

# INSURANCE INSTITUTE FOR HIGHWAY SAFETY

February 28, 2011

The Honorable David L. Strickland  
Administrator  
National Highway Traffic Safety Administration  
1200 New Jersey Avenue, SE  
Washington, D.C. 20590

## **Petition for Rulemaking; 49 CFR Part 571 Federal Motor Vehicle Safety Standards; Rear Impact Guards; Rear Impact Protection**

Dear Administrator Strickland:

The Insurance Institute for Highway Safety (IIHS) hereby petitions the National Highway Traffic Safety Administration (NHTSA) to upgrade the Federal Motor Vehicle Safety Standards (FMVSS) on rear impact protection for semi-trailers (49 CFR 571.223, 224). The current standards allow underride guard designs that fail catastrophically when struck by passenger vehicles at speeds that frequently produce minimal intrusion and injury risk in regulatory and consumer information frontal crash test programs. The standards should be upgraded to require underride guards that are strong enough to remain in place during a crash, allowing the energy absorbing structures of passenger vehicles to deform and provide protection to their occupants.

According to the Fatality Analysis Reporting System (FARS), about 10 percent of passenger vehicle occupant fatalities occur in crashes involving large trucks. Blower et al. (2001) estimated that the rears of trucks are involved in 12 percent of passenger vehicle occupant fatalities in two-vehicle crashes with large trucks. To address these crashes, NHTSA issued its final rule establishing FMVSS 223 and 224 in 1996, and the rule became effective on January 26, 1998. FMVSS 224 specifies the dimensional requirements for rear underride guards as well as the types of trailers required to be fitted with guards. FMVSS 223 specifies minimum strength requirements in quasi-static tests at three locations on the guard. In one of the tests, the guard also must absorb a certain amount of energy by deforming plastically up to 125 mm. This reflects NHTSA's concern that "overly rigid guards could result in passenger compartment forces that would increase the risk of occupant injuries even in the absence of underride" (61 FR 2005). At the same time, the agency recognized the need for adequate guard strength because "the more the guard yields, the farther the colliding vehicle travels and the greater the likelihood of passenger compartment intrusion" (61 FR 2009). In the end, NHTSA believed the standards would produce guard designs that could be struck by passenger vehicles at speeds of 40-56 km/h and deform enough to prevent excessive deceleration while not allowing the occupant compartment to strike the trailer.

The passenger vehicle fleet has changed dramatically since the early 1990s when the standards were developed. The front-end structures of virtually all modern vehicles are designed to limit intrusion and deceleration levels in the frontal consumer evaluation tests conducted by NHTSA and IIHS. Because these designs can effectively absorb the energy of a 56 km/h full-width rigid wall impact and a 64 km/h deformable barrier crash with 40 percent overlap, the main purpose of an underride guard should be to provide a stable reaction surface for the passenger vehicle structure. It should not be necessary to increase the risk of occupant compartment intrusion in order to limit deceleration levels in lower speed crashes through deformation of the underride guard.

IIHS recently studied cases from the Large Truck Crash Causation Study (LTCCS) involving rear impacts of trailers with underride guards built to comply with one or both of the safety standards (Brumbelow and Blonar, 2010). Many instances of guard failure were identified that produced excessive passenger vehicle underride, but no cases of serious injury to an occupant who may have benefitted from striking a

less stiff underride guard. The most common failures were due to excessive bending of one outboard end of the guard in partial overlap crashes, weakness in the attachment between the guard and trailer, or deformation of the trailer chassis itself.

To further investigate these issues, IIHS conducted a series of six crash tests in which a 2010 Chevrolet Malibu struck the rear of a semi-trailer equipped with an underride guard. Trailers manufactured by Hyundai, Vanguard, and Wabash were evaluated. All three designs easily passed FMVSS 223 quasi-static tests at P1 and P3 locations conducted by IIHS. The Vanguard and Wabash guards even met the more stringent P3 requirements of Canadian Motor Vehicle Safety Standard (CMVSS) 223 and are certified to that standard. The strongest guard was the Wabash, which at the P3 test location exceeded the current FMVSS and CMVSS peak force requirements by 187 and 70 percent, respectively.

