated glass, it would have stayed intact and served as a life net to prevent her from being ejected and severely injured. See figure above.

Partial ejection: Case B

Rhonda, a middle-aged woman, was driving her Chevy Tahoe SUV and was wearing her seatbelt. When struck in the rear corner by another car, the Tahoe SUV went out of control and rolled over. During the rollover sequence, the driver’s side window’s tempered glass shattered, causing Rhonda to be partially ejected and suffer massive, fatal head trauma. If the driver’s side window glass had instead been of laminated glass, it would have stayed intact and served as a life net to prevent her from being partially ejected and killed.

Perform notably safer in these rollover tests and in real-world accidents compared with US and Japanese vehicles that have not been subjected to such dynamic lateral rollover testing during their development and validation phases. Furthermore, NHTSA itself conducted similar dynamic rollover tests back in the early 1970s and found that such a test procedure was valid and sufficiently repeatable. The merits of testing to assess the entire vehicle performance, including data on forces experienced by the test dummies, clearly outweighs the criticism that it does not precisely roll the identical way in a series of such tests. But then again, this would show what does in fact happen in real-world rollover accidents.

While NHTSA requires dynamic tests for front impact, side impact and rear impact, there is still no dynamic rollover test. And now, after over 40 years of ignoring occupant ejection mitigation via windows, NHTSA has come up with a totally unrealistic headform impactor test. NHTSA tries to rationalize this minimalist test by boldly stating, “The test has been carefully designed to represent the dynamic rollover event.”

However, it appears instead that the FMVSS 226 compliance test has been carefully crafted to require only very minimal performance so that virtually any side window with a side-curtain airbag can meet that requirement. The proposed FMVSS 226 for ejection mitigation is only a very minimal and unrealistic test when compared with what happens in real-world rollover accidents. Auto makers should not settle for designing and testing their vehicles and side window glass and side-curtain airbags simply to comply with, or even moderately exceed, such minimum requirements. Auto makers instead must treat the vehicle in total, including roof structure, seatbelts, side-curtain airbags, interior padding, side window glass, door structure and door latches, and make sure their development process includes dynamic rollover testing at least at 50mph, or preferably higher.

It is important to conduct dynamic lateral rollover tests at 50mph-plus to ensure that all production systems perform safely. By doing so, the lethality of occupant ejection in side impacts and rollovers would be greatly minimized, and we would get closer to the compassionate vision of zero fatalities that is advocated worldwide.