

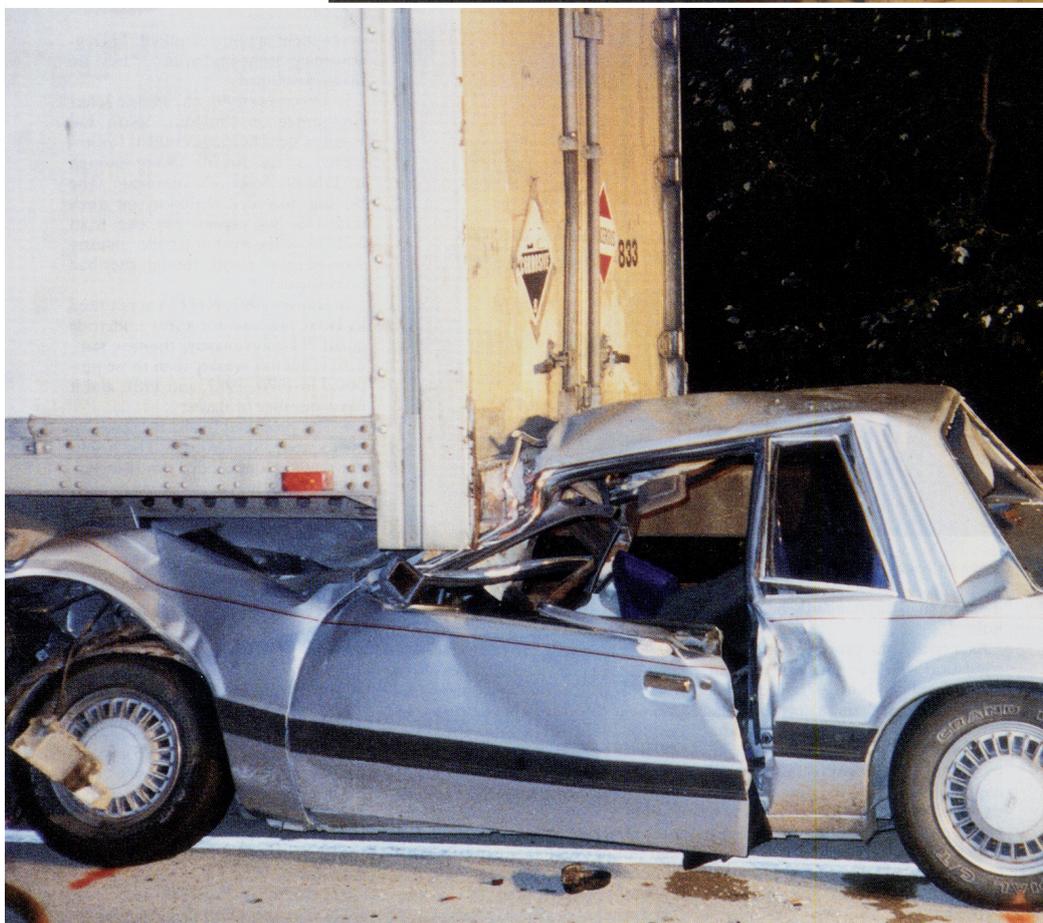
Deep impact

Byron Bloch discovers the importance of rear and side guards for trucks and trailers in preventing truck underride tragedies, and how much more there is to do in the name of safety

■ Regardless of what causes a passenger vehicle to crash into the rear or side of a large truck or trailer – driver misjudgment, a lack of conspicuousness that leaves the trailer less visible in the dark of night, inclement weather, or some other reason – the rear and sides of the truck or trailer must have sufficient underride prevention guards so that the collision does not result in severe or fatal injuries to the occupants of the impacting passenger vehicle.

Truck underride is when a passenger vehicle crashes into and continues under a truck, riding beneath the rear or side of a large truck or trailer. The rigid structures of the taller truck or trailer crash through the windshield and windshield pillars, ripping and crushing the roof, and penetrating deep into the passenger compartment survival space. The consequences to the driver and passengers are devastating, often with severe or fatal head injuries, and sometimes partial or complete decapitation.

Truck underride is preventable. The prevention of the truck-underride hazard is accomplished with guard devices designed into or attached to the rear or side of large trucks or trailers. When a passenger vehicle makes contact with a guard of sufficient strength, that guard prevents the vehicle from underriding, thereby safely maintaining the occupants' survival space.





Above and left: In an underride situation, the rigid structures of the taller truck or trailer crash through the windshield, and windshield pillars, ripping and crushing the roof, and penetrating the passenger compartment

The safety importance of full-width rear guards and sideguards is reflected in the authoritative 1977 report on car-into-truck fatal accidents by the Highway Safety Research Institute (HSRI) at the University of Michigan, USA. This benchmark report, based upon an analysis of many truck underride accidents, showed that many fatal underride crashes involved the rear and rear corners of large trailers, and many went into and beneath the sides of the trailer. The report also noted that many collisions were 'surprise events' for motorists who didn't expect to find a large truck ahead of them on the road.

It all began back in 1953, when the US Interstate Commerce Commission (ICC) issued a requirement for trucks and trailers to have 'rear end protection'. The basic requirements allowed the guard device to be too high, too narrow, and too weak, and proved to be grossly ineffective by failing to prevent the lethal underride of passenger vehicles.

In 1966, the US Congress enacted legislation that created the National Highway Traffic Safety Administration (NHTSA),

with its mandate to establish Federal Motor Vehicle Safety Standards (FMVSS) as minimum requirements to help make vehicles safer and more crashworthy. One of the very first rule-making subjects was to focus on truck underride. As a result, NHTSA funded a project called 'Development of Standards for a Heavy Vehicle Underride Guard', conducted in 1968 by Aerospace Research Associates Inc. (ARA), which described feasible designs for rear guards and sideguards on large trailers.

In 1970, NHTSA funded a car-into-truck crash test study at Cornell University, which recommended that guards be no higher than 18in above the ground, and be capable of withstanding 60,000 lb (27,215kg) of resistive force. Cornell demonstrated the effectiveness of a rear guard that was low enough to engage the front of the car, and of sufficient strength to prevent underride.

Also in 1970, the Truck Trailer Manufacturers Association acknowledged that: 'It is within our competency to design and mount on new trailers an underride guard capable of withstanding the test loads described in the DOT proposal and

at a height of 18in (46cm) above the road... It is possible to provide the dual capability of 50,000 lb (22,680kg) at the 24in (61cm) height and 37,000 lb (16,783kg) at the 18in height using the same structure.' However, lobbying efforts delayed the issue of a new safety standard for underride guards.

At a 1977 US Senate Hearing on Truck-Car Crash Safety, illustrative car-into-trailer crash-test films were shown to the Senate Committee from the Insurance Institute for Highway Safety (IIHS), as well as testimony from the IIHS president, William Haddon. It was clear that the truck-underride hazard was needlessly killing US motorists, and that something constructive needed to be done. The NHTSA issued a contract for truck underride crash tests to be conducted at Dynamic Science in order to recommend guard requirements.

In 1977, the IIHS showed that the old-design ICC rear guards were ineffective. They were too high, too narrow, and too weak to prevent underride. The ICC-type guard often failed, and the truck's rear structures would crash through the windshield and crush and rip through the roof, penetrating the passenger compartment with catastrophic results. IIHS also conducted crash tests to demonstrate stronger, safer rear guards on trailers.

In 1980, the Dynamic Science Study for NHTSA reaffirmed that old-style ICC guards were ineffective. Based on a series of car-into-truck tests, the report recommended that guards be capable of withstanding 70,000 lb (31,751kg) of resistive load, to provide underride protection for crashes at 40mph (64km/h) and higher.

So in a 20-year period, these three major studies all came to the same conclusions: ICC rear guards were inadequate, and safer guards should be lower, wider, and stronger. Although European regulations encouraged the adoption of upgraded rear guards in the 1980s, the US trucking industry failed to install safer rear guards. NHTSA was politicized and constrained from issuing a safety standard that would enforce such installations in the USA.

In 1995, NHTSA issued FMVSS 223 and 224 to require improved rear guards that were lower, wider, stronger, and energy-absorbing. This new regulation was only a minimum requirement, and was applicable only to new trailers manufactured after January 26, 1998. The upgraded rear guards were required to be no higher than 22in (56cm) above the ground, have a resistive strength of 100,000N (22,400 lb), and extend laterally almost full-width across the rear with no more than 4in (10.1cm) in-board from the sides of the trailer.



Above: Frames from a 1977 IIHS crash test
Left: The safety effectiveness of full-width underride guards being tested at Monash University in Australia

In 1993, car-into-truck crash tests were conducted at the Accident Research Centre of Monash University in Victoria, Australia. An offset impact into the rear corner of the truck showed how the truck's rear corner rips through the windshield and roof pillars and into the passenger compartment survival space.

The truck was then fitted with a full-width guard, anchored at the corners and equipped with diagonal braces. In this second offset impact into the rear corner of the truck, the safer rear guard prevents much intrusion into the passenger compartment survival space. The safety effectiveness of full-width underride guards with well-braced corner members was clearly demonstrated and proved.

And so, after a 25-year delay, a somewhat stronger and safer rear underride guard was destined for all new trailers in the USA from January 1998. Trucks were not included, nor was anything to be done by either NHTSA or the trucking industry about the side underride hazard.

Having recognized the deficiencies in the obsolete and ineffective ICC regulation, when NHTSA came into being in 1967, one of the initial vehicle safety issues it tackled was the need for truck-underride protection. The NHTSA-proposed rule-making docket noted that rear underride guards would be the initial focus and that 'it is anticipated that the proposed standard will be amended, once technical studies are complete, to extend the requirement for underride protection to the sides of large vehicles'.

Also in 1977, the Highway Safety Research Institute (HSRI) of the University of Michigan issued its report entitled 'Car-

Full-width rear guards

The rear-guard device on many trucks and trailers doesn't have full-width structural supports across the rear of the trailer, allowing unsafe gaps at the outboard rear corners. In many accidents, the unprotected outboard portion of the guard allows the sharp rear corner of the trailer to rip into the passenger car's survival space and inflict fatal head injuries to the driver or passenger. The guard is simply not well enough supported across its entire width to prevent the underride.

In many accidents, one of the two vertical struts completely fails and separates from the horizontal member, which then swings forward and allows the car to continue underriding further forward beneath the rear of the trailer. This can often occur in offset impacts, when the driver tries to steer to the left or right, away from striking the trailer.

The use of multiple vertical struts and diagonal braces and gusset plates, including protective structures that attach full-width out to the corners of the trailer, would provide sufficient strength so that the guard structure would offer at least 50,000 lb (22,680kg) of resistive force, and none of the attachments would catastrophically fail or separate.

Truck Fatal Accidents in Michigan and Texas'. After analyzing many specific truck-underride accidents, as well as accident data, HSRI concluded that there would be 261 rear-end underride car-into-truck fatal collisions per year, and 195 side underrides per year, for a total of 456 fatal underrides per year nationwide.

In other words, the side-underride safety problem was essentially equivalent to the rear-underride safety problem. If rear guards were needed to reduce the toll of rear-underride accidents, then there should be an equivalent sideguard.

I have investigated many truck underride accidents across the USA over the past 30+

years. In the side underride crashes, I have observed that the total lack of any sideguard allowed deep underride beneath the side of the trailer, deep intrusion into the passenger compartment survival space, and severe or fatal injuries to the driver and passengers.

Various sideguard designs have been feasible and economical for about 40 years. As an early example, NHTSA funded a project on Development of Standards for a Heavy Vehicle Underride Guard, conducted in 1968 by Aerospace Research Associates Inc, which described feasible designs for sideguards on large trailers.

Beginning in the early 1980s, a regulation by the European Economic Commission (EEC) described sideguards for trucks and trailers. The initial intent was to use sideguards primarily for the protection of cyclists, motorcyclists, and pedestrians, so they wouldn't get trapped beneath the sides and wheels of trucks and trailers. However, as the years went by, these sideguards on European trucks and trailers proved to be effective at helping to prevent underride by motor vehicles as well.

Moving vans have 'drop-section' or 'belly box' designs that serve as a type of sideguard. US trailer manufacturers and their lobbyist organization, the Truck Trailer Manufacturers Association (TTMA), are delaying the adoption of any sideguards, and suggest that sideguards would be so low that they would interfere with the trailer's ability to travel on the roads. Yet that has never been a problem with moving vans.

US manufacturer Great Dane Trailers introduced the Aero Flair full-panel sideguard in 1992. The literature noted that, 'Aero Flair is the first production, horizontal, air deflector for van trailers. It is designed to control air flow, directing it to the rear, reducing drag and turbulence and increasing fuel economy.' Although side underride was not explicitly discussed, the use of strong triangular braces to attach the Aero Flair side panel to the trailer would increase resistive strength, helping prevent side underride.

The resistive-force capability of a sideguard would be 50,000-70,000 lb (22,680-31,751kg) along most of its length, as extrapolated from the various series of car-into-trailer crash tests conducted by NHTSA. The sideguard would also have an energy-absorbing capability, much like that shown in the FHWA car-into-guard rail tests, and similar to the capability within FMVSS 223 and 224. This would be sufficient at least to withstand a perpendicular or right-angled intersection impact by a 3,500-4,000 lb (1,588-1,814kg) vehicle at 50mph (80km/h).

Typical car-into-trailer accident scenarios are illustrated and validated by the crash tests conducted by Krone of Germany.

In the first crash test, the car impacts the sideguard, the car's frontal crush zone deforms as it is designed to do, and the car comes to a stop. In the second crash test, the car is safely deflected away to its right. In both tests, the safety performance of sideguards is well demonstrated.

The trailer sideguard acts much like a roadside guard rail, deflecting the car safely away. In 60mph (96km/h) car-into-guard rail tests conducted in the 1970s by the US Federal Highway Administration (FHWA), passenger cars are shown impacting at an angle into the guard rail, which deforms slightly inward, deflecting the car safely away.

In the USA, the current underride guard test is described in FMVSS 223, which concerns the guard device itself, and FMVSS 224, which concerns the manner of its installation on the trailer. However, the test only requires a slowly applied force at a few specified locations along the guard device, with a maximum force of only 100,000N (22,480 lb). This was based upon a series of 30mph (48km/h) crash tests that NHTSA conducted, using small and mid-size sedans (such as a Honda Civic, Ford Tempo, Chevy Corsica) impacting into prototype rear guards. In some of the tests, the trailer body actually penetrated through the base of the windshield into the vehicle interior, but NHTSA did not consider this as serious passenger compartment intrusion (PCI).

As with other NHTSA standards, these are only a minimum, and are not an assurance that the guard device reflects state-of-the-art technology or will provide optimal safety in preventing lethal underride. Some trailer manufacturers use only two vertical struts to attach to the trailer body and the main horizontal member of the guard, some with short welds or a few bolts.

This minimal design also neglects the corners of the trailer, which are often involved as the oncoming motorist tries,



Above: The consequences of rear and side underride accidents with trailers can be devastating

Below: Another tragedy (see 'Needless fatalities' below)



at the last second, to get around the slower or stopped trailer ahead. The back of the trailer endures constant wear and tear from backing into loading docks and weathering; consequently, the rear guard may have reduced strength as the years go by. The bottom line is that too many of these minimal guards fail in real-world accidents, and underride is not prevented.

There is a need to greatly upgrade the rear-underride and side-underride requirements in the USA, Europe, and elsewhere. Trucks and trailers need rear guards that will withstand a rear impact, both centric and offset, and angular (at the corners), and which will prevent underride at 50mph (80km/h) or higher, especially

now that virtually all passenger vehicles are equipped with airbags and seatbelts with pre-tensioners, which enable survivability at such speeds.

Sideguards need to be integrated within truck and trailer design, preferably from the inception rather than as an add-on feature. The testing protocol should involve using a shaped moving deformable barrier (MDB) weighing 3,400 lb (1,542kg) in 50mph (80km/h) crash tests at perpendicular and 45° impacts into the frontal, middle, and rear sectors of the sideguard. This dynamic test requirement for sideguards would be analogous to current side-impact crash-testing for passenger vehicles and LTVs, as done by NHTSA and the IIHS. ■

Needless fatalities

On a cold November evening, a mid-size BMW sedan was being driven on a multilane interstate highway near Chicago, USA. The roadway was covered with snow and slush, and the car skidded uncontrollably to its right, and crashed at a shallow angle into and beneath the left-hand side of a large tractor-trailer traveling in a parallel lane.

When the car went beneath the trailer, the car became entrapped and the left-rear tires and left side of the trailer body crashed deep into the right-front passenger's survival space, inflicting fatal injuries to the passenger. The driver did not incur major injuries.

The trailer had no sideguards, but if it had been equipped with sideguards, the car would have been safely deflected away from the trailer, and underride would have been prevented.

Most European trailers have sideguards or sideskirts, which can and should be strengthened and reinforced to be more resistant to vehicle impacts.

About the author

Byron Bloch is a nationally-recognized and court-qualified auto safety expert in the USA. For 40 years he has evaluated collision accident vehicles and exemplar vehicles, to assess how and why occupants were severely injured or killed. He has testified at US Congressional Hearings and to NHTSA and in court cases on vehicle safety issues and to advocate safer designs, including seat strength, fuel tank fires, the need for airbags, truck underride hazards, the need for stronger roofs in rollovers, and side-impact protection. His website is: www.autosafetyexpert.com.