The 2010 Chevrolet Malibu has a Top Safety Pick designation by IIHS and five-star frontal NCAP scores (1990-2010 program) for both the driver and front passenger. Despite its good frontal crash test performance, the Malibu sustained catastrophic underride when it struck the rear of the Hyundai and Vanguard trailers in 56 km/h tests with overlaps of 100 and 50 percent, respectively (the overlap refers to the portion of the Malibu's width overlapping the underride guard). The stronger guard on the Wabash trailer performed well in the full-width and 50 percent overlap conditions, providing much greater protection against underride than the other two guards. However, when the overlap was further reduced to 30 percent, the end of the guard bent forward and allowed underride. Summaries of the dynamic and quasi-static tests are listed in Appendix A.

These crash tests show there is considerable practical potential to improve rear underride guards on truck trailers. If all underride guards were as strong as that on the Wabash trailer, it is likely that many of the underrides with large overlaps in LTCCS (13 of the 22 failures of FMVSS 224-compliant guards) would have been prevented and the vehicle occupants protected by crashworthiness built into modern vehicles. If that strength was extended to the ends of the underride guards, the protection against underride would have been enhanced for the other 9 LTCCS crashes. Modern passenger vehicle designs perform well in barrier tests at impact speeds as high as or higher than those that produce failure of FMVSS-compliant underride guards. The occupant compartment intrusion resulting from guard failures exposes occupants to risks of severe head, neck, and other injuries in crashes that otherwise would be easily survivable.

The failure of the Wabash guard in the test at 30 percent overlap means that 50 percent of the rear of even the strongest trailer (the left and right quarters) is poorly protected against underride by a passenger vehicle contacting that area. The guard prevented underride in the full-width and 50 percent overlap tests by transferring the crash loads to stiff portions of the trailer chassis. To extend this protection to the full width of the trailer, the test at the P1 location should be moved farther outboard as well as subjected to a higher force requirement. On many trailers, the strong side rails should provide an acceptable location for attaching a guard to protect against underride in small overlap crashes.

In its final rule, NHTSA stated that the "importance of careful attachment hardware material selection and attachment design cannot be overemphasized" (61 FR 2013). Yet two of the three guards tested by IIHS met the P3 requirements of FMVSS 223 by substantial margins, despite having attachment bolts that sheared or pulled away from the guard in the quasi-static tests — failures similar to those produced in the crash tests. Only the Wabash guard showed no sign of attachment failure in the regulatory or crash tests. Although the Wabash guard exceeded the P3 requirements by 187 percent, this was only slightly greater than the force sustained by the Vanguard guard prior to shearing of its attachment bolts. This demonstrates why simply increasing the overall peak force requirements of FMVSS 223 would be insufficient. To encourage intelligent guard design, the regulations should include a stipulation that all attachment hardware must remain intact for the duration of the test or until reaching a force threshold that is much higher than that required for the guard itself.

To ensure the compliance tests correspond to on-road underride protection, NHTSA should not allow guards to be certified separately from the trailers to which they will be attached. Several of the IIHS crash tests produced deformation to various portions of the trailer, suggesting the total resistance of the guard-attachment-trailer system is lower than that of a guard alone when tested on a rigid fixture. Ideally, the regulation would require guards to be certified while attached to complete trailers. At a minimum, they should be attached to sections of the trailer rear that include all the major structural components and that are constrained far enough forward that the load paths near the guard are not changed, unlike many of the fixtures illustrated in NHTSA's compliance test reports.

It is important to note that all of the guards tested were at least 8.4 cm closer to the ground than required by FMVSS 224 (Appendix A, Table A-1). This is consistent with the FMVSS 224-compliant guards in LTCCS, which averaged 9 cm lower than the maximum allowed ground clearance. All of the tested guards overlapped at least a portion of the Malibu's bumper bar, which extended up to 53 cm. If the Wabash guards had been 56 cm from the ground, as allowed by the regulation, it is possible that the good performance in the full-width and 50 percent overlap tests would have been compromised. NHTSA should determine how some trailer manufacturers are able to install guards with substantially less ground clearance than required, and consider whether the requirement should be reduced for at least the most common van and flatbed trailer types. This would extend the improved engagement with passenger vehicles that is offered by the lower guards to more of the trailer fleet.

Finally, in upgrading FMVSS 224, NHTSA should evaluate whether the standards can be extended to more truck and trailer types. More than half of the truck units in the LTCCS cases studied by IIHS were exempt from NHTSA's underride guard regulations, or would have been exempt if built after the rules' effective date. Wheels-back trailers and straight trucks accounted for most exemptions, and many of these vehicles had some type of underride guard installed. This suggests it would not be impractical for NHTSA to include other types of trailers and trucks in its regulation, which is necessary for an upgraded standard to have maximum effect.

In summary, IIHS provides analyses and test results showing that NHTSA could greatly reduce the likelihood of rear truck underride by reopening rulemaking on FMVSS 223 and 224 to:

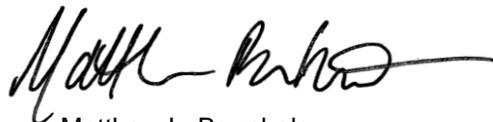
1. Substantially increase the quasi-static force requirements, at least to levels that would guarantee all guards are as strong as the Wabash;
2. Move the P1 test location farther outboard to improve offset crash protection;
3. Require that attachment hardware remains intact throughout the tests;
4. Require guards be certified while attached to the trailers for which they are designed;
5. Investigate whether the maximum guard ground clearance can be reduced; and
6. Reduce the number of exempt truck and trailer types.

IIHS urges NHTSA to begin such rulemaking as soon as possible to reduce the preventable injuries and deaths occurring when passenger vehicles strike the rears of large trucks at speeds the passenger vehicles are clearly designed to handle in the absence of underride.

Sincerely,



David S. Zuby  
Chief Research Officer



Matthew L. Brumbelow  
Senior Research Engineer

**References**

Blower, D.; Krishnaswami, V.; Putcha, D; and Svenson, A. 2001. Analysis of truck-light vehicle crash data for truck aggressivity reduction. SAE Technical Paper 2001-01-2726. Warrendale, PA: Society of Automotive Engineers.

Brumbelow, M.L. and Blonar, L. 2010. Evaluation of US rear underride guard regulation for large trucks using real-world crashes. *Proceedings of the 54th Stapp Car Crash Conference*, 119-31. Warrendale, PA: Society of Automotive Engineers.

**Appendix A**

IIHS conducted a series of six crash tests with a 2010 Chevrolet Malibu striking the rear of a tractor-trailer equipped with an underride guard (Table 1). The underride categories are those used in the IIHS study of LTCCS cases (Brumbelow and Blonar, 2010), with severe underride indicating intrusion extending into the occupant compartment and catastrophic underride involving complete loss of the front occupant survival space. Figure 1 (next page) shows the Malibus at the time of maximum forward excursion relative to the trailers. Detailed crash test reports are available at <http://techdata.iihs.org/>.

All three underride guard designs met FMVSS 223 requirements at P1 and P3 test locations, although by varying amounts (Table 2). Two of the guards also met the more stringent CMVSS 223 requirements at P3, which are conducted with the guard cut in half. All quasi-static tests were conducted with the guard installed on a rigid fixture with the same hardware used to attach the guard to the trailer.

**Table A-1  
 Front-into-Trailer Rear Crash Tests, 2010 Chevrolet Malibu**

Trailer	Speed (km/h)	Malibu's overlap with guard	Guard ground clearance (cm)	Guard performance	Underride
2007 Hyundai	56	Full-width	47.6	Attachments failed	Catastrophic
2007 Vanguard	40	50%	42.2	Attachments failed	Moderate
2007 Vanguard	56	50%	42.7	Attachments failed	Severe
2011 Wabash	56	Full-width	44.5	Good	None
2011 Wabash	56	50%	44.3	End bent forward	None
2011 Wabash	56	30%	45.3	End bent forward	Catastrophic

**Table A-2  
 Quasi-Static Test Results**

Requirement	FMVSS P1 peak force (kN)	FMVSS P3 peak force (kN)	FMVSS P3 energy absorbed (kJ)	CMVSS P3 peak force (kN)	CMVSS P3 energy absorbed (kJ)
	<b>50</b>	<b>100</b>	<b>5.6</b>	<b>175</b>	<b>10</b>
2007 Hyundai	109	163	13.9	135	11.8
2007 Vanguard	143*	257	14.0	209	11.8
2011 Wabash	162	287	22.1	297*	21.5*

\*Test was stopped prior to 125 mm

**Figure A-1**  
**Maximum Forward Excursion Relative to Trailer, 2010 Chevrolet Malibu**



56 km/h, full-width tests with 2007 Hyundai trailer (left) and 2011 Wabash trailer (right)



56 km/h, 50 percent overlap tests with 2007 Vanguard trailer (left) and 2011 Wabash trailer (right)



40 km/h, 50 percent overlap with 2007 Vanguard trailer (left)  
56 km/h, 30 percent overlap test with 2011 Wabash trailer (right)