STATUS REPORT
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UNDERRIDE CRASHES

can be catastrophic for people in passenger vehicles that run into the backs of heavy trucks. The steel guards on the backs of big rigs are supposed to stop smaller vehicles from sliding underneath trailers, but a new Institute analysis of real-world crashes indicates that too often rear guards intended to prevent underride buckle or break away from their trailers — with deadly consequences. To understand how this happens, the Institute ran a series of crash tests and discovered that guards meeting federal safety standards can fail in relatively low-speed crashes. Based on this research, the Institute is petitioning the National Highway Traffic Safety Administration (NHTSA) to

require underride guards that are strong enough to remain in place during a crash and to broaden rules to mandate guards for more large trucks and trailers.

Any crash between a large truck and a passenger vehicle is a risky event. In 2009, 70 percent of the 3,163 people who died in large truck crashes were occupants of cars or other passenger vehicles. Underride makes death or serious injury more likely since the upper part of the passenger vehicle's occupant compartment typically crushes as the truck body intrudes into the vehicle safety cage. Rear guards are the main countermeasure for reducing underride deaths and injuries.

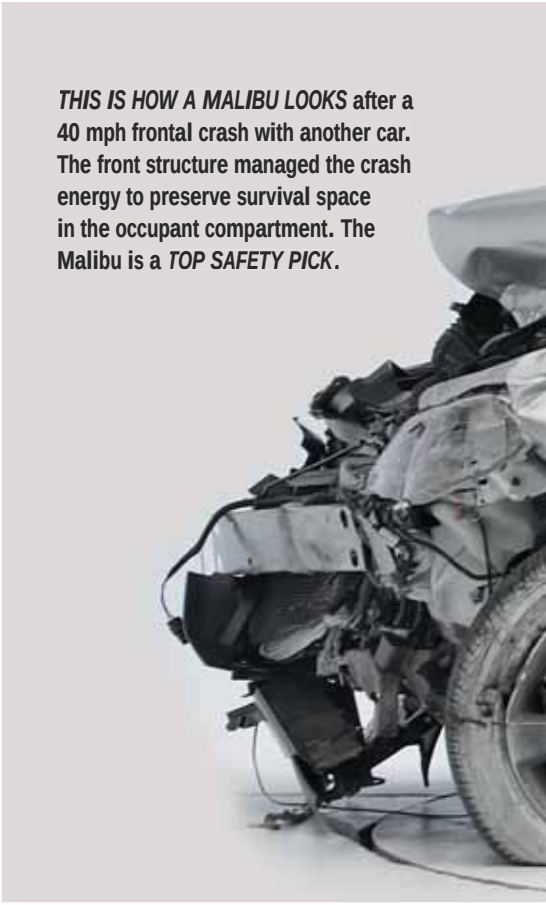
A 2009 Institute study and a similar one by NHTSA examined why people still die in crashes despite tremendous advances in passenger vehicle occupant protection. Underride crashes with large trucks were identified as among the most deadly (see *Status Report*, March 7, 2009, and Feb. 6, 2010; on the web at iihs.org).

in a vehicle that earns top marks in frontal crash tests, but if the truck's underride guard fails — or isn't there at all — your chances of walking away from even a relatively low-speed crash aren't good."

NHTSA has estimated that about 423 people in passenger vehicles die each year when their vehicles strike the backs of large trucks. More than 5,000 passenger vehicle occupants are injured.

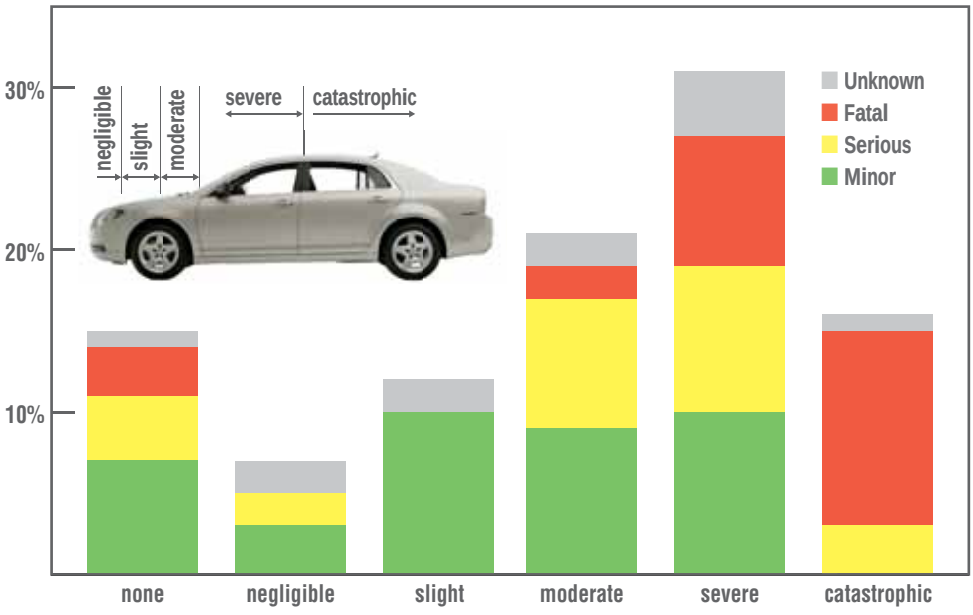
Pinpointing precisely how many large truck underride deaths occur each year is difficult because federal databases that track crashes are known to underestimate the incidence of underride. A 1997 Institute study estimated that underride occurred in half of fatal crashes between large trucks and passenger vehicles (see *Status Report*, Feb. 15, 1997).

Real-world crashes: To identify crash patterns leading to rear underride of heavy trucks and semi-trailers with and without guards, Institute researchers analyzed case files from the Large Truck Crash Causation



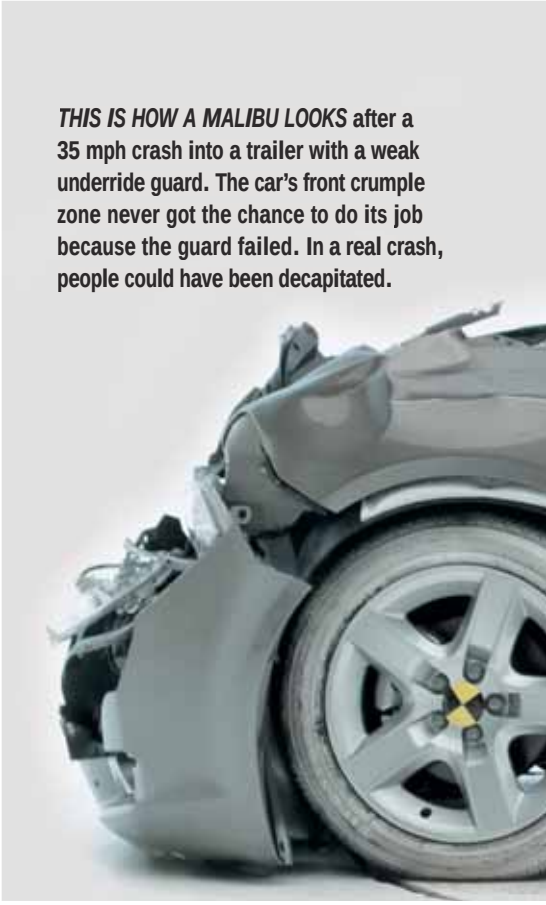
THIS IS HOW A MALIBU LOOKS **after a 40 mph frontal crash with another car. The front structure managed the crash energy to preserve survival space in the occupant compartment. The Malibu is a *TOP SAFETY PICK*.**

UNDERRIDE AND INJURY SEVERITY IN 115 REAL-WORLD CRASHES



"Cars' front-end structures are designed to manage a tremendous amount of crash energy in a way that minimizes injuries for their occupants," says Adrian Lund, Institute president. "Hitting the back of a large truck is a game changer. You might be riding

Study, a federal database of roughly 1,000 real-world crashes in 2001-03. Underride was a common outcome of the 115 crashes involving a passenger vehicle striking the back of a heavy truck or semi-trailer. Only 22 percent of the crashes *(continues on p. 4)*



THIS IS HOW A MALIBU LOOKS **after a 35 mph crash into a trailer with a weak underride guard. The car's front crumple zone never got the chance to do its job because the guard failed. In a real crash, people could have been decapitated.**

REGULATORS SLOW TO ACT ON UPGRADE

The Institute has studied the underride crash problem for more than 30 years, including mid-1970s crash tests demonstrating how then-current guards were ineffective in preventing underride (see *Status Report*, March 29, 1977; on the web at iihs.org).

Federal rules put in place in 1953 required interstate carriers to have rear underride guards meeting specifications for ground clearance, setback, and width, but not strength, energy absorption, or attachment methods.

The National Highway Safety Bureau, predecessor to the National Highway Traffic Safety Administration (NHTSA), indicated in 1967 that it would develop a new standard, but the agency abandoned the effort in 1971 even though the National Transportation Safety Board recommended that energy-absorbing underride and override barriers on trucks, trailers, and buses be required.

In 1977 the Institute demonstrated that a 30 mph crash of a Chevrolet Chevette into a tractor-trailer with a rear guard meeting the US rule resulted in severe damage to the car's occupant compartment. The Institute petitioned NHTSA for a new standard.

It took the agency nearly 20 years to publish new rules. The upgrade took effect in 1998 and resulted in lower and wider underride guards under Federal Motor Vehicle Safety Standard 224. Another standard, Federal Motor Vehicle Safety Standard 223, introduced quasi-static test requirements specifying minimum levels of strength and energy absorption (see *Status Report*, March 2, 1996). The standards cover new trailers but exempt many types of heavy trucks used in everyday commerce including straight trucks, wheels-back trucks, and special purpose trucks. The result is that the majority of trucks on the road aren't subject to underride rules.

Meanwhile, the passenger vehicle fleet has changed dramatically since NHTSA wrote the standards. Regulators then were concerned that "overly rigid guards could result in passenger compartment forces that would increase the risk of occupant injuries even in the absence of underride." The agency also recognized the need for balancing energy absorption with guard strength because "the more the guard yields, the farther the colliding vehicle travels and the greater likelihood of passenger compartment intrusion."

The Institute's latest analysis indicates that guards too weak to adequately mitigate underride are a bigger problem than overly stiff guards.

(continued from p. 2) didn't involve underride or had only negligible underride, a finding in line with prior studies.

Nearly half of the passenger vehicles had underride damage classified as severe or catastrophic, meaning the entire front end or more of the vehicle slid beneath the truck, resulting in loss of survival space in the occupant compartment due to intrusion. These vehicles accounted for 23 of the 28 crashes in which someone in the passenger vehicle died.

Many of the cases of severe underride involved trucks and trailers exempt from underride-related safety standards. More than half of the trucks in the study weren't required to have guards, although many had them anyway. The two largest exempt groups were trailers with rear wheels set very close to the back of the trailer and straight trucks (single-unit trucks with a cab and cargo body on one chassis). Dump trucks represented a particularly hazardous category of straight truck. They accounted for about one-third of the straight trucks but half of all the straight truck crashes involving severe or catastrophic underride.

When trailers did have regulation guards, researchers identified 3 main failure modes. The most common reason was simply that the attachment between the guard and trailer was weak. This was the case in wide overlap crashes (involving the center of the guard) when the attachment between the guard's vertical supports and trailer chassis broke where the guard was bolted or welded to the trailer. Weakness also was a problem in narrow overlap crashes where a passenger vehicle struck one outboard end of a guard's main horizontal beam, causing it to bend forward or shear off completely. In the third type of failure, an underride guard remained attached to its trailer, but the trailer chassis itself buckled, causing the guard to rotate up and forward.

The Institute didn't attempt to compare the performance of underride guards built before and after the 1996 release of upgraded federal standards regarding guard size, strength testing, and energy absorption *(see p.3)*. NHTSA recently did try to see if guards complying with the rules that took effect in 1998 reduce death and injury risk for people in passenger vehicles. In a technical report published in late 2010, the agency said it couldn't identify a decline in underride deaths, mainly because the Fatality Analysis Reporting System doesn't record trailer model years and other details needed to determine whether a particular trailer was covered by the current rule. Databases from North Carolina and Florida that contained model year information suggested there may have been an improvement, but the number of crashes was small and other details were missing so the estimates were inconclusive.

Crash tests: The Institute's study raised questions about how and why guards failed, so researchers followed up with a series of 6 crash tests evaluating 3 semi-trailer rear guards complying with US rules. Two of the trailers also are certified to Canadian requirements, which are more stringent than the United States when it comes to strength and energy absorption. The tests involved crashing a 2010 Chevrolet Malibu into the rear of parked trailers.

When a Chevrolet Malibu, a *TOP SAFETY PICK*, struck the back of a Hyundai trailer (top) in the full-width test at 35 mph, damage was so severe that people in a real crash like this test would have died. The underride guard bent forward, shearing its attachment bolts and pulling away from the trailer. This was the weakest underride guard the Institute evaluated. In contrast, the Wabash trailer's guard (right) successfully stopped the car from underriding the trailer. The Wabash was the strongest of the 3 underride guards the Institute evaluated.

The goal wasn't to evaluate the Malibu's crashworthiness. The midsize sedan is an Institute *TOP SAFETY PICK* and earns a 5-star safety rating in NHTSA's New Car Assessment Program.

"The aim was to see if some underride guards perform better than others and to identify what crash speeds and configurations produce different types of failure," Lund says. "Damage to the cars in some of these tests was so devastating that it's hard to watch the footage without wincing. If these had been real-world crashes there would be no survivors."

Decapitation is a threat in underride crashes. In 3 of the crash tests the heads of the dummies in the underriding car made contact with either the intruding trailer or the car's hood after it tore free and pushed into the occupant compartment. One such test involved a Hyundai trailer whose underride guard bent forward, sheared its attachment bolts, and broke after the Malibu hit it in the center rear at 35 mph. This was the weakest guard tested. The trailer was manufactured by Hyundai Translead, a San Diego, Calif.-based subsidiary of South Korea's Hyundai Motor Co.

In contrast, a Wabash trailer outfitted with a guard certified to Canadian specifications successfully prevented underride of the Malibu's passenger compartment in a center-rear test at 35 mph. The trailer was manufactured by Lafayette, Ind.-based Wabash National Corp. Its guard was the strongest of the 3 evaluated.

"It's clear to our engineers that Wabash understands how underride guards and trailers work together as a unit instead of treating them as separate components," Lund says. "Strong attachments kept the Wabash guard in place so it could engage the Malibu, allowing the car's structure to absorb and manage the crash energy. In the real world, this would be a survivable crash."

Overlap tests are more challenging: To find out what happens when a car hits the trailer with only part of its front instead of head-on, the Institute ran offset tests with overlaps of 50 percent and 30 percent. When the Institute evaluates passenger vehicles in its frontal crashworthiness program, it uses a 40 percent overlap test at 40 mph.

In a 25 mph test with a 50 percent overlap, the guard on a Vanguard trailer tore away, allowing moderate underride. At 35 mph with the same overlap the underride was severe. The trailer was manufactured by Vanguard National Trailer Corp., a

Monon, Ind.-based subsidiary of China International Marine Containers Ltd. The guard is certified to US and Canadian standards.

After the Wabash's good performance in the full-width test, engineers had high hopes for the offset tests. The guard successfully prevented underride in the test where the Vanguard failed (50 percent overlap at 35 mph), even though the struck end started to bend forward. The outcome for the Wabash was different when the overlap was reduced to 30 percent. The struck end of the guard again bent forward, and this time there was severe underride.

This test shows that even the strongest guard left as much as half of the rear of the trailer vulnerable to severe underride. The guard only worked as intended when the striking car engaged the center.

"The best underride guard was a big improvement over the weakest one, but it still failed when hit near the outermost end of the guard," Lund says. "Failures like this were among the most common in our analysis of real-world crashes. Canada's underride standard is tougher than US requirements but still not strong enough or comprehensive enough to prevent underride in crash configurations that cause many severe injuries."

Offset tests stress guards' unsupported outboard ends. The vertical frame supports that attach guards to their trailer chassis are located closer to guards' centers than ends. Preventing underride in narrow overlap crashes like these might mean devising a new way of attaching guards to trailers to utilize the side rails, in addition to requiring manufacturers to conduct compliance tests with guards on trailers.

"Under current certification standards, the trailer, underride guard, bolts, and welding don't have to be tested as a whole system," Lund points out. "That's a big part of the problem. Some manufacturers do test guards on the trailer. We think all guards should be evaluated this way. At the least, all rear guards should be as strong as the best one we tested."

Another problem is that regulatory gaps allow many heavy trucks to forgo guards altogether. When they are present on exempt trucks, guards don't have to meet 1996 rules for strength or energy absorption.

"Underride standards haven't kept pace with improvements in passenger vehicle crashworthiness," Lund says. "Absent regulation, there's little incentive for manufacturers to improve underride countermeasures, so we hope NHTSA will move quickly on our petition."

For a copy of "Evaluation of US rear underride guard regulation for large trucks using real-world crashes" by M.L. Brumbelow and L. Blanar, email publications@iihs.org.

Vanguard trailer, 35 mph test, 50 percent overlap; *SEVERE UNDERRIDE* due to failed attachments connecting the underride guard to the trailer.

Wabash trailer, 35 mph test, 50 percent overlap; *NO UNDERRIDE* even though the struck end of the guard bent forward.

Wabash trailer, 35 mph test, 30 percent overlap; *SEVERE UNDERRIDE* as the struck end bent forward.

MORE PEOPLE BUCKLE UP AMID HIGHER FINES FOR VIOLATIONS

New research sponsored by the National Highway Traffic Safety Administration shows that increasing fines for violating safety belt laws can boost compliance.The study by Bedford Research and the Pacific Institute for Research and Evaluation confirms that changing safety belt laws from secondary to primary enforcement is most effective in encouraging people to buckle up. But steeper fines lead to further gains in belt use, beyond what primary laws alone can accomplish, the study shows.

The authors found that upgrading from a secondary to a primary law, which allows police to stop a driver on the basis of that violation alone, increases front-seat belt use by 10 to 12 percentage points. That's in line with previous research about the importance of primary laws (see *Status Report*, Jan. 31, 2005, and Aug. 3, 2010; on the web at iihs.org).

When the researchers looked at what happens when fines are increased from the national median of $25 to $60, they found gains of 3 to 4 percentage points. Raising fines to $100 increases belt use by 6 to 7 percentage points.

The researchers calculated these increases using data from annual observational surveys in each state. They obtained similar results when they did the same analysis using a national crash database with information on belt use by fatally injured front-seat occupants.

The news that bigger fines lead to higher compliance gives states another tool for tackling a difficult problem. As the study's authors note, increasing safety belt use has been a slow process in the United States. In 2010, use stood at 85 percent — far higher than a few decades ago but lower than in many European countries, Australia, and Canada. US belt use varies widely among states, from 68 percent in 2009 in Wyoming to 98 percent in Michigan.

Despite safety belts' importance in reducing injuries, fines generally are low, compared with other traffic violations. Only New Mexico and the District of Columbia assess points against drivers' licenses when adults aren't buckled.

The solution isn't just to make penalties as stiff as possible. As the report notes, police are unlikely to enforce laws if they believe the penalties are too high. Still, when it comes to belt violations there's room for harsher consequences. Recent surveys have found that fines of as much as $50 would enjoy broad support, although acceptance of penalty points for violations is much lower, the report notes.

"Strategies to increase seat belt use: an analysis of levels of fines and the type of law" by J.L. Nichols et al., is available at www.nhtsa.gov.

LAURA P. SULLIVAN

FORMER INSTITUTE CHAIRMAN

Laura P. Sullivan, the only woman to serve as chairman of the Institute's board of directors, died Dec. 10, 2010, in Chicago. She was 63 years old.

Sullivan was vice president, corporate secretary, and counsel of State Farm until her retirement at the end of 2004. An Iowa native, she joined State Farm as a senior attorney in 1975. Before that, she was director of the property and casualty division of the Iowa Insurance Department.

Sullivan served on the Institute's board from 1984 to 1997 and again from 2002 to 2004. She was chairman during 1987-88.

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Underride guards can fail in real-world crashes, and crash tests demonstrate the need for new standards to address the deadly problem 1

Moves to upgrade standards on underride guards have been slow coming 3

Belt use rises when fines for not buckling up are increased 7

Laura P. Sullivan was the first woman to serve as Institute chairman 7

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