U.S. Department
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National Highway
Traffic Safety Administration

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PRELIMINARY REGULATORY EVALUATION

FMVSS No. 223
Rear Impact Guards
and
FMVSS No. 224
Rear Impact Protection

Office of Regulatory Analysis and Evaluation
National Center for Statistics and Analysis
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People Saving People

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Appendix

EXECUTIVE SUMMARY

This preliminary regulatory evaluation (PRE) studies the impact of proposed upgrades for Federal Motor Safety Standard (FMVSS) Nos. 223 and 224 and accompanies the Notice for Proposed Rulemaking (NPRM) to upgrade the standards.

The National Highway Traffic Safety Administration (NHTSA) published FMVSS Nos. 223 and 224 in 1996 and these two standards became effective in 1998. These standards are intended to reduce injuries and fatalities resulting from the collision of light vehicles into the rear ends of heavy trailers and semitrailers. FMVSS No. 223 specifies performance requirements that rear impact guards must meet before they can be installed on new trailers and semitrailers. The second standard, FMVSS 224, establishes requirements that most new trailers and semitrailers with a gross vehicle weight rating (GVWR) of 4,536 kilograms (10,000 pounds) or more be equipped with a guard meeting the requirements of FMVSS No. 223, and also includes requirements for the mounting location of the guard relative to the rear end of the vehicle.

In 2005, Transport Canada upgraded Canadian Motor Vehicle Safety Standard (CMVSS) No. 223, “Rear impact guards,” that included increased performance requirements for guard strength and energy dissipation over and above that of the US requirements. The upgraded CMVSS No. 223 became effective on September 1, 2007.

The agency contracted University of Michigan Transportation Research Institute to conduct a study on heavy vehicle crash characterization for rear underride by collecting a set of information related to underride guards and rear underride in fatal crashes to support this proposal. Data were collected on the extent of underride, damage to the underride guard, and whether the collision was offset. In addition data were collected on estimated relative impact velocity, the mass of the striking vehicle, and the front geometry of the striking vehicle.[1]

On February 28, 2011, the Insurance Institute for Highway Safety (IIHS) submitted a petition for rulemaking to upgrade FMVSS Nos. 223 and 224 to mitigate rear underride crashes into trucks and trailers. IIHS provided a review of a sample of underride crashes in the Large Truck Crash Causation Study (LTCCS) database, and results of quasi-static tests of rear impact guards and crash tests of a passenger car into the rear of trailers as supporting material.

Proposed Requirements

The agency analyzed real world crash data involving trucks and trailers and evaluated the feasibility of harmonization with other standards, specifically the Canadian standard, CMVSS No. 223. Based on the agency's analysis, this NPRM proposes the following:

Modifications to FMVSS No. 223

1. Replace the current loading and performance requirements at the P3 location[2] with that specified in CMVSS No. 223. Specifically,
    a. Rear impact guards are required to resist a uniform distributed load of 350,000 Newtons (N) without deflecting more than 125 millimeters (mm).

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[1] Blower, D and Woodrooffe, J (2013), Contract No. DTNH22-11-D-00236/0004: Heavy-Vehicle Crash Data Collection and Analysis to Characterize Rear and Side Underride and Front Override in Fatal Truck Crashes, University of Michigan Transportation Research Institute, Ann Arbor, Michigan.

[2] The P3 location as specified in FMVSS No. 223 is a point located 305 mm to 635 mm on the left or right side from the center of the horizontal member.

b. Rear impact guards that demonstrate resistance to uniform distributed load of 700,000 N or less are required to absorb at least 20,000 Joules (J) of energy within 125 mm of guard deflection when a uniform distributed load is applied and have a post-test ground clearance not exceeding 560 mm.

c. Rear impact guards that demonstrate resistance to uniform distributed load greater than 700,000 N are required to maintain a post-test ground clearance not exceeding 560 mm.

2. Require that any portion of the rear impact guard and attachments not separate from its mounting structure after completion of the uniform distributed loading test.

Modifications to FMVSS No. 224

1. Replace the current definition of "rear extremity" with that specified in CMVSS No. 223 that permits aerodynamic fairings to be located within a certain zone at the rear of the trailer.
2. Add back "low chassis vehicles" into the list of vehicles excluded from FMVSS No. 224 in the applicability section which was inadvertently omitted in a 1996 final rule (61 FR 2035).

Benefits

Undiscounted, the agency estimates that about one life and three (3) serious injuries would be saved annually by requiring all applicable trailers to be equipped with CMVSS No. 223 compliant guards. By saving these lives and injuries, the 7 percent discounted total monetized benefit of the proposed rule would be $13.61 million in 2013 dollars. These monetized benefits include both quality of life valuation based on the value of statistical life (VSL) and societal economic savings.

The following table lists the discounted injury benefits (i.e., lives saved and injuries reduced) and monetized savings. The lower bounds represent the savings for the 7 percent discount rate and the higher bounds represent savings for the 3 percent discount rate. Details are described in the main body of the analysis.

Discounted Benefits of the Proposed Rule in 2013 dollars, in Millions

Benefit	No-discount	3%	7%
Societal economic benefits:	$2.24	$1.98	$1.76
VSL benefits:	$15.71	$13.31	$11.85
Total safety benefits:	$17.94	$15.29	$13.61

The agency also determined that rear impact guards on excluded vehicles such as wheels back, low chassis, pole, and logging trailers would not be effective in mitigating fatalities and injuries in light vehicle impacts into the rear of these vehicles. Therefore, the agency is not proposing to extend the application of FMVSS No. 224 to excluded vehicles.

Costs

The annual average incremental fleet cost of equipping all applicable trailers with CMVSS No. 223 rear impact guards is estimated to be $2.5 million in 2013 dollars. In addition, the added weight of 48.9 lbs. per vehicle would result in an estimated annual fleet fuel cost of approximately $8.22 and $9.23 million discounted at 7% and 3%, respectively. As such the total incremental cost would range from $10.76 million to $11.77 million discounted at 7% and 3%, respectively.

Cost of Proposed Rule with Average Increase in Weight (in Millions of 2013 dollars)

Cost	No-discount	3%	7%
Material	$2.54	$2.54	$2.54
Fuel	$10.44	$9.23	$8.22
Total	$12.98	$11.77	$10.76

Net Cost Per Equivalent Life Saved

The estimated equivalent lives saved (ELS) ranges from 1.3 lives to 1.4 lives discounted at 7% and 3%, respectively. The net cost of the proposed rule is the regulatory cost minus the societal economic savings. The estimated net cost ranges from $9.0 million to $9.8 million discounted at 7% and 3%, respectively. The net cost per ELS ranges from $6.77 million to $6.99 million discounted at 3% and 7%, respectively as shown in the following tables.

Equivalent Lives Saved (ELS)

Discount	No-discount	3%	7%
ELS	1.6362	1.4472	1.2882

Net Cost (in Millons of 2013 dollars)

Cost and Benefit	No-discount	3%	7%
Total cost	$12.98	$11.77	$10.76
Societal benefits	$2.24	$1.98	$1.76
Net Cost	$10.74	$9.80	$9.00

Net Cost per ELS (Millions of 2013 dollars)

Discount	No-discount	3%	7%
Net Cost	$10.74	$9.80	$9.00
Net Cost per ELS	$6.57	$6.77	$6.99

Net Benefits

A net benefit of the proposed rule is the difference between the VSL benefit[3] and the net cost. The estimated net benefit ranges from $2.85 million to $3.52 million discounted at 7% and 3%, respectively.

Net Benefits* (in Millions of 2013 dollars)

Discount	No-discount	3%	7%
VSL benefit	$15.71	$13.31	$11.85
Net Cost	$10.74	$9.80	$9.00
Net Benefit	$4.96	$3.52	$2.85

[3] Based on the DOT 2013 guideline, which establishes $9.2 million for VSL in 2013 dollars and an annual increase rate of 1.07 percent for VSL

Leadtime

The agency is proposing a lead time of two years from the publication of the final rule for manufacturers to comply with the requirements.

Summary of Annual Costs and Benefits

The following table summarizes the annual total costs, total benefits, and net benefits for both 3 and 7 percent discount rates.

Costs and Benefits (in Millions of 2013 dollars)

Discount	Regulatory Costs*	Societal Economic Savings	VSL Savings	Total Benefits	Net Benefits
3%	$11.77	$1.98	$13.31	$15.29	$3.52
7%	$10.76	$1.76	$11.85	$13.61	$2.85

*Cost are not discounted since they occur at the time of purchase

I. INTRODUCTION

A. Background

Rear underride crashes are those where the front end of a vehicle impacts the rear of a generally larger vehicle, and slides under the chassis of the rear-impacted vehicle. Some level of underride may occur when a smaller vehicle impacts the rear of larger vehicles such as single unit trucks and trailers which generally have a higher ride height than passenger cars. In some crashes with excessive underride, the passenger vehicle underrides so far that the rear end of the trailer strikes and enters its passenger compartment. This condition is called passenger compartment intrusion (PCI) and collisions with PCI can result in passenger vehicle occupant injuries and fatalities caused by occupant contact with the rear end of the trailer. However, excessive underride can be prevented if the front-end of the smaller vehicle engages structural elements of the larger vehicle.

On January 8, 1981, NHTSA proposed a rear underride guard standard designed to mitigate the effects of a light duty vehicle (passenger car, light truck and van) colliding with the rear of a straight body or combination truck. The proposed standard applied to full and semi-trailers with a GVWR greater than 10,000 pounds. Rear underride occurs when the front of a passenger car or light truck slides under ("underrides") the rear of the trailer. In the worst cases, trailer design allows the light vehicle to underride so far that the trailer's rear extremity crushes the striking vehicle's A-pillars, windshield and/or roof area and allows it to enter the passenger compartment. One of the primary goals of the proposal was the prevention of PCI.

On January 3, 1992, NHTSA published a Supplemental Notice of Proposed Rulemaking (SNPRM) which was very similar to the 1981 proposal, except that the guard's strength would be specified in an equipment safety standard, rather than a vehicle-based safety standard. In the SNPRM, NHTSA adopted the term "rear impact guard" instead of the term "underride guard", to reflect the agency's belief that the guard would help protect the occupants of a colliding vehicle by absorbing crash forces as well as preventing excessive underride. The agency proposed the following rear impact guard requirements; (1) a 22 in. maximum guard-to-ground clearance for the horizontal cross member, a 4 inch maximum between the ends of the horizontal cross member and the sides of the trailer, a 12 in. maximum offset allowance from the rear extremity, 3 quasi-static load application points along the horizontal member, maximum deflection or displacement allowed for each test point, and compliance labelling requirements. The proposed applicability was to trailers and semi-trailers with a GVWR greater than 10,000 pounds, and excluded single unit trucks, truck tractors, pole trailers, low chassis trailers, special purpose vehicles and "wheels back" vehicles. In addition, the guard would be compliance tested on a rigid test fixture. On January 3, 1992, a companion safety standard was also proposed which required trailers to be equipped with underride guards meeting the requirements of the equipment standard.

NHTSA promulgated Federal Motor Vehicle Safety Standard (FMVSS) No. 223, “Rear impact guards,” and FMVSS No. 224, “Rear impact protection,” in 1996 which operate together to reduce the number of injuries and fatalities resulting from passenger vehicles underriding the rear of heavy trailers and semitrailers. FMVSS No. 223 specifies dimensional, strength, and energy absorption requirements that rear impact guards must meet before they can be installed on new trailers and semitrailers. FMVSS No. 224 requires that most new trailers and semitrailers with a GVWR of 4,536 kilograms (10,000 pounds) or more be equipped with a rear impact guard meeting FMVSS No. 223 specifications and specifies the location of the guard relative to the rear end of the trailer.[4] The standards became effective in January 1998.

B. Information and Actions Resulting in the Agency to Re-Evaluate Requirements on Rear Underride Protection

1. 2009 NHTSA Study

In 2009, NHTSA[5] conducted a study to evaluate why fatalities were still occurring in frontal crashes despite high rate of seat belt use and presence of air bags and advanced safety features. NHTSA reviewed cases of frontal crash fatalities to belted drivers or right-front passengers in model year (MY) 2000 or newer vehicles in the Crashworthiness Data System of the National Automotive Sampling System (NASS-CDS) through calendar year 2007. Among the 122 fatalities examined in this review, 49 (40%) were in exceedingly severe crashes that were not survivable, 29 (24%) were in oblique or corner impact crashes where there was low engagement of the vehicle's structural members to absorb the crash energy, 17 (14%) were underrides into trucks and trailers (14 were rear underride and 3 were side underride), 15 (12%) were fatalities to vulnerable occupants (occupants 75 years and older), 4 (3.3%) were narrow object impacts, and 8 (6.6%) were other types of impact conditions. In survivable frontal crashes of newer vehicle models resulting in fatalities to belted vehicle occupants, rear underride into large trucks and trailers were the second highest cause of fatality.

[4] Pole trailers, pulpwood trailers, road construction controlled horizontal discharge trailers, special purpose vehicles, wheels back trailers, low chassis trailers, and temporary living quarters as defined in 49 CFR 529.2 are excluded from FMVSS No. 224 requirements.

[5] Kahane, et al. "Fatalities in Frontal Crashes Despite Seat Belts and Air Bags – Review of All CDS Cases – Model and Calendar Years 2000-2007 – 122 Fatalities," September 2009, DOT-HS-811102.

2. 2010 NHTSA evaluation of the effectiveness of rear impact guards

In 2010, NHTSA[6] conducted a study of crash data involving trailers to determine the effectiveness of rear impact guards (those compliant with FMVSS Nos. 223 and 224) in preventing fatalities and serious injuries in crashes where a passenger vehicle impacts the rear of a trailer. The analysis could not find a statistically significant decrease in the frequency of fatalities and injuries resulting from rear underride into trailers. The study also found that passenger compartment intrusion is more apt to occur when the corner of the trailer is impacted, rather than the center of the trailer. Finally, the study concluded that it was not possible to establish a nationwide downward trend in fatalities when a passenger vehicle impacts the rear of a trailer – neither in terms of total number of fatalities, percentage of passenger vehicle fatalities in crashes into the rear of trailers relative to passenger vehicle fatalities in all crashes involving trailers, nor in terms of the number of fatal crashes into the rear of trailers per 1,000 light vehicle crashes involving trailers.

3. 2013 UMTRI Study

NHTSA initiated research in late 2009 with the University of Michigan Transportation Research Institute (UMTRI) to gather supplemental data on the rear geometry of trucks and trailers, the configuration of rear impact guards on trucks and trailers, and the incidence and extent of underride, and fatalities in rear impacts with trucks and trailers. UMTRI collected the supplemental information as part of its Trucks in Fatal Accidents (TIFA) survey for the years 2008 and 2009.[7,8] This supplemental data provided information on underride and the rear geometry of the impacted heavy vehicle that was previously not available. The data enabled the agency to obtain national estimates of rear impact crashes into heavy vehicles that resulted in PCI. Details of the UMTRI study completed in 2013 are presented in Chapter V.

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[6] Kirk Allen, "The Effectiveness of Underride Guards for Heavy Trailers", October, 2010, DOT HS 811 375.
[7] Analysis of Rear Underride in Fatal Truck Crashes, 2008, DOT HS 811 652, August, 2012.
[8] Heavy-Vehicle Crash Data Collection and Analysis to Characterize Rear and Side Underride and Front Override in Fatal Truck Crashes, DOT HS 811 725, March 2013.

4. 2005 Upgrade to Rear Impact Guard Requirements in Canada

In 2005, Transport Canada issued upgraded rear impact protection requirements for trailers and semitrailers in Canadian Motor Vehicle Safety Standard (CMVSS) No. 223, "Rear impact guards."[9] The upgraded requirements ensured rear impact guards have sufficient strength and energy absorption capability to prevent passenger compartment intrusion of compact and subcompact passenger cars in impacts to the rear of trailers at 56 kilometers per hour (km/h) (35 miles per hour (mph)).[10] In contrast, the requirements in FMVSS Nos. 223 and 224 were intended for preventing PCI in compact and subcompact passenger cars impacting the rear of trailers at 48 km/h (30 mph).[11] The new requirements in CMVSS No. 223 became effective in 2007. Currently, the agency estimates that approximately 93 percent of applicable new trailers sold in the U.S. are equipped with rear impact guards that also comply with the Canadian standard.

5. Petition for rulemaking from the Insurance Institute for Highway Safety

On February 28, 2011, the Insurance Institute for Highway Safety (IIHS) submitted a petition for rulemaking to NHTSA to upgrade the FMVSSs on rear impact protection for trailers so that rear impact guards are strong enough to remain in place and absorb energy during an impact and thereby provide protection to occupants in the impacting vehicle. Specifically, IIHS requested the agency to:

a. increase the strength requirements for rear impact guards (at least to the levels that are currently required in Canada);
b. evaluate whether ground clearance of rear impact guards can be further reduced;
c. reduce the number of heavy vehicles (trucks and trailers) exempted from requiring rear impact guards;
d. require attachment hardware to remain intact during the quasi-static tests;

[9] Canada Gazette Part II, Vol. 138, No. 20, 2004-10-06.
[10] Boucher D., Davis, D., "Trailer Underride Protection – A Canadian Perspective," SAE Paper No. 2000-01-3522, Truck and Bus Meeting and Exposition, December 2000, Society of Automotive Engineers.
[11] 61 FR 2004.

e. require rear impact guards to be certified while attached to the trailer for which it is designed; and
f. move the P1 location[12] for the 50,000 Newton (N) point load quasi-static test more outboard to improve offset crash protection.

IIHS based its petition on a detailed review of rear impacts into trucks and trailers from the Large Truck Crash Causation Study (LTCCS)[13] and a series of trailer rear impact crash tests at 56 km/h (35 mph) impact speed with a 2010 Chevrolet Malibu. IIHS noted that among the 30 LTCCS cases of passenger vehicle crashes into the rear of trailers with rear impact guards, nearly all the guards failed to prevent PCI. IIHS stated that the most common failures of the rear impact guards were due to weakness in the attachment between the guard and the trailer, deformation of the trailer chassis, and bending of an outboard end of the guard in small overlap crashes. IIHS stated that more than half of the truck units in the LTCCS cases it reviewed were exempted from the Federal rear impact guard regulations, among which wheels back and single unit trucks accounted for most of the exemptions.

Results of the 56 km/h crash tests with the 2010 Chevrolet Malibu showed that the trailer guard compliant with FMVSS Nos. 223 and 224 was unable to prevent PCI into the Malibu. In contrast, trailers with rear impact guards compliant with CMVSS No. 223 were able to mitigate PCI into the Malibu in crashes where the Malibu fully engaged or had a 50 percent overlap (the overlap refers to the portion of the Malibu's width overlapping the underride guard). The results of IIHS tests are described in detail in Chapter IV.

6. 2014 Petition for rulemaking from Mrs. Karth and the Truck Safety Coalition

On May 5, 2014, Ms. Marianne Karth and members of the Truck Safety Coalition (TSC) presented the Secretary of Transportation with more than 11,000 identical petitions from members of the public requesting that the agency improve the safety of rear impact guards on trailers and SUTs and that the Department of Transportation begin studies and rulemakings for

[12] The P1 location as specified in FMVSS No. 223 is a point location 3/8th of the length of the horizontal member on the left or right side from the center of the horizontal member.
[13] LTCCS is based on a 3-year data collection project by NHTSA and FMCSA and is the first-ever national study to attempt to determine the critical events and associated factors that contribute to serious large truck crashes. http://ai.fmcsa.dot.gov/ltccs/default.asp, last accessed on July 8, 2014.

side guards and front override guards. Ms. Karth and TSC stated that if the Federal standards for rear impact guards were amended to be equivalent to the Canadian standard, injuries and fatalities could be avoided. These two petitioners requested that the rear impact guards on trailers and semitrailers be mounted 16 inches from the ground, with vertical supports located 18 inches from the side edges of the trailer. On July 10, 2014, the agency granted the petition for rulemaking submitted by Ms. Karth and TSC with respect to rear impact guards.[14] NHTSA is planning on issuing two separate notices – an advanced notice of proposed rulemaking (ANPRM) pertaining to rear impact guards and other safety strategies for SUTs, and a notice of proposed rulemaking (NPRM) focusing on rear impact guards on trailers and semitrailers.

7. 2013 and 2014 Recommendations from the National Transportation Safety Board (NTSB) On Rear Impact Guards

In June 2013, the NTSB published a study of real world crashes involving SUTs that resulted in injuries and deaths.[15] The study used a variety of data sources: Crash Outcome Data Evaluation System (CODES)[16] from Delaware, Maryland, Minnesota, Nebraska, and Utah, Trucks in Fatal Accidents (TIFA), and the Fatality Analysis Reporting System (FARS), the National Automotive Sampling System (NASS)/General Estimates System (GES), and LTCCS. With respect to rear impacts and rear impact protection, the study found that SUTs were involved in 2,309 crashes annually in which passenger vehicles collided with the rear of SUTs; rear underride occurred in more than 70 percent of these crashes. Based on this study, the NTSB issued seven new recommendations to NHTSA for mitigating crashes and death and injury in crashes involving SUTs. Of these seven recommendations, two involve rear impacts guards:

H-13-15: Develop performance standards for rear underride protection systems for single unit trucks with gross vehicle ratings over 10,000 pounds.

H-13-16: Once the performance standards requested in H-13-15 have been developed, require newly manufactured single unit trucks with gross vehicle weight ratings over 10,000 pounds to be equipped with rear underride protection systems meeting the performance standards.

[14] 79FR 39362.

[15] Crashes Involving Single-Unit Trucks that Resulted in Injuries and Deaths, Safety Study NTSB/SS-13/01 PB2013-106637, Adopted June 17, 2013. Also available at http://www.ntsb.gov/doclib/safetystudies/SS1301.pdf, last accessed on July 8, 2014.

[16] CODES links hospital discharge records with police accident report. Further information is available at http://www-nrd.nhtsa.dot.gov/Pubs/811181.pdf, last accessed on July 8, 2014.

On April 3, 2014, the NTSB issued seven new recommendations to NHTSA among which one involves rear impact protection for trailers. The NTSB recommendation on rear impact protection was based on its review of NHTSA's real world crash databases, the 2013 UMTRI study, IIHS's 2011 petition for rulemaking, and the IIHS study reviewing LTCCS cases and the crash tests with the 2010 Chevrolet Malibu into the rear of trailers. The NTSB's recommendation states:

H-14-004: Revise requirements for rear underride protection systems for newly manufactured trailers with gross vehicle weight ratings over 10,000 pounds to ensure that they provide adequate protection of passenger vehicle occupants from fatalities and serious injuries resulting from full-width and offset trailer rear impacts.

II. PROPOSED REQUIREMENTS

A. Accommodation of Aerodynamic Devices on Trailers

Aerodynamic fairings on the rear of trailers, also known as “boat tails,” are rear mounted panels on trailers that reduce aerodynamic drag and fuel consumption. In the US, the use of boat tails is governed by the U.S. Federal Highway Administration (FHWA) regulation 23 CFR 658.16 “Exclusions from length and width determinations.” Specifically, 23 CFR 658.16(b)(4) excludes an aerodynamic device from the measured length of a commercial motor vehicle provided:

1. the device does not extend a maximum of 5 feet beyond the rear of the vehicle;
2. the device has neither the strength, rigidity nor mass to damage a vehicle, or injure a passenger in a vehicle, that strikes a trailer so equipped from the rear;
3. the device does not obscure tail lamps, turn signals, marker lamps, identification lamps, or any other required safety devices, such as hazardous materials placards or conspicuity markings.

Since FMVSS No. 224 requires rear impact guards to be located at a maximum distance of 305 mm forward of the rear extremity of the trailer, aerodynamic devices installed in the rear of trailers could bring the trailer out of compliance with FMVSS No. 224 requirements. Currently, aerodynamic devices cannot extend beyond one foot (305 mm) of the trailer with the rear impact guard installed at the rear extremity of the trailers (as shown in **Error! Reference source not found.**), unless specifically granted an exemption.

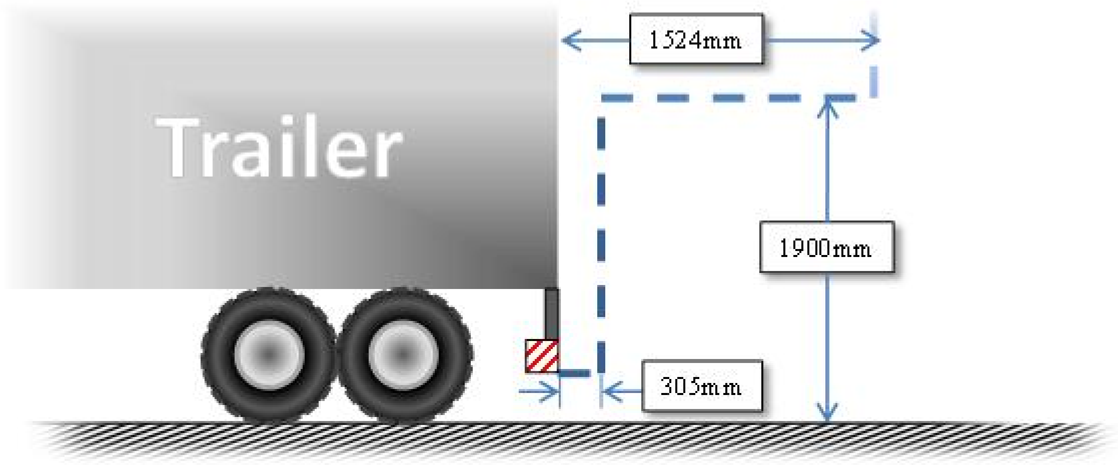

Figure 1: Permitted zone for aerodynamic fairings in the rear of trailers.

ATDynamics, a manufacturer of a trailer rear aerodynamic device, named the TrailerTail®, requested the U.S. Department of Transportation exclude the TrailerTail® aerodynamic device from the length measurement for commercial motor vehicles. The TrailerTail® device extends 4 feet (1219 mm) beyond the rear extremity of the trailer when deployed (**Error! Reference source not found.**). Each Trailertail® panel is 0.5 inches thick and constructed of two aluminum sheets with EPS foam in between. In support of their request, ATDynamics submitted independent third party evaluation of its aerodynamic device. The third party, KARCO Engineering, conducted crash tests of a E350 Econoline van into the rear of a trailer with fully deployed TrailerTail® aerodynamic device which showed that the TrailerTail® does not increase vehicle structural damage or personal injury in a rear end collision. Karco Engineering also determined that TrailerTail® met all the conditions listed in 23 CFR 658.16(b)(4).

On October 10, 2008, FHWA acknowledged through a letter posted on their website[17] that the ATDynamics Trailer Tail® was tested by an independent laboratory, KARCO Engineering, and was found to be in compliance with all elements of 23 CFR 658.16(b)(4). Therefore, in accordance with Federal regulations, the ATDynamics TrailerTail® aerodynamic device is excluded from the length measurements for commercial motor vehicles.

Figure 2: ATDynamics Trailer Tail deployed (left) and stowed (right)

The California Air Resources Board regulation requires 53 foot or longer box-type trailers to achieve a minimum of 5 percent overall reduction in greenhouse gas emissions by 2016. The ATDynamics Trailertail is advertised as providing up to a 6.58 percent fuel savings.

In 2008, CMVSS No. 223 had the same definition for rear extremity as FMVSS No. 224, so Canada also had similar issues on permitting aerodynamic devices, such as TrailerTail®. Therefore, Transport Canada contracted the Centre for Surface Transportation Technology of the National Research Council (NRC) in Canada to study the aerodynamic gains of boat tails and determine which types of vehicles and what percentage of vehicles on the Canadian roads would strike the boat tail before striking the rear underride guard of trailers. NRC also examined the effect of snow, ice, and debris accumulation by the boat tails and downstream visibility.

[17] http://www.ops.fhwa.dot.gov/freight/sw/aerodevice23cfr65816.htm.

NRC conducted wind tunnel experiments with different lengths, heights, and shapes of aerodynamic rear mounted trailer panels (boat tails) to assess their drag reduction capability. The NRC developed computational fluid dynamics models to evaluate visibility and particulate accumulation. Collision risk analysis with boat tails was conducted using dimensional data and population data of motor vehicles registered in Canada.

The NRC report was published in December 2010.[18] The main findings of the NRC study are as follows:

1) Reduction in drag and fuel consumption: The boat tails reduced aerodynamic drag by 7.6 to 11.8 percent when the vehicle is operating at 65 mph. This corresponds to an estimated 4.7 to 7.3 percent reduction in fuel consumption.
2) Length of boat tails: The most significant aerodynamic drag reduction occurs for boat tail lengths from 0 to 2 feet. For boat tails longer than 2 feet, there is further drag reduction, but only incrementally. Boat tails longer than 4 feet offer minimal or no additional reduction in drag compared to shorter boat tails.
3) Height of boat tails: Boat tails are most effective if at least 75 percent of the height of the trailer has full length boat tails. For most trailers, this corresponds to having full length boat tails at heights above 1,800 mm from the ground.
4) Boat tail length and shape at lower heights: Although full length side panel boat tails that extend the entire height of the trailer offer the best reduction in drag, nearly the same level of drag reduction can be achieved by having at least some boat tail structure at the lower part of the trailer, even if it is significantly shorter than the higher section of the boat tail. The

[18] "Trailer Boat Tail Aerodynamic and Collision Study, Technical Report," National Research Council, Canada, Project 54-A3871, CSTT-HVC-TR-169, December 2010.

complete absence of boat tail structure at the bottom of the trailer significantly reduces the effectiveness of boat tails.

5) Boat tail bottom panel: The presence of the bottom panel is more critical than the length of the side panels for drag reduction. As much as 20 percent of the aerodynamic drag reduction is from the bottom panel.

6) Visibility and particulate material: Both 2 feet and 4 feet boat tail lengths provide a significant improvement in reduced turbulence downstream of the trailer. However, there is a risk of particulate accumulation (snow and ice) on the bottom panel of boat tails.

7) Collision Risk:

   - If 4 foot long boat tails are fitted to trailers along their entire height, 33.6 percent of vehicles on Canadian roads would strike the boat tail before striking the rear impact underride guard, however many of these contacts with the boat tail could be to the grille/hood rather than the windshield.
   - In order to prevent at least 90 percent of the vehicles on the roads from initial boat tail strikes, the full length boat tails (4 feet) should be mounted on the trailer higher than 1,740 mm from the ground.
   - There are boat tail configurations that provide up to 9 percent reduction in aerodynamic drag and less than 15% risk of collision before striking the underride guard. These configurations have shorter boat tail lengths (2 feet) at heights below 1,740 mm above ground.

Following the completion of the National Research Council of Canada study, Transport Canada developed a proposal for a clearance zone to allow aerodynamic devices (boat tails) that, in a collision, would not reduce safety for occupants of vehicles which may strike the rear of a trailer. The proposal, published on October 6, 2010, modified the existing definition of "rear extremity" of the trailer (which was similar to that currently specified in FMVSS No. 224) to:

"rear extremity" means the rearmost point on a trailer that is above a horizontal plane located above the ground clearance and below a horizontal plane located 1,900 mm above the ground when the trailer is configured as specified in subsection (7) and when the trailer's cargo doors, tailgate and other permanent structures are positioned as they normally are when the trailer is in motion. However, nonstructural protrusions, including but not limited to the following, are excluded from the determination of the rearmost point:

(*a*) tail lamps;

(*b*) rubber bumpers;

(*c*) hinges and latches; and

(*d*) flexible aerodynamic devices that are capable of being folded to within 305 mm from the transverse vertical plane tangent to the rearmost surface of the horizontal member and that, while positioned as they normally are when the trailer is in motion, are located forward of the transverse plane that is tangent to the rear bottom edge of the horizontal member and that intersects a point located 1,210 mm rearward of the rearmost surface of the horizontal member and 1,740 mm above the ground.

Based on this proposal, the permitted zone for boat tails at the rear of trailers is as shown in Figure 1. The proposal, which provides a new definition of "rear extremity" of the trailer, was finalized on August 8, 2011.

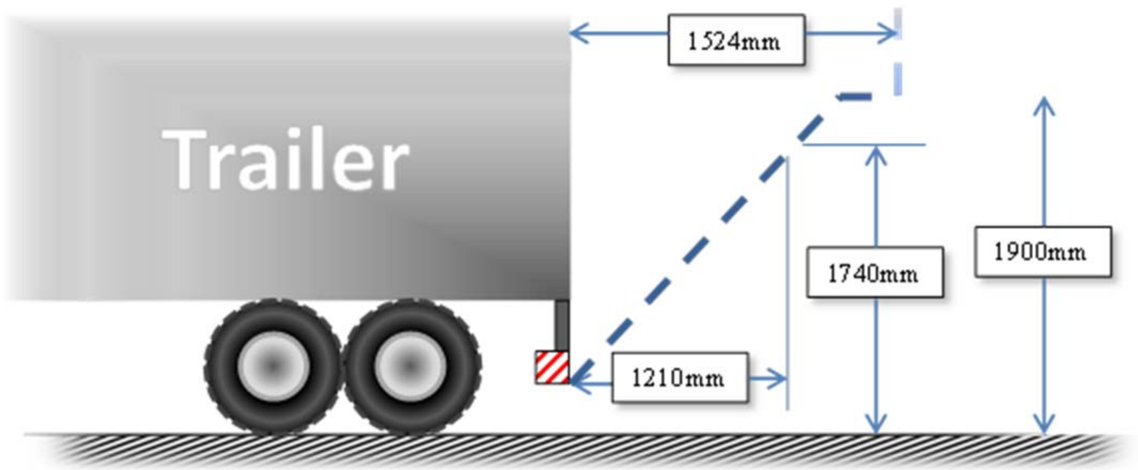

Figure 1: Permissible zone for locating aerodynamic devices per CMVSS rear extremity definition

On January 24, 2011, NHTSA responded to a letter from the Canadian Trucking Alliance concerning the installation of ATDynamics TrailerTail® on van trailers to reduce fuel consumption and stated that based on KARCO Engineering's evaluation of TrailerTail®, the agency does not find reason to oppose the use of TrailerTail®. However, in an actual compliance setting, NHTSA would make an independent determination of the effect of the TrailerTail® on vehicle safety. The agency also noted that it was in discussion with Transport Canada regarding a "permissible zone" in the rear of vehicle for non-structural aerodynamic devices.

Agency Decision:

The agency is proposing to revise the definition of rear extremity in FMVSS No. 224 to harmonize with that in CMVSS No. 223. The agency expects that along with the Environmental Protection Agency's (EPA's) Smartway[19] program and the California regulation for reduced

[19] http://epa.gov/smartway/forpartners/technology.htm.

greenhouse gas emissions of box-type trailers by 2016, there will be a significant increase in the use of aerodynamic devices in the rear of trailers in the coming years. When aerodynamic devices become prevalent on trailers, it would not be practical for the agency to evaluate each application for exemption from FMVSS No. 224 requirements as conducted by ATDynamics Inc., on a case by case basis. Therefore, the agency believes there is merit to addressing the installation of aerodynamic devices on trailers in Federal standards. Transport Canada consulted with NHTSA before it issued its proposal on a revised definition of rear extremity of a trailer. The revised definition of rear extremity in CMVSS No. 223 includes input from NHTSA's rulemaking, research, and chief counsel's office.

B. Other Maintenance Upgrades

Add "low chassis vehicles" to the list of excluded vehicles from FMVSS No 224 requirements

Since the latest FMVSS No. 223/224 final rule was published in 1996, the agency noticed that "low chassis vehicle" is inadvertently missing from the list of vehicle types explicitly excluded from the requirement. We believe this is an inadvertent error for the following reasons:

The preamble to the 1996 final rule (61 FR 2020) indicates the agency's intent to exclude low chassis vehicles.

The 1996 final rule (61 FR 2035) includes low chassis vehicles in the list of vehicle types excluded from the requirements of FMVSS No. 224. It also provided a definition of low chassis vehicles.

The regulatory text in the 1998 final rule responding to petitions for reconsideration (63 FR 3662) does not have low chassis vehicle among the excluded list of vehicles but retained the definition of low chassis vehicle. However, there was no explanation in the preamble of the 1998 final rule for this omission in the applicability section.

Therefore, Rulemaking concludes that low chassis vehicles was inadvertently omitted from the list of excluded vehicles in the applicability section of FMVSS No. 224 in the 1998 final rule and we are proposing to add it back to the list as was the original intent in the 1996 final rule.

Correction to S3 in FMVSS No. 223

Section S3. *Application* in FMVSS No. 223 incorrectly refers to FMVSS No. 224 as “Federal Motor Safety Standard No. 224.” The agency is modifying this to “Federal Motor Vehicle Safety Standard No. 224.”

C. Summary of Proposal

To address the concerns discussed above and in the interest of reducing injuries and fatalities due to light vehicle impacts into the rear of trailers the agency is proposing the following:

1) Modify FMVSS No. 223 by requiring that in the rear impact guard strength and energy absorption tests, there is no separation of any portion of the guard attachments from its mounting structure.

2) Modify FMVSS No. 223 by replacing the current loading and performance requirements at the P3 location with that specified in CMVSS No. 223. Specifically,

    a. Rear impact guards are required to resist a uniform distributed load of 350,000 N without deflecting more than 125 mm.

    b. Rear impact guards that demonstrate resistance to a uniform distributed load of 700,000 N or less are required to absorb at least 20,000 J of energy within 125 mm of guard deflection when a uniform distributed load is applied and have a post-test ground clearance not exceeding 560 mm.

    c. Rear impact guards that demonstrate resistance to a uniform distributed load greater than 700,000 N need not meet the energy absorption requirements but are required to maintain a post-test ground clearance not exceeding 560 mm.

3) Modify FMVSS No. 223 by adding specifications for the distributed load force application device and test procedures for conducting the distributed load test.

4) Modify FMVSS No. 223 by including a definition for “ground clearance” and a method of assessing post-test ground clearance.

5) Modify S3 of FMVSS No. 223 by replacing “Federal Motor Safety Standard,” with “Federal Motor Vehicle Safety Standard.”

6) Modify FMVSS No. 224 by adding “low chassis vehicles” to the list of vehicles excluded from FMVSS No. 224 requirements.

7) Modify FMVSS No. 224 by replacing the current definition of “rear extremity” with that specified in CMVSS No. 223 that permits aerodynamic fairings to be located within a certain zone at the rear of the trailer.

III. REAR IMPACT GUARD AND PROTECTION RESEARCH

A. Rear underride as a cause of fatality in frontal crashes to belted occupants of newer passenger car models

In 2009, NHTSA[20] conducted a study to evaluate why fatalities were still occurring in frontal crashes despite high rate of seat belt use and presence of air bags and advanced safety features. NHTSA reviewed cases of frontal crash fatalities to belted drivers or right-front passengers in model year (MY) 2000 or newer vehicles in the Crashworthiness Data System of the National Automotive Sampling System (NASS-CDS) through calendar year 2007. A breakdown of this data is shown in Figure 3. Among the 122 fatalities examined in this review, 49 (40%) were in exceedingly severe crashes that were not survivable, 29 (24%) were in oblique or corner impact crashes where there was low engagement of the vehicle's structural members to absorb the crash energy, 17 (14%) were underrides into trucks and trailers (14 were rear underride and 3 were side underride), 15 (12%) were fatalities to vulnerable occupants (occupants 75 years and older), 4 (3.3%) were narrow object impacts, and 8 (6.6%) were other types of impact conditions. In survivable frontal crashes of newer vehicle models resulting in fatalities to belted vehicle occupants, rear underride into large trucks and trailers were the second highest cause of fatality.

[20] Kahane, et al. "Fatalities in Frontal Crashes Despite Seat Belts and Air Bags – Review of All CDS Cases – Model and Calendar Years 2000-2007 – 122 Fatalities," September 2009, DOT-HS-811102.

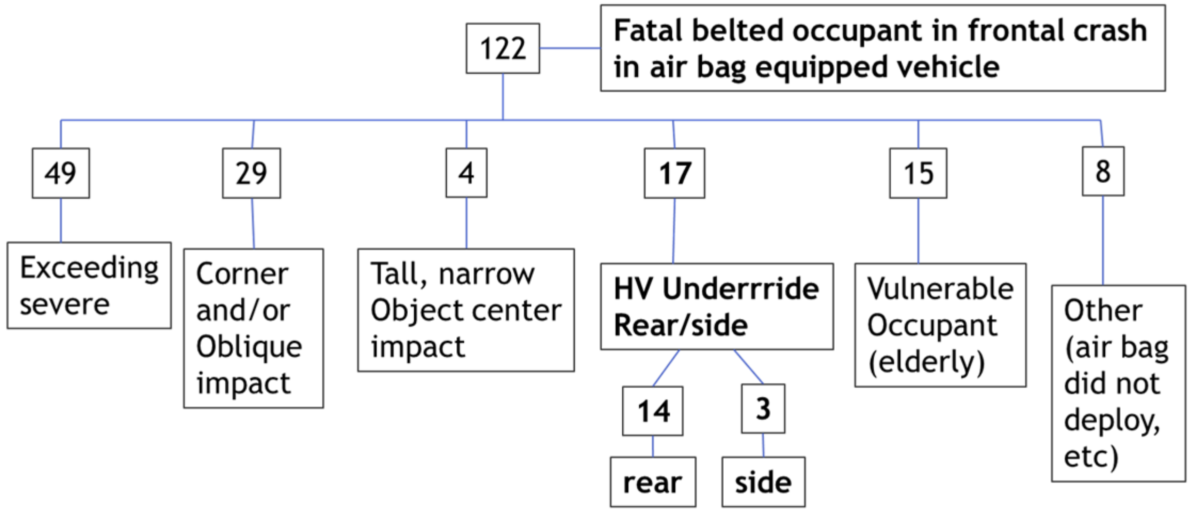

Figure 3: Breakout of belted occupant fatalities in frontal crashes of air bag equipped passenger vehicles

B. Evaluation of the effectiveness of rear impact guards

In 2010, NHTSA[21] conducted a study of crash data involving trailers to determine the effectiveness of rear impact guards (those compliant with FMVSS Nos. 223 and 224) in preventing fatalities and serious injuries in crashes where a passenger vehicle impacts the rear of a trailer. The analysis could not find a statistically significant decrease in the frequency of fatalities and injuries resulting from rear underride into trailers. The study also found that passenger compartment intrusion is more apt to occur when the corner of the trailer is impacted, rather than the center of the trailer. Finally, the study concluded that it was not possible to establish a nationwide downward trend in fatalities when a passenger vehicle impacts the rear of a trailer – neither in terms of total number of fatalities, percentage of passenger vehicle fatalities in crashes into the rear of trailers relative to passenger vehicle fatalities in all crashes involving trailers, nor in terms of the number of fatal crashes into the rear of trailers per 1,000 light vehicle crashes involving trailers.

[21] Kirk Allen, "The Effectiveness of Underride Guards for Heavy Trailers", October, 2010, DOT HS 811 375.

C. field data on the extent of underride in rear impacts into heavy vehicles

NHTSA initiated research in late 2009 with the University of Michigan Transportation Research Institute (UMTRI) to gather supplemental data on the rear geometry of trucks and trailers, the configuration of rear impact guards on trucks and trailers, and the incidence and extent of underride, and fatalities in rear impacts with trucks and trailers. UMTRI collected the supplemental information as part of its Trucks in Fatal Accidents (TIFA) survey for the years 2008 and 2009.[22,23] This supplemental data provided information on underride and the rear geometry of the impacted heavy vehicle that was previously not available. The data enabled the agency to obtain national estimates of rear impact crashes into heavy vehicles that resulted in PCI. Details of the NHTSA/UMTRI study completed in 2013 are presented in Chapter V.

D. 2005 Upgrade to Rear Impact Guard Requirements in Canada

In 2005, Transport Canada issued upgraded rear impact protection requirements for trailers and semitrailers in Canadian Motor Vehicle Safety Standard (CMVSS) No. 223, "Rear impact guards."[24] The upgraded requirements ensured rear impact guards have sufficient strength and energy absorption capability to prevent passenger compartment intrusion of compact and subcompact passenger cars in impacts to the rear of trailers at 56 kilometers per hour (km/h) (35 miles per hour (mph)).[25] In contrast, the requirements in FMVSS Nos. 223 and 224 were

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[22] Analysis of Rear Underride in Fatal Truck Crashes, 2008, DOT HS 811 652, August, 2012.
[23] Heavy-Vehicle Crash Data Collection and Analysis to Characterize Rear and Side Underride and Front Override in Fatal Truck Crashes, DOT HS 811 725, March 2013.
[24] Canada Gazette Part II, Vol. 138, No. 20, 2004-10-06.
[25] Boucher D., Davis, D., "Trailer Underride Protection – A Canadian Perspective," SAE Paper No. 2000-01-3522, Truck and Bus Meeting and Exposition, December 2000, Society of Automotive Engineers.

intended for preventing PCI in compact and subcompact passenger cars impacting the rear of trailers at 48 km/h (30 mph).[26] The new requirements in CMVSS No. 223 became effective in 2007. Currently, the agency estimates that approximately 93 percent of applicable new trailers sold in the U.S. are equipped with rear impact guards that also comply with the Canadian standard.

E. Canadian and European Standards for Rear Impact Guards

When FMVSS Nos. 223 and 224 were promulgated, all passenger cars were required to comply to a full frontal 48 km/h (30 mph) rigid barrier crash test by ensuring that the injury measures of crash test dummies positioned in the front seating positions were within the allowable limits.[27] In 2000, NHTSA issued updates to FMVSS No. 208 to provide improved frontal crash protection for all occupants by means that include advanced air bag technology.[28] The upgraded standard required passenger cars to comply with a full frontal 56 km/h (35 mph) rigid barrier crash test by ensuring that the injury measures of crash test dummies restrained in front seating positions were within the allowable limits.

In 2005, Transport Canada issued upgraded rear impact protection requirements for trailers and semitrailers.[29] Given that passenger car models manufactured in 2005 and later in Canada are required to provide adequate occupant protection to restrained occupants in 56 km/h (35 mph)

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[26] 61 FR 2004.

[27] Details of the crash test procedure, crash test dummies, and allowable limits of injury measures for the crash test dummies used in the tests is specified in FMVSS No. 208, “Occupant crash protection,” 1996.

[28] 65FR 30680, Docket No. NHTSA-2000-7013, Final rule; Interim final rule, May 12, 2000.

[29] Canada Gazette Part II, Vol. 138, No. 20, 2004-10-06.

full frontal rigid barrier crashes, Transport Canada required rear impact guards to provide sufficient strength and energy absorption to prevent PCI of compact and subcompact passenger cars impacting the rear of trailers at 56 km/h (35 mph).[30]

The CMVSS No. 223, "Rear impact guards," is applicable to trailers and semitrailers and has similar geometric specifications for rear impact guards as FMVSS No. 224. CMVSS No. 223 specifies quasi-static loading tests similar to those in FMVSS No. 223. However, CMVSS No. 223 replaced the 100,000 N quasi-static point load test at the P3 location in FMVSS No. 223 with a 350,000 N uniform distributed load test on the horizontal member.[31] The guard is required to withstand this load and absorb at least 20,000 J of energy within 125 mm of deflection, and have a ground clearance after the test not exceeding 560 mm (22 inches). Through extensive testing,[32] Transport Canada demonstrated that these requirements would ensure that compact and subcompact passenger cars would not have passenger compartment intrusion when rear ending a CMVSS No. 223 compliant trailer at 56 km/h (35 mph).

The European standard, ECE R.58, "Rear underrun protective devices (RUPD); Vehicles with regard to the installation of an RUPD of an approved vehicle; Vehicles with regard to their rear underrun protection," specifies rear impact protection requirements for SUTs and trailers weighing more than 3,500 kg (7,716 lb). The dimensional and strength requirements for rear

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[30] Boucher, D. and Davis, D., "A Discussion on Rear Underride Protection in Canada," Informal Document, 127th WP.29, 25-28 June 2002, http://www.unece.org/fileadmin/DAM/trans/doc/2002/wp29/TRANS-WP29-127-inf05e.pdf.
[31] The load is applied uniformly across the horizontal member by a uniform load application structure with length that exceeds the distance between the outside edges of the vertical support of the horizontal member and which is centered on the horizontal member of the guard.
[32] Boucher, D, "Heavy Trailer rear underride crash tests performed with passenger vehicles," Technical Memorandum No. TMVS-0001, Transport Canada, Road Safety and Motor Vehicle Regulation Directorate, July 2000.

impact guards are similar to those specified in FMVSSs Nos. 223 and 224. ECE R.58 specifies that both during and after the quasi-static force application test, the horizontal distance between the rear of the rear impact guard and the rear extremity of the vehicle not be greater than 400 mm. However, ECE R.58 does not specify any energy absorption requirements. Table 1 presents a comparison of rear impact protection requirements in the U.S., Canada, and Europe.

Table 1: Comparison of rear impact protection requirements in U.S., Canada, and Europe

Requirement	U.S.	Canada	Europe
Applicable standards	FMVSS No. 223/224	CMVSS No. 223	ECE R.58
Applicable vehicles	Trailers	Trailers	Trailers and SUTs
Geometric requirements in unloaded condition			
Ground clearance	560 mm	560 mm	550 mm
Longitudinal distance from rear extremity	305 mm	305 mm	NA
Lateral distance from side of vehicle	100 mm	100 mm	100 mm
Quasi-static load tests			
Point load at P1 (outer edge of guard)	50 kN	50 kN	25 kN
Point load at P2 (center of guard)	50 kN	50 kN	25 kN
Point load at P3 (at the guard supports)	100 kN with no more than 125 mm displacement, 5,650 J energy absorption	NA	100 kN with distance of rear impact guard from vehicle rear extremity of 400 mm after test.
Distributed load	NA	350 kN with no more than 125mm displacement and 20,000 J energy absorption; guard ground clearance less than 560 mm after test.	NA

Table 1 suggests that rear impact protection for trailers in Canada is more stringent than that in the U.S and in Europe. However, rear impact protection requirements in Europe (ECE R.58) also apply to single unit trucks while FMVSS Nos. 223/224 and CMVSS No. 223 do not. Japan and Australia accept compliance of applicable trailers to ECE R.58.

IV. EVALUATION OF REAR IMPACT GUARDS BY IIHS

In 2010, IIHS completed a review of LTCCS data to evaluate fatal crashes into the rear of heavy vehicles.[33] IIHS conducted a review of 115 LTCCS cases of vehicle underride into the rear of heavy vehicles and documented the presence and type of underride guard and its performance in mitigating underride. Among the 115 cases reviewed, nearly half of the passenger vehicles had underride classified as severe or catastrophic. IIHS noted that for the cases involving trailers with rear impact guards, guard deformation or complete failure of the guard was frequent and commonly due to weak attachments, buckling of the trailer chassis, and bending of the lateral end of the guard under low overlap loading. IIHS stated that 57 percent of the heavy vehicles in the 115 LTCCS cases were excluded from FMVSS No. 224 requirements, among which a large proportion were wheels back vehicles and single unit trucks such as dump trucks. In its review of the LTCCS cases, IIHS was not able to estimate the crash speeds.

Following the review, in 2011, IIHS conducted an initial round of crash tests in which the front of a model year (MY) 2010 Chevrolet Malibu (a midsize sedan) impacted the rear of trailers equipped with an underride guard.[34] Three trailer/guard designs (2007 Hyundai, 2007 Vanguard, and 2011 Wabash trailers) were evaluated in various conditions. Each guard design was certified to FMVSS No. 223 requirements, and two (Vanguard and Wabash) also met the more stringent CMVSS No. 223 requirements. A 2010 Chevrolet Malibu was first crashed into a trailer at 56 km/h (35 mph) with full overlap (the overlap refers to the portion of the Malibu's width

[33] Brumbelow, M.L., Blanar, L., "Evaluation of US rear uderride guard regulation for large trucks using real world crashes." Proceedings of the 54th Stapp Car Crash Conference, 119-31, 2010. Warrendale, PA, Society of Automotive Engineers.
[34] Brumbelow, M. L., "Crash Test Performance of Large Truck Rear Impact Guards," 22nd International Conference on the Enhanced Safety of Vehicles (ESV), 2011. http://www-nrd.nhtsa.dot.gov/pdf/esv/esv22/22ESV-000074.pdf.

overlapping the underride guard). If the rear impact guard of a trailer model was successful in preventing passenger compartment intrusion in the full overlap crash test, a new Malibu was crashed into a new trailer of the same model with 50 percent overlap of the Malibu. If the rear impact guard was successful in preventing PCI in this case as well, a third test was performed with only 30 percent overlap of the Malibu. The test results showed that in the full overlap 56 km/h (35 mph) crash test of the Malibu with the guard of the Hyundai trailer (built to only FMVSS No. 223 requirements) resulted in catastrophic underride with PCI of the Chevrolet Malibu. The guard on the Vanguard trailer that complied with the upgraded CMVSS No. 223 rear impact guard requirements could not prevent PCI in a 56 km/h (35 mph) crash test with 50 percent overlap of the Malibu because the attachments of the guard to the trailer failed. The rear impact guard on the Wabash trailer, also certified to meet CMVSS No. 223 requirements, prevented PCI in 35 mph crash tests with full and 50 percent overlap of the Malibu, but could not prevent PCI in the crash test with 30 percent overlap.

Quasi-Static Load Testing of Rear Impact Guards

IIHS conducted quasi-static load tests using a 203 mm square force application device (similar to that specified in FMVSS No. 223) at P1 and P3 locations of the horizontal member of the rear impact guards on the 2007 Hyundai, 2007 Vanguard and the 2011 Wabash trailers. The load was applied at a rate of 1.3 mm/sec until the force application device displaced 125 mm. Figure 2 shows the force-displacement curves for all three guards in the quasi-static test at the P3 location. Deformation patterns of the underride guards varied substantially in the quasi-static tests. In the test at P3 location on the Hyundai guard, a peak force of 163,000 N was achieved and then the vertical support member of the Hyundai guard was pulled slowly from some of the bolts attaching it to the fixture, whereas the vertical member itself deformed only minimally. In the test at P3 of the Vanguard guard, the vertical member flexed for the first 50 mm of loading achieving a peak load of 257,000 N and then the attachment bolts began to shear, causing the measured force to drop below that measured for the Hyundai later in the test. The Wabash guard reached its peak force of 287,000 N earliest, and then the vertical member began buckling near its attachment to the horizontal member. As the buckling continued, the rear surface of the guard eventually bottomed out against the diagonal gusset, causing the load to increase again late in the test. The Vanguard rear impact guard absorbed 14,000 J of energy, the Hyundai rear impact guard absorbed 13,900 J of energy and the Wabash guard absorbed 22,100 J of energy in the P3 point-load tests.

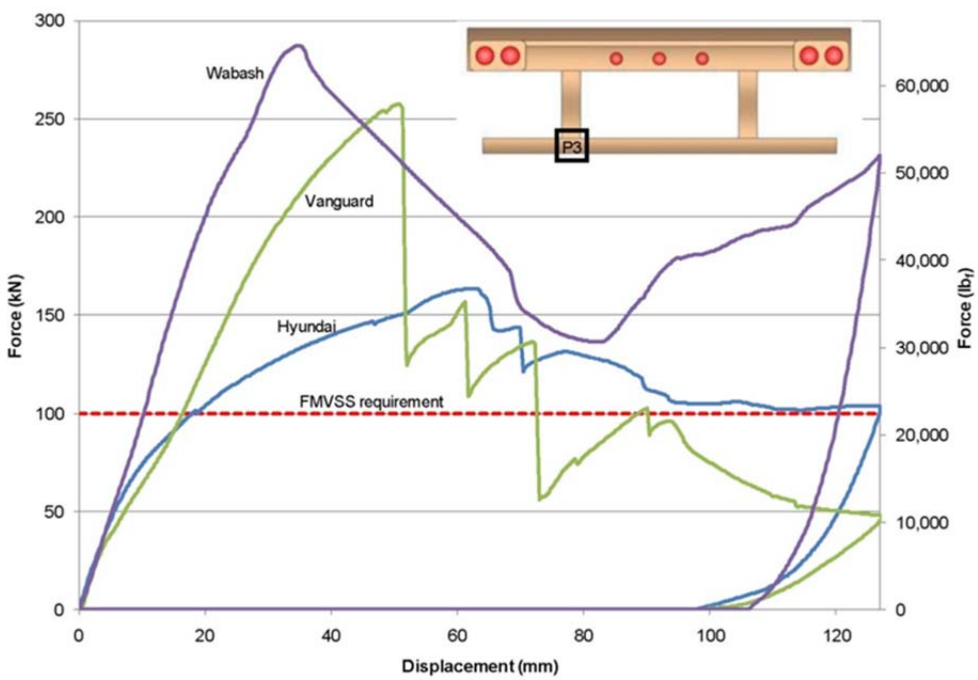

Figure 2: IIHS quasi-static test at P3 of the 2007 Hyundai, 2007 Vanguard, and 2011 Wabash trailer rear impact guards.

Table 2 summarizes the results of the initial five IIHS 56 km/h full-width crash tests. In the first test, the 2007 Hyundai guard was ripped from the trailer's rear cross member early in the crash, allowing the Malibu to underride the trailer almost to the B-pillar. The heads of both dummies were struck by the hood of the Malibu as it deformed against the rear surface of the trailer. Under the same test conditions, the main horizontal member of the 2011 Wabash guard bent forward in the center but remained attached to the vertical support members, which showed no signs of separating from the trailer chassis.

Table 2: Results of IIHS initial round of 56 km/h crash tests of the 2010 Chevrolet Malibu into the rear of trailers.

Conditions	Trailer	Guard performance	Underride	Max. longitudinal A-pillar deformation (cm)
100% overlap	2007 Hyundai	Attachments failed	Catastrophic	80
	2011 Wabash	Good	None	0
50% overlap	2007 Vanguard	Attachments failed	Severe	27
	2011 Wabash	End bent forward	None	6
30% overlap	2011 Wabash	End bent forward	Catastrophic	87

Table 3 summarizes the peak injury measures[35] of the 50th percentile male Hybrid III dummies (HIII 50M) in the front seating positions of the Malibu. For comparison purposes, Table 4 also presents the HIII 50M dummy injury measures in the full frontal 56 km/h rigid barrier crash test of the 2010 Chevrolet Malibu conducted as part of the New Car Assessment Program (NCAP). Head injury measures recorded by the dummies in the tests with severe underride were much higher than those reported for the Malibu's NCAP rigid wall test at the same speed. Chest acceleration and deflection measures were generally higher in tests without PCI than those with PCI. The frontal air bag deployed in the 100, 50, and 30 percent overlap crash tests of the Malibu into the rear of the Wabash trailer. The driver and passenger injury measures in the

[35] HII 50M dummy injury measures are those applicable to current model passenger vehicles as specified in FMVSS No. 208, see http://www.ecfr.gov/cgi-bin/text-idx?SID=77e2aab5d088f2e9b46d15606090f9b0&node=se49.6.571_1208&rgn=div8.

Malibu full width crash test with the Wabash trailer (where the guard prevented PCI) was similar to the injury measures in the Malibu NCAP frontal crash test.

Table 3: IIHS initial round of testing – Injury measures of dummies in front seating positions of the Malibu.

Test			Head Resultant acceleration (g)	Head Injury Criterion (15 ms)	Chest Resultant Acceleration (3 ms clip, g)	Chest Displacement (mm)	Left Femur Force (kN)	Right Femur Force (kN)
Full-width	Hyundai	*Driver*	128	754	21	19	0.3	0.3
		Passenger	107	557	14	20	0.1	0.1
	Wabash	*Driver*	54	328	36	38	2.2	1.2
		Passenger	50	319	36	37	2.3	1.8
	NCAP (rigid wall)	*Driver*	49	330	43	40	2.0	1.2
		Passenger	55	389	42	32	0.5	0.8
50% overlap	Vanguard	*Driver*	109	254	14	20	2.2	0
	Wabash	*Driver*	36	160	25	33	3.7	0.9
30% overlap	Wabash	*Driver*	130	880	37	16	0.6	0.1

Following the preliminary crash tests in 2011, IIHS conducted similar crash tests of a 2010 Chevrolet Malibu sedan with eight additional 2012 and 2013 model year trailers from various manufacturers, including a newly redesigned Hyundai and Vanguard models. All guards in this round of testing were not only in compliance with FMVSS No. 223 but were also in compliance with CMVSS No. 223. Table 4 presents certification data from trailer manufacturers showing compliance with CMVSS No. 223. Only one trailer manufacturer utilized the option in CMVSS No. 223 to test using half the guard with a point load force application of 175,000 N at P3, while the other rear impact guards were certified with the uniform distributed quasi-static load application of 350,000 N on the full guard. All the rear impact guards tested also complied with the requirement that the ground clearance of the guard after the test not exceed 560 mm.

Table 4: Trailer manufacturers' certification data (CMVSS No. 223) of rear impact guards

	P1	P2	Uniform Distributed Load	Uniform (1/2 of guard)
Requirement :	**50 kN**	**50 kN**	**350 kN / 20 kJ**	**175 kN / 10 kJ**
Strick	50.7	50.5		233.4 kN / 18.9 kJ
Vanguard	*50	*50	370.1 kN / 25.3 kJ	
Hyundai/ Translead	51.6	53.6	367.5 kN / 37.5 kJ	
Stoughton	53.7	56	404.6 kN @ 101.6mm/ 31.2 kJ	
Great Dane	*50	*50	386.7 kN @ 125mm / 28.8 kJ	
Manac	55.1	55.8	37.5 kN / 25.0 kJ	

* Loaded until 50 kN reached

The ground clearance of the bumper (vertical distance of the bottom of the bumper from the ground) of the 2010 Chevrolet Malibu is 403 mm and the vertical height of the bumper is 124 mm. Therefore, the Malibu bumper is located at a vertical height between 403 mm and 527 mm above the ground with its centerline located 465 mm above ground. The vertical height of the top of the engine block from the ground is 835 mm. The ground clearance of the horizontal member of each rear impact guard ranged between 400 mm and 498 mm (Table 5).

Table 5: Trailer guard ground clearance

Trailer	Guard Ground Clearance (mm)
2011 Wabash	445
2012 Manac	498
2012 Stoughton	477
2013 Great Dane	400
2012-2013 Hyundai	409
2013 Strick	413
2013 Utility	455
2013 Vanguard	452

Table 6, Table 7, and Table 8 present the extent of underride, deformation of the Malibu, performance of the guard, and whether there was passenger compartment intrusion in the 56 km/h frontal impact crash tests of the Malibu into the rear of trailers with full overlap, 50 percent overlap, and 30 percent overlap of the Malibu, respectively. All the rear impact guards on the trailers that were compliant with CMVSS No. 223 were able to prevent passenger compartment intrusion in full overlap crashes. In the tests with 50 percent overlap of the Malibu, all the guards except the 2013 Vanguard was able to prevent PCI. The Vanguard rear impact guard failed at the attachments where the bolts sheared off during the crash resulting in PCI of the Malibu. All the rear impact guards tested except the 2012 Manac guard were not able to prevent PCI in the 30 percent offset crash tests of the Malibu.

Table 6: Rear impact guard performance in frontal impact crash tests of a 2010 Chevrolet Malibu into the rear of trailers with full overlap with the guard

2010 Chevrolet Malibu Into Trailer - Crash Test Results (100% Overlap @ 56 km/h)								
Trailer	**Guard Performance**			**PCI (due to underride)**	**Max. longitudinal deformation (cm)**		**Underride* (cm)**	**Peak Impulse (g at ms)**
	Overall	**Fastener Breakage**	**Material Failure**		**A-Pilar**	**Roof**		
2011 Wabash	Good	None	None	None	0	0	99	30g at 82ms
2012 Manac	Good	Some	None	None (windshield shattered)	0	0	135	18g at 101ms
2012 Stoughton	Good	None	None	None	0	0	117	25g at 85ms
2013 Great Dane	Good	None	None	None	0	0	96	21g at 109ms
2012 Hyundai	Good	None	None	None	0	0	92	23g at 49ms
2013 Strick	Good	None	None	None (windshield shattered)	0	0	121	26g at 93ms
2013 Utility	Good	None	None	None	0	0	99	30g at 47ms
2013 Vanguard	Good	Some	Some Tearing	None (windshield shattered)	0	0	94	34g at 80ms
**Calculated by relative center of mass positions collected at initial impact and maximum displacement.*								

Table 7: Rear impact guard performance in frontal impact crash tests of a 2010 Chevrolet Malibu into the rear of trailers with 50 percent overlap with the guard

2010 Chevrolet Malibu Into Trailer - Crash Test Results (50% Overlap @ 56 km/h)								
Trailer	**Guard Performance**			**PCI (due to underride)**	**Max. longitudinal deformation (cm)**		**Underride* (cm)**	**Peak Impulse (g at ms)**
	Overall	**Fastener Breakage**	**Material Failure**		**A-Pilar**	**Roof**		
2011 Wabash	Good	None	None	None (windshield shattered)	6	None	135	19g at 95ms
2012 Manac	Good	None	None	None (windshield shattered)	0	None	129	19g at 50ms
2012 Stoughton	Good	None	None	None (windshield shattered)	11	None	147	14g at 66ms
2013 Great Dan	Good	Some	None	None (windshield shattered)	0	None	152	14g at 97ms
2013 Hyundai	Good	None	None	None (windshield shattered)	0	None	116	16g at 49ms
2013 Strick	Good	None	None	None (windshield shattered)	15	None	146	15g at 80ms
2013 Utility	Good	None	None	None (windshield shattered)	5	None	139	18g at 58ms
2013 Vanguard	Fail (full detachment)	Extensive	Extensive	Trailer rear sill directly contacted dummy head	146	Extensive	205	17g at 48ms
*Calculated by relative center of mass positions collected at initial impact and maximum displacement.								

Table 8: Rear impact guard performance in frontal impact crash tests of a 2010 Chevrolet Malibu into the rear of trailers with 30 percent overlap with the guard

2010 Chevrolet Malibu Into Trailer - Crash Test Results (30% Overlap @ 56 km/h)								
Trailer	**Guard Performance**			**PCI (due to underride)**	**Max. longitudinal deformation (cm)**		**Underride* (cm)**	**Peak Impulse (g at ms)**
	Overall	**Fastener Breakage**	**Material Failure**		**A-Pilar**	**Roof**		
2011 Wabash	Fail	None	None	Trailer rear sill directly contacted dummy head	87	33	242	Not Reported
2012 Manac	Good	Some	None	None (windshield shattered)	5	None	160	17g at 66ms
2012 Stoughton	Fail	None	None	Trailer rear sill directly contacted dummy head	89	Extensive	218	12g at 144ms
2013 Great Dan	Fail	None	None	Trailer rear sill directly contacted dummy head	111	Extensive	244	18g at 151ms
2013 Hyundai	Fail	None	None	Trailer rear sill directly contacted dummy head	112	Extensive	242	18g at 200ms
2013 Strick	Fail	None	None	Trailer rear sill directly contacted dummy head	117	Extensive	245	16g at 202ms
2013 Utility	Fail	None	None	Trailer rear sill directly contacted dummy head	123	Extensive	237	10g at 225ms
2013 Vanguard	*Not tested due to failure of 50% overlap test at 56 km/h*							
**Calculated by relative center of mass positions collected at initial impact and maximum displacement.*								

Table 9, presents the injury measures of crash test dummies (HIII-50M) in the driver and front passenger seating positions in 56 km/h crash tests conducted by IIHS with 100 percent overlap of the 2010 Malibu with rear impact guard. Table 10, and Table 11 present the injury measures for the HIII-50M in the driver position in 56 km/h crash tests with 50 percent and 30 percent overlap of the 2010 Malibu with the rear impact guard, respectively.

The frontal air bags deployed in all the 100 percent and 50 percent overlap crash tests of the Malibu into the rear of 2011-2013 model year trailers. The air bag deployed in all the 30 percent overlap crash tests of the Malibu into the rear of 2011-2013 model year trailers except for the tests into the rear of the 2012 Hyundai, 2013 Great Dane, and 2013 Strick trailer. When the Malibu experienced PCI in a crash test, the dummy injury measures, specifically the head injury criteria (HIC) and the neck injury criteria (Nij) generally exceeded the allowable Injury Assessment Reference Values (IARV) of 700 and 1.0, respectively, regardless of whether the air bag deployed on not.[36] When PCI was prevented by the rear impact guard, the accelerations on the vehicle are higher which results in higher chest deflection measures, although well within the allowable level, indicating higher acceleration loads on the dummy.

[36] Except in the neck injury measure (Nij = 0.65) in the 50 percent overlap crash with the Vanguard trailer.

Table 9: Dummy injury measures in frontal impact crash tests of a 2010 Chevrolet Malibu into the rear of trailers with full overlap with the rear impact guard

2010 Chevrolet Malibu Into Trailer - Driver HIII 50M Injury Measures (100% overlap @ 56 km/h)									
	Driver				Passenger				
Trailer	HIC-15 (700)	Max N_{ij} (1.00)		Rib Compression (63mm)	HIC-15 (700)	Max N_{ij} (1.00)		Rib Compression (63mm)
2011 Wabash	328	0.33	Tension-Flexion	38	319	0.35	Compression-Extension	37
2012 Manac	206	0.28	Tension-Flexion	35	143	0.38	Tension-Flexion	37
2012 Stoughton	267	0.37	Tension-Flexion	40	265	0.37	Tension-Flexion	37
2013 Great Dane	49	0.22	Tension-Extension	32	65	0.16	Compression-Extension	35
2012 Hyundai	54	0.22	Tension-Flexion	39	110	0.20	Tension-Flexion	35
2013 Strick	107	0.26	Tension-Flexion	39	125	0.32	Tension-Flexion	37
2013 Utility	130	0.25	Tension-Flexion	37	173	0.33	Tension-Flexion	33
2013 Vanguard	212	0.31	Tension-Flexion	35	237	0.40	Tension-Flexion	31

Table 10: Dummy injury measures in frontal impact crash tests of a 2010 Chevrolet Malibu into the rear of trailers with 50 percent overlap with the rear impact guard

2010 Chevrolet Malibu Into Trailer - Driver HIII 50M Injury Measures (50% overlap @ 56 km/h)				
Trailer	HIC-15 (700)	Max N_{ij} (1.00)		Rib Compression (63mm)
2011 Wabash	101	0.23	Tension-Flexion	33
2012 Manac	38	0.13	Tension-Flexion	29
2012 Stoughton	65	0.17	Tension-Flexion	25
2013 Great Dane	78	0.24	Tension-Flexion	28
2013 Hyundai	155	0.35	Compression-Extension	32
2013 Strick	163	0.18	Tension-Flexion	27
2013 Utility	37	0.17	Tension-Flexion	30
2013 Vanguard	1954	0.35	Compression-Flexsion	21

Table 11: Dummy injury measures in frontal impact crash tests of a 2010 Chevrolet Malibu into the rear of trailers with 30 percent overlap with the rear impact guard

2010 Chevrolet Malibu Into Trailer - Driver HIII 50M Injury Measures (30% overlap @ 56 km/h)				
Trailer	HIC-15 (700)	Max N_{ij} (1.00)		Rib Compression (63mm)
2011 Wabash	880	1.16	Tension-Extension	16
2012 Manac	58	0.28	Tension-Flexion	31
2012 Stoughton	9069	1.23	Tension-Extension	14
2013 Great Dane	8708	2.45	Tension-Extension	16
2013 Hyundai	7346	1.94	Tension-Extension	19
2013 Strick	7742	2.38	Compression-Flexsion	19
2013 Utility	7415	2.55	Tension-Extension	17
2013 Vanguard	*Not tested due to failure of 50% overlap test at 56 km/h*			

Summary of the IIHS Test Data

The results, summarized in Table 12 and Table 13, show that the trailer guard compliant with FMVSS No. 223 was unable to withstand an impact of the Malibu at 56 km/h (35 mph) and it resulted in PCI in the Malibu. The tests also demonstrated that trailers that comply with the Canadian standard, CMVSS No. 223, were able to mitigate passenger compartment intrusion in 35 mph impacts of the Malibu with full and 50 percent overlap with the rear impact guard. However, seven of the eight rear impact guards compliant with the Canadian standard could not prevent passenger compartment intrusion when only 30 percent of the Malibu front end engaged the rear impact guard.

In the quasi-static test at P3 location of the Vanguard rear impact guard, the attachments bolts sheared but still were able to meet the load and energy absorption requirements of CMVSS No. 223. However, in the 35 mph crash test with 50 percent overlap of the 2010 Malibu with the vanguard trailer, the guard bolts sheared resulting in PCI of the Malibu. These results suggest that the integrity of the attachment hardware in the quasi-static test may provide valuable information on the dynamic performance of the guard in crashes.

In the tests where there was no PCI of the Malibu, the injury measures of the restrained test dummies in the Malibu were below injury threshold levels. When PCI was prevented by the rear impact guard, it resulted in generally higher chest injury measures, although well within the allowable limits.

When the Malibu sustained PCI, the head and neck injury measures were generally greater than the allowable threshold levels indicating high risk of serious head and neck injuries, regardless of whether the air bag deployed on not. The IIHS tests showed that when PCI occurs, air bag deployment does not improve injury outcome.

Table 12. Occurrence of PCI in 35 mph crash tests (conducted by IIHS) of the 2010 Chevrolet Malibu into the rear of trailers.

Trailer Model	Designed to	Full Width	50% overlap	30% overlap
2011 Wabash	CMVSS No. 223	None	None	Yes
2012 Manac	CMVSS No. 223	None	None	None
2012 Stoughton	CMVSS No. 223	None	None	Yes
2013 Great Dane	CMVSS No. 223	None	None	Yes
2012 - 2013 Hyundai	CMVSS No. 223	None	None	Yes
2013 Strick	CMVSS No. 223	None	None	Yes
2013 Utility	CMVSS No. 223	None	None	Yes
2013 Vanguard	CMVSS No. 223	None	Yes*	N/A
2007 Hyundai	FMVSS No. 224	Yes	N/A**	N/A

* The attachment of the guard to the trailer failed during impact.
** Since the guard was unable to withstand the loads in the first test, the second and third tests were not conducted.

Table 13: Summary of IIHS's frontal impact crash tests of a 2010 Chevrolet Malibu into the rear of trailers

Trailer	Compliance	Overlap/Underride		Injury			
	P_3 Peak Force (kN) Energy Absorbed (kJ)	**Overlap**	**Underride* (cm)**	**HIC-15 (700)**	**Max N_{ij}** (1.00)**		**Rib Compression (63mm)**
2011 Wabash	287 kN / 22.1 kJ (point load)	100%	99	328	0.35	Compression-Extension	37
		50%	135	101	0.23	Tension-Flexion	33
		30%	242	880	1.16	Tension-Extension	16
2012 Hyundai	367.5 kN / 37.5 kJ (distributed load)	100%	92	54	0.2	Tension-Flexion	35
		50%	116	155	0.35	Compression-Extension	32
		30%	242	7346	1.94	Tension-Extension	19
2012 Manac	361.8 kN / 25.0 kJ (distributed load)	100%	135	206	0.38	Tension-Flexion	37
		50%	129	38	0.13	Tension-Flexion	29
		30%	160	58	0.28	Tension-Flexion	31
2012 Stoughton	404.6 kN / 31.2 kJ (distributed load)	100%	117	267	0.37	Tension-Flexion	37
		50%	147	65	0.17	Tension-Flexion	25
		30%	218	9069	1.23	Tension-Extension	14
2013 Great Dane	386.7 kN / 28.8 kJ (distributed load)	100%	96	49	0.16	Compression-Extension	35
		50%	152	78	0.24	Tension-Flexion	28
		30%	244	8708	2.45	Tension-Extension	16
2013 Strick	233.4 kN / 18.9 kJ (½ guard)	100%	121	107	0.32	Tension-Flexion	37
		50%	146	163	0.18	Tension-Flexion	27
		30%	245	7742	2.38	Compression-Flexsion	19
2013 Utility	Not Available	100%	99	130	0.33	Tension-Flexion	33
		50%	139	37	0.17	Tension-Flexion	30
		30%	237	7415	2.55	Tension-Extension	17
2013 Vanguard	370.1 kN / 25.3 kJ (distributed load)	100%	94	212	0.4	Tension-Flexion	31
		50%	205	1954	0.65	Compression-Flexsion	21
		30%	*Not tested due to failure of 50% overlap test at 56 km/h*				
2007 Hyundai	163 kN / 13.9 kJ Point Load	100%	catastrophic	754		NA	19
		50%	*Not tested due to failure of 100% overlap test at 56 km/h*				
		30%	*Not tested due to failure of 100% overlap test at 56 km/h*				

*Calculated by relative center of mass positions collected at initial impact and maximum displacement.

**For 100% overlap only the driver dummy is presented for comparison to 50% and 30% overlap scenarios.

V. SAFETY PROBLEM

A. 2013 NHTSA/UMTRI Study

In 2009, the agency initiated an in-depth field analysis for assessing the extent of the underride and for characterizing the factors in rear end impacts that result in truck/trailer underride to help direct potential changes to our safety requirements that would reduce severe passenger vehicle underride in truck and trailer rear end impacts.

The first-phase of the field analysis was published in 2012[37] and the final report of the analysis of 2008 and 2009 Trucks in Fatal Accidents (TIFA) along with supplemental information was published in March 2013.[38] The TIFA database contains records for all the medium and heavy trucks that were involved in fatal traffic crashes in the 50 U.S. states and the District of Columbia. TIFA data, collected by UMTRI, contains additional detail beyond what the FARS contains. The agency contracted UMTRI to collect supplemental data for the years 2008 and 2009 as part of the TIFA survey. The supplemental data included the rear geometry of the trucks and trailers, type of equipment at the rear of the trailer if any, whether a rear impact guard was present, and the type of rear impact guard and standards it complied with. For trucks and trailers involved in fatal rear impact crashes, additional information was collected on the extent of underride, damage to the rear impact guard, impact speeds, and whether the collision was offset or fully engaged the guard.

[37] Analysis of Rear Underride in Fatal Truck Crashes, DOT HS 811 725, August 2012. Also available at http://www.nhtsa.gov/Research/Crashworthiness/Truck%20Underride, last accessed on July 24, 2014.
[38] Heavy-Vehicle Crash Data Collection and Analysis to Characterize Rear and Side Underride and Front Override in Fatal Truck Crashes, DOT HS 811 725, March 2013. Also available at http://www.nhtsa.gov/Research/Crashworthiness/Truck%20Underride, last accessed on July 24, 2014.

Average annual estimates were derived from the 2008 and 2009 TIFA data files along with supplemental information collected in the 2013 UMTRI study. The agency's review of these data files found that there are 3,762 trucks and trailers involved in fatal accidents annually among which, trailers accounted for 67 percent, SUTs for 29 percent, tractor alone for 1.8 percent, and the remaining 2.5 percent were unknown.[39] About 489 trucks and trailers are struck in the rear in fatal crashes, constituting about 13 percent of all trucks and trailers in fatal crashes (Figure 4). Among rear impacted trucks and trailers in fatal crashes, 68 percent are trailers, 31 percent are SUTs, and 1 percent are tractors alone.

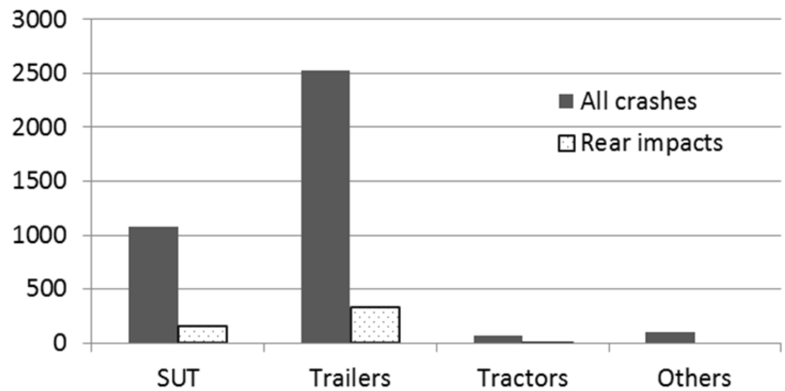

Figure 4: Annual number of trucks and trailers involved in fatal crashes (in all crash types and in rear impact crashes only).

B. Rear Impact Guard Presence on SUTs and Trailers

UMTRI evaluated the rear geometry of all the trailers and SUTs involved in fatal crashes in the 2008 and 2009 TIFA data and estimated whether the rear geometry met the specifications for requiring a rear impact guard per FMVSS No. 224 for trailers and FMCSR 393.86(b) for SUTs.[40] Based on this evaluation, UMTRI estimated that 65 percent of trailers required rear impact guards per FMVSS No. 224 (Table). Among the 35 percent of trailers that were excluded from

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[39] Bobtail and tractor/other configurations were combined into "others" category) and tractor/trailer and straight trucks with trailer were combined into "trailers" category.

[40] UMTRI only evaluated the rear geometry to determine whether a single unit truck required a rear impact guard. It did not determine how the truck was operated and whether it was used in interstate commerce.

FMVSS No. 224 requirements, 26 percent were wheels back trailers,[41] 2 percent were low chassis vehicles,[42] 1 percent had equipment in the rear, and 5 percent were exempt vehicles because of type of cargo or operation. UMTRI estimated that 38 percent of the SUTs involved in fatal crashes were required to have rear impact guards (based on the truck rear geometry according to FMCSA 393.86(b)), while only 18 percent were equipped with them (15). It is likely that the remaining 20 percent of the SUTs that required a guard but did not have one were not used in interstate commerce. Among the 62 percent of SUTs that were exempt from installing rear impact guards, 27 percent were wheels back SUTs,[43] 12 percent were low chassis SUTs,[44] 2 percent were wheels back and low chassis SUTs, and 21 percent had equipment in the rear that interfered with rear impact guard installation (see 15).

Table 15: Rear geometry of trailers and SUTs and whether a rear impact guard was required according to UMTRI's evaluation of trucks and trailers involved in fatal crashes in the 2008-2009 TIFA data files.

Type of Rear Geometry	Percentage of Trailers	Percentage of SUTs
Rear Impact Guard Required		
Guard present	65%	18%
Guard not present	0%	20%
Rear Impact Guard Not Required		
Excluded vehicle	6%	8%
Wheels back vehicle	26%	27%
Low chassis vehicle	2%	12%
Wheels back and low chassis vehicle	0%	2%
Equipment	1%	21%

[41] Wheels back trailers according to FMVSS No. 224 is where the rearmost axle is permanently fixed and is located such that the rearmost surface of tires is not more than 305 mm forward of the rear extremity of the vehicle.
[42] Low chassis trailers, are those where the chassis extends behind the rearmost point of the rearmost tires and the vertical distance between the rear bottom edge of the chassis assembly and ground is less than or equal to 560 mm.
[43] Wheels back SUTs according to FMCSR 393.86(b) is where the rearmost axle is permanently fixed and is located such that the rearmost surface of tires is not more than 610 mm forward of the rear extremity of the vehicle.
[44] Low chassis SUTs according FMCSR 393.86(b) is where the rearmost part of the vehicle includes the chassis and the vertical distance between the rear bottom edge of the chassis assembly and the ground is less than or equal to 762 mm (30 inches).

Since the data presented in Table 2 takes into consideration all trucks and trailers involved in all types of fatal crashes in 2008 and 2009 (total of 2,287 trucks and 5,236 trailers), it is reasonable to assume that the percentage of trucks and trailers with and without rear impact guards in Table 2 is representative of that in the truck and trailer fleet.

C. Light Vehicle Fatal Crashes into the Rear of Trailers and SUTs

Among the types of vehicles that impacted the rear of trucks and trailers, 73 percent were light vehicles, 18 percent were large trucks, 7.4 percent were motorcycles, and 1.7 percent were other/unknown vehicle types. UMTRI categorized passenger cars, compact and large sport utility vehicles, minivans, large vans (e.g. Econoline and E150-E350), compact pickups (e.g S-10, Ranger), and large pickups (e.g Ford F100-350, Ram, Silverado) as light vehicles. Since we do not expect trucks and buses to underride other trucks in rear impacts, the data presented henceforth only apply to light vehicles impacting the rear of trucks and trailers.

D. Underride Extent in Fatal Crashes of Light Vehicles into the Rear of Trailers and SUTs

In the UMTRI study of 2008 and 2009 TIFA data, survey respondents estimated the amount of underride in terms of the amount of the striking vehicle that went under the rear of the truck. The categories were “no underride,” “less than halfway up the hood,” “more than halfway but short of the base of the windshield,” and “at or beyond the base of the windshield.” When the extent of underride is “at or beyond the base of the windshield,” there is PCI that could result in serious injury to occupants in the vehicle. Rear impacts into trailers and trucks could result in some level of underride without PCI since the front end of the vehicle crushes and rear impact guards deform to some extent during impact. Such impacts into the rear of heavy vehicles without PCI may not pose additional crash risk to light vehicle occupants than that in crashes with another light vehicle at similar crash speeds.

About 319 light vehicle fatal crashes into the rear of trucks and trailers occur annually. UMTRI determined that about 36 percent (121) of light vehicle impacts into the rear of trucks and trailers resulted in PCI. Among fatal light vehicle impacts, the frequency of PCI was greatest for passenger cars and sport utility vehicles (40 and 41.5 percent, respectively) and lowest for large vans and large pickups (25 and 26 percent respectively), as shown in Figure 5. It is likely that large vans and large pickups did not actually underride the truck or trailer but sustained PCI because of the high speed of the crash and/or because of very short front end of the vehicle.

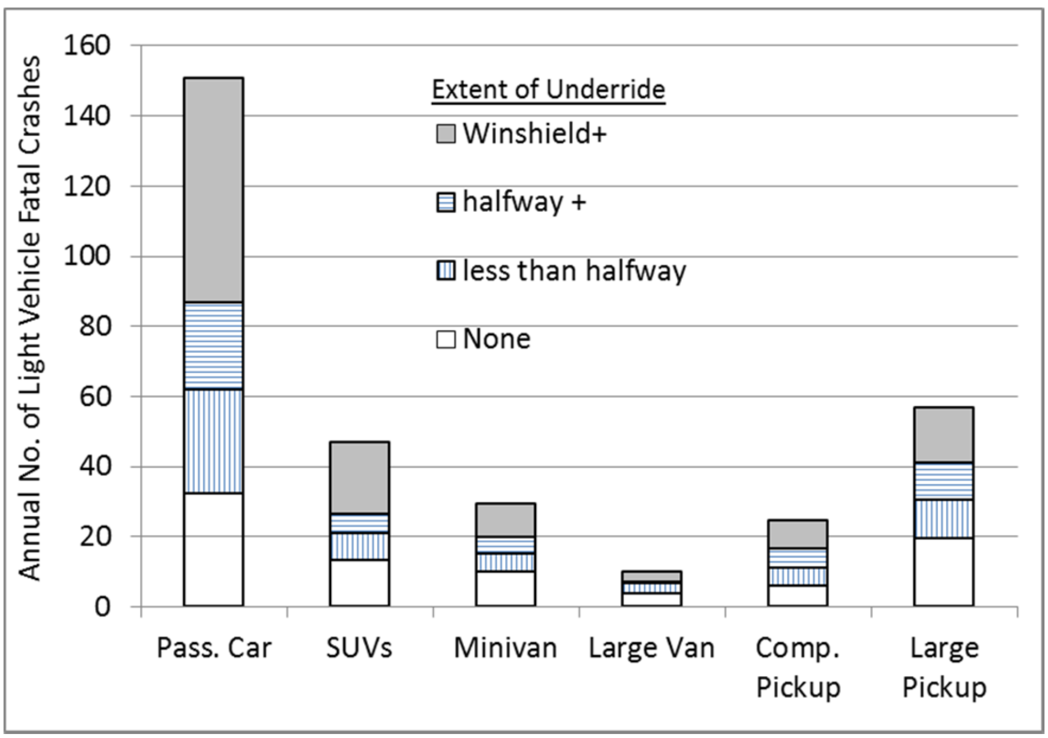

Figure 5: Annual light vehicle fatal crashes into the rear of trucks and trailers by type of light vehicle and extent of underride[45] (2008-2009 TIFA UMTRI study)

[45] The extent of underride in this and subsequent figures and tables means the following: None means "no underride"; less than halfway means "underride extent of less than halfway up the hood"; halfway+ means

Fatal light vehicle crashes into the rear of trucks and trailers was further examined by the type of truck and trailer struck and whether a guard was required (according to FMVSS No. 224 for trailers and FMCSR 393.86(b) for SUTs) (Figure 6 and Figure 7).

Among fatal light vehicle crashes into trucks and trailers, 36 percent are into trailers with guards, 25 percent into SUTs without any guards, 7 percent into SUTs with guards, 14 percent into wheels back trailers, 5 percent into exempt trailers (due to equipment in rear, type of operation, low bed), and 14 percent were other types of trucks (Figure 6).

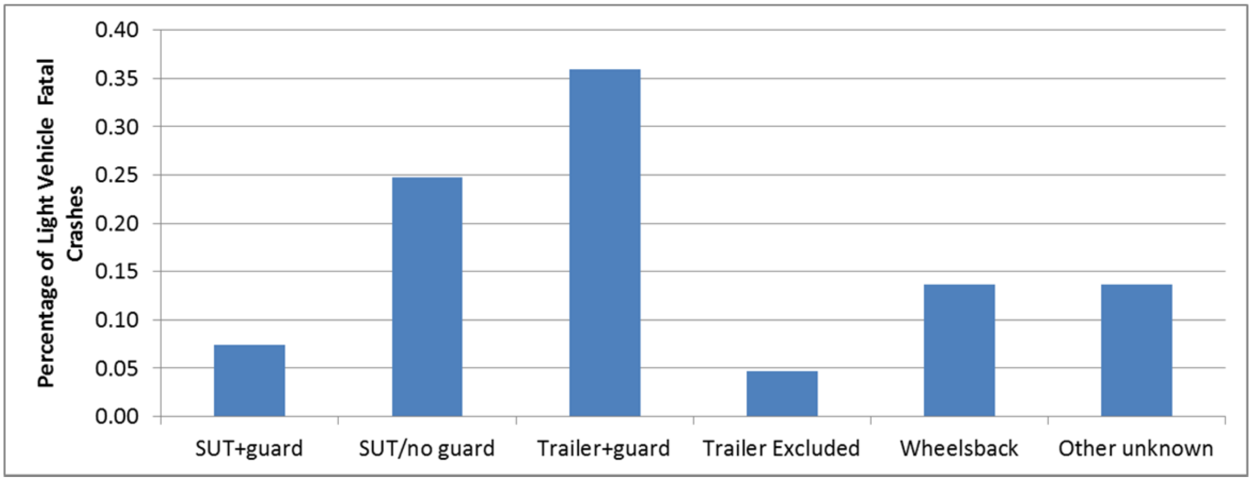

Figure 6. Percentage of light vehicle fatal crashes into the rear of trucks and trailers (2008-2009 TIFA UMTRI Study)

Among these light vehicle fatal crashes, 121 result in PCI among which 51 percent occur in impacts with trailers with guards, 19 percent in impacts with SUTs without guards, 7 percent with SUTs with guards, 6 percent with wheels back trailers, and 3 percent with excluded trailers (Figure 7).[46] Annually, there are 62 light vehicle impacts with PCI into the rear of trailers with

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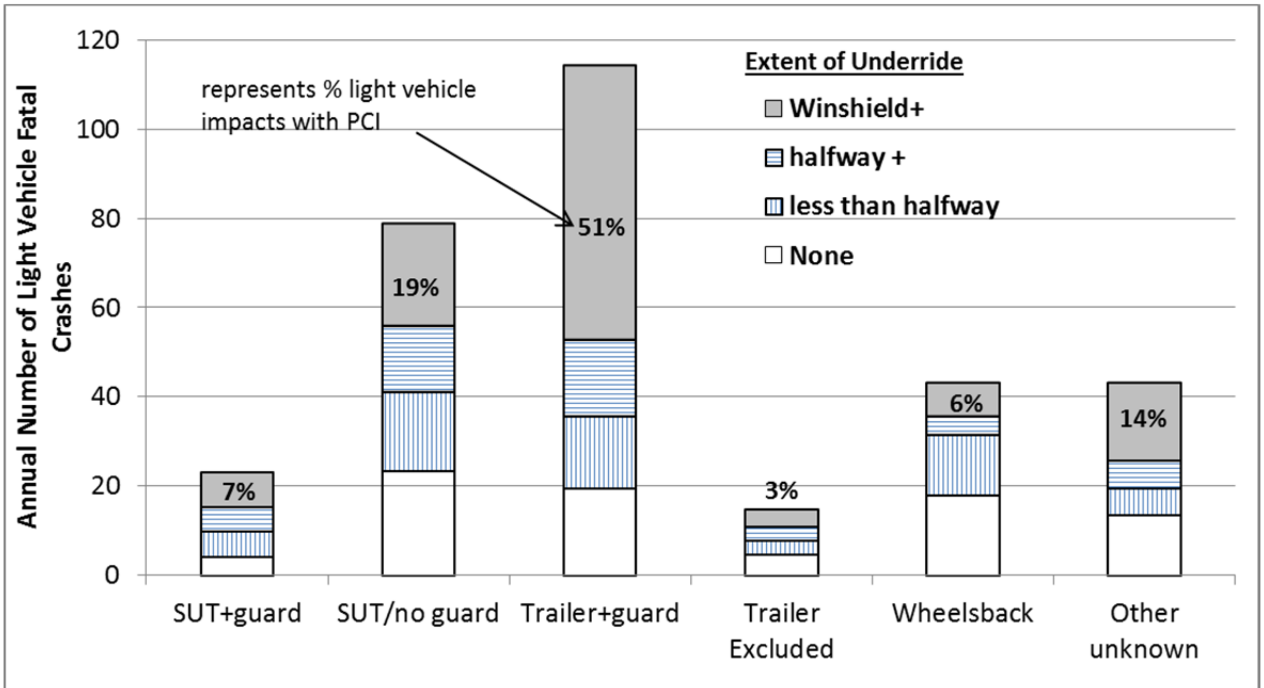
"underride extent at or more than halfway up the hood but short of the base of the windshield"; windshield+ means "extent of underride at or beyond the base of the windshield" or PCI.

[46] Underride extent was determined for 303 light vehicles, about 95 percent of the 319 light vehicle impacts into the rear of trucks and trailers. Unknown underride extent was distributed among known underride levels.

guards, 11 into the rear of trailers that are excluded from requiring rear impact guards (wheels back, low chassis, type of cargo or operation), 8 into the rear of SUTs with guards, 23 into the rear of SUTs without guards, and 18 into the rear of trailers and trucks of unknown configuration (Figure 7).



	Light vehicle fatal crashes into the rear of trailers & SUTs		Light vehicle fatal crashes into the rear of trailers & SUTs resulting in PCI	
	Annual #	Percentage	Annual #	Percentage
SUT+guard	24	7%	8	7%
SUT/no guard	79	25%	23	19%
Trailer+guard	115	36%	62	51%
Trailer Exempt	15	5%	4	3%
Wheelsback	44	14%	7	6%
Other unknown	44	14%	18	14%
Total	319		121	

Figure 7: Annual light vehicle fatal crashes into the rear of trailers and SUTs by type of truck/trailer and extent of underride

It is noteworthy that trailers with guards represent 36 percent of annual light vehicle fatal rear impacts but represent 51 percent of annual light vehicle fatal rear impacts with PCI. On the other hand, SUTs (with and without guards) represent 32 percent of annual light vehicle fatal rear impacts but represent 26 percent of annual light vehicle fatal rear impacts with PCI. The field data suggests that there are more light vehicle fatal impacts into the rear of trailers than SUTs and a higher percentage of fatal light vehicle impacts into the rear of trailers result in PCI than those into the rear of SUTs.

E. Relative Speed of Light Vehicle Fatal Crashes into the Rear of Trailers and SUTs

Using information derived by reviewing police crash reports,[47] UMTRI estimated the relative speed of fatal light vehicle crashes into the rear of trucks and trailers. Relative velocity was computed as the resultant of the difference in the truck (trailer) velocity and the striking vehicle velocity and could only be estimated for about 30 percent of light vehicle fatal crashes into the rear of trailers and SUTs. Most of the crashes (with known relative velocity) were at very high speeds and many were unsurvivable. The mean relative velocity at impact into the rear of trailers and SUTs was estimated at 44 mph. Among fatal light vehicle impacts into the rear of trailers that resulted in PCI, 74 percent were with relative velocity greater than 56 km/h (35 mph) (Figure 8). Among the remaining 26 percent fatal light vehicle impacts into the rear of trailers, 21 percent were trailers with guards and 5% were trailers excluded from FMVSS No. 224 requirements. Among fatal light vehicle impacts into the rear of SUTs that resulted in PCI, 70 percent were with relative velocity greater than 56 km/h (35 mph). Among the remaining 30 percent fatal light vehicle impacts into the rear of SUTs, 3 percent of the SUTs had rear impact

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[47] Information included police estimates of travel speed, crash narrative, crash diagram, and witness statements. The impact speed was estimated from the travel speed, skid distance, and an estimate of the coefficient of friction.

guards, 10 percent of the SUTs could be required to have a guard based on rear geometry but did not have a guard, 3 percent were excluded from requiring a guard (wheels back, low chassis vehicles), and 14 percent had equipment in the rear precluding rear impact guards.

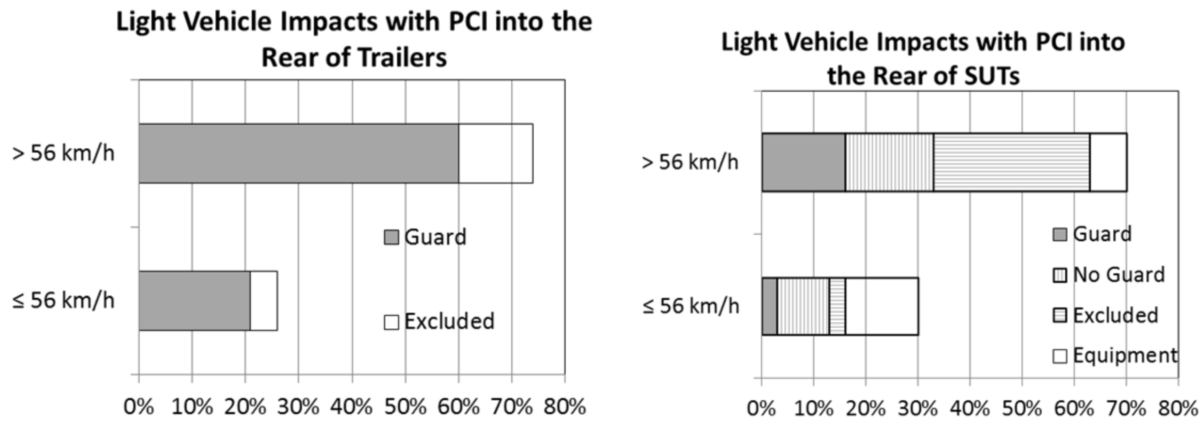
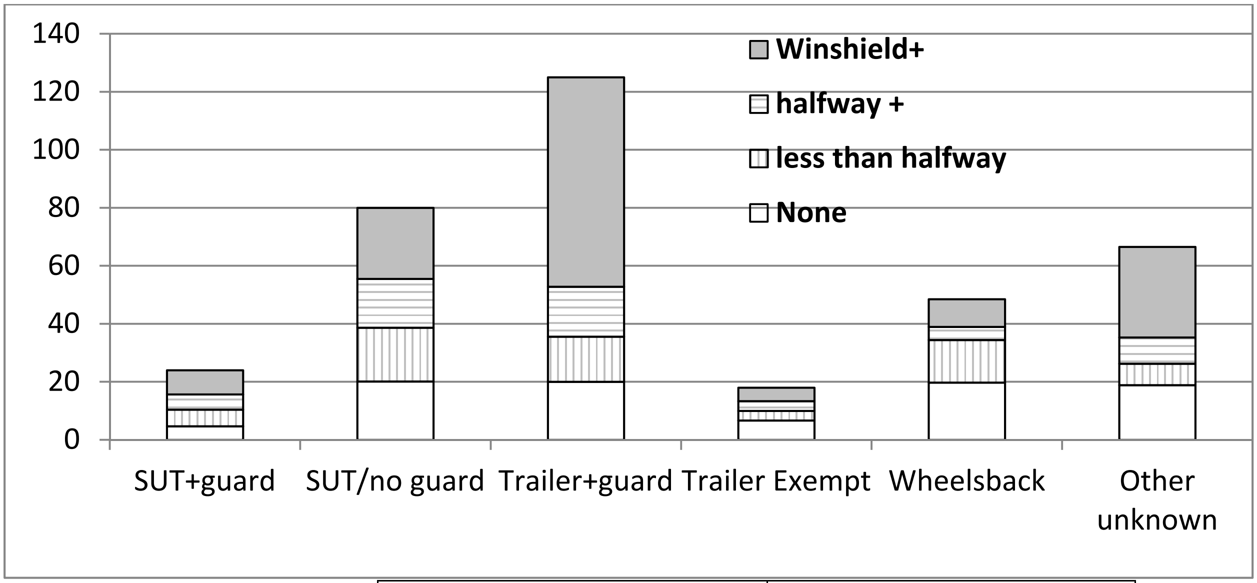


Figure 8: Percentage of fatal light vehicle crashes into the rear of trailers and SUTs that resulted in passenger compartment intrusion - categorized by the relative speed of the crash, presence of rear impact guard, exclusion, and equipment in rear of vehicle

F. Fatalities Associated with Light Vehicle Crashes into the Rear of Trailers and SUTs

There are about 362 light vehicle occupant fatalities annually due to impacts into the rear of trailers and SUTs. Of these fatalities, 192 (53 percent) are in impacts with trailers, 104 (29 percent) are in impacts with SUTs, and 66 (18 percent) are unknown truck type (Figure 9). Among the 192 light vehicle occupant fatalities resulting from impacts with the rear of trailers, 125 occurred in impacts with trailers with rear impact guards while the remaining 67 were in impacts to trailers without guards (trailers excluded from requiring rear impact guards). PCI was associated with 86 annual light vehicle occupant fatalities resulting from impacts into the rear of trailers; 72 of these fatalities were in impacts with trailers with rear impact guards and 14 with trailers without guards (see Figure 9).

Among the 104 light vehicle occupant fatalities resulting from impacts with the rear of SUTs, 80 occurred in impacts with SUTs without rear impact guards while the remaining 24 were in impacts to SUTs with guards. PCI was associated with 33 annual light vehicle occupant fatalities resulting from impacts into the rear of SUTs; 25 of these fatalities were in impacts with SUTs without rear impact guards and 8 with SUTs with guards (see Figure 9).



	Light vehicle fatalities in crashes into the rear of trailers & SUTs		Light vehicle fatalities in PCI crashes into the rear of trailers & SUTs	
	Annual #	Percentage	Annual #	Percentage
SUT+guard	24	7%	8	7%
SUT/no guard	80	25%	25	21%
Trailer+guard	125	39%	72	59%
Trailer Exempt	18	6%	5	4%
Wheels back	48	15%	9	7%
Other unknown	67	21%	31	26%
Total	362		150	

Figure 9: Annual light vehicle occupant fatalities in impacts into the rear of SUTs and trailers categorized by the geometry of the rear of the impacted vehicle and the extent of underride

Among light vehicle occupant fatalities in impacts into the rear of trailers and SUTs, more than 60 percent were in vehicles with no underride, underride less than halfway or underride up to the hood without PCI. It is likely these fatalities are occurring due to occupants being unrestrained, other occupant characteristics (e.g. age), and other crash circumstances. Additionally, as shown in Figure 8, only 26 percent and 30 percent of light vehicle impacts with PCI into the rear of trailers and SUTs, respectively, had a relative velocity less than or equal to 56 km/h (35 mph). Since currently manufactured light vehicles are tested to ensure adequate occupant crash protection to restrained dummies in a 56 km/h (35 mph) rigid barrier frontal crash test, light vehicle occupant fatalities in impacts into the rear of trucks and trