CAR CARRIERS AND UNDERRIDE COLLISIONS

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(Note: For the purposes of this article, a car carrier is defined as a two axle truck with a flat bed for hauling vehicles which rolls back and tilts for loading.)

Car carriers are sometimes involved in unerride collisions, in which a passenger vehicle collides into the rear of the car carrier. This can occur if the passenger vehicle operator dozes off or is distracted. The closing velocity between the passenger vehicle and the car carrier, and the consequent severity of the accident, can be significant if the car carrier is stopped or is decelerating. In some cases, the rear edge of the car carrier bed enters the passenger compartment of the colliding vehicle, and occupants suffer head injuries, neck and spinal cord injuries, and even decapitation.

Underride can occur when a sedan sized passenger vehicle collides with the rear of a commercial sized truck having a bed 30 inches or more off the ground. The problem results from the height mismatch between the parts of the passenger vehicle that are designed to withstand collision (the bumper and engine compartment) and the rear face of the truck bed. Because of the mismatch, the passenger vehicle slides under the bed of the truck, thereby allowing the bed to collide with the passenger compartment of the passenger vehicle. This part of the car (the windshield and A pillars, if the car is colliding headon) is not designed to withstand frontal impact, and passenger compartment intrusion (PCI) by the truck bed may occur.

Means of protecting the passengers from PCI have been proposed and studied for 50 years. Generally the concepts take the form of an Underride Guard (URG) which is attached to the rear of the

truck and extends below the bed to catch the car and limit underride. Federal regulations for URG in the US were first issued in 1953 (49 CFR 393.86). These regulations stated the design requirements for the URG and required all trucks, trailers, and semitrailers with a Gross Vehicle Weight Rating of 10,000 lb or more and manufactured in 1953 or later to have URG. Subsequent regulations which went into effect in 1998 (49 CFR 571.223) changed the design and performance requirements for URG, but only for trailers and semitrailers with GVWR over 10,000 lb. The URG regulations for so-called "straight trucks" (ie, unarticulated trucks, or trucks that are not tractors in combination with trailers or semitrailers) promulgated under 49CFR 393.86 remained effective for those trucks only. The US Department of Transportation has been criticized for not including straight trucks in the stricter regulations. One of the reasons given for not including them is that, although straight trucks make up a large portion of the total heavy truck population in the US, they are involved in relatively few rear end collision accidents compared to trailers and semitrailers.

The dimensional requirements for URG for straight trucks (49 CFR 393.86 part (b)(1) are:

(i) The distance from the bottom of the guard to the ground must be 30 inches or less.
(ii) Separation between a two-piece URG must be 24 inches or less.
(iii) The outer faces of the guard must be 18 inches or less from the outer face of the truck body.
(iv) The guard must be 24 inches or less from the back face of the truck body.

Car carriers can be included in a category of straight trucks called Special Purpose Trucks, which may be exempt from all URG regulations, if they meet certain configuration requirements. The basic requirement for classifying a truck as one of these special purpose trucks that do not need URG is that some part of the truck perform as a URG. To do this, the structure must conform to the dimensional requirements for URG stated in section (b)(1) of 49CFR 393.86. It is interesting to note that there is also a requirement for URG to be "substantially constructed and attached…" under section (b)(2) of this regulation, but the language exempting special purpose trucks (section (b)(3)) does not refer to this "substantial construction" section – only to the dimensional requirements.

Typical modern car carriers more than meet the dimensional requirements of the underride regulation with the "foot" and light housing parts of the tiltframe assembly. Dimensions taken by the author from a typical 21 foot 10,000 lb capacity car carrier body with a wheel lift stinger on a 17,500 lb GVWR chassis cab are compared with the requirements of the regulation below:

Dimension	49 CFR 393.86(b)(1)	Car Carrier
Vertical distance, bottom of guard to ground	30 in. max	19 to 25 in.
Outer surface, guard to side extremity	18 in. max	5.25 in.
Distance forward of rear extremity of vehicle	24 in. max	12 in.

It could be argued that the stinger and wheel lift crossarm also act as a URG, although this possibility apparently has not been investigated by anyone to date. These components could provide a

"staged" deceleration of the colliding vehicle by being the first point of contact for a centered collision. If the kinetic energy (½MV²) of the colliding vehicle is high, the stinger/crossarm will deform from the impact and absorb some of the kinetic energy, then the "foot" and light housing of the tiltframe may absorb more kinetic energy as the colliding vehicle continues on its impact path into the rear of the car carrier. The deformation of the stinger/crossarm assembly might take the form of bending the crossarm or buckling the stinger tubing and hydraulic extension cylinder. The height of the stinger above ground is approximately correct for contacting the engine and transmission of the colliding vehicle, thus engaging relatively robust parts of the colliding vehicle which are attached to the vehicle's frame.

One aspect of the design of car carriers is unfortunate for limiting Passenger Compartment Intrusion (PCI) during collisions of the type discussed here. This aspect is the rear overhang – the distance between the centerline of the rear axle and the rear edge of the bed. Car carriers have perhaps the largest rear overhang of the most common types of commercial trucks. The rear axle is located at approximately the center of the bed for most car carriers. The axle must be located in that location as a compromise between considerations of safe load distribution and minimizing the load angle. Any other type of truck body with the rear axle located closer to the rear face of the bed has the advantage that the tires and axle assembly can act to limit underride by the colliding vehicle. In fact, truck bodies with tires located within a few inches of the rear face of the body are also exempt from the federal requirement for URG because of this.

A large rear overhang means the geometry of rear end collisions for car carriers is conducive to PCI unless the car carrier tiltframe and stinger stop the colliding vehicle before this can occur. However, if the colliding vehicle is stopped too abruptly, passengers can be injured severely or killed because of the effects of rapid deceleration on organs such as the brain, spinal cord, and thoracic aorta. The tiltframe and stinger must, therefore, be strong enough to stop the colliding vehicle before PCI, but must have a yield point low enough to absorb the kinetic energy of a colliding vehicle over a long enough time period to limit the deceleration rate felt by the passengers. The Department of Transportation has developed criteria for head and thoracic acceleration rates which are used in crash dummy testing of vehicle passenger restraint systems (Ref. 4). The Head Injury Criterion (HIC) is an exponentially weighted formula involving acceleration measured at the Center of Gravity (CG) of the brain. A value for this criterion of 1000 is considered the concussion tolerance level. The maximum thoracic acceleration rate for the passenger restraint systems in these tests, measured at the CG of the thorax, is 60 times the acceleration rate of gravity (60g).

Proving that the performance of any URG system, including the tiltframe/stinger system for a car carrier, meets these conflicting criteria of preventing PCI and limiting deceleration rates is very difficult. It is a complicated theoretical problem, and there are many parameters which affect URG performance. These parameters include the closing speed of the vehicles involved, the masses (weights) of the vehicles, the angle of incidence, the centric/eccentric point of impact, the heights of the vehicles, the engine size and shape for the colliding passenger vehicle, and the characteristics of the "crush zone" of the colliding vehicle. Actual crash testing has generally been used to evaluate URGs. For an adequate evaluation, a series of crash tests has to be conducted, in order that realistic and representative values for all the collision parameters be included.

References

1. 49 CFR 393: "Parts and Accessories for Safe Operation", Code of Federal Regulations
2. 49 CFR 571.223 and .224: "Rear Impact Guards" and "Rear Impact Protection", respectively, Code of Federal Regulations
3. Federal Register Vol 61 No. 16, Wednesday, January 24, 1996: "49CFR part 571".
4. SAE J885 Rev DEC2003: Surface Vehicle Information Report: "Human Tolerance to Impact Conditions as Related to Motor Vehicle Design", SAE International.

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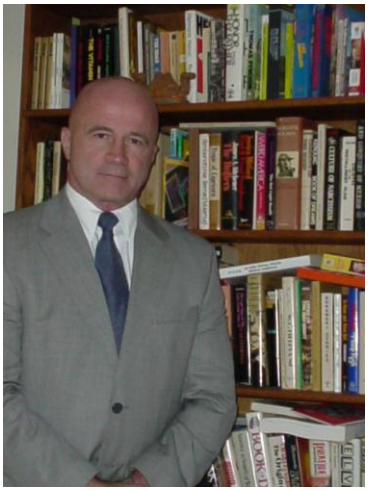

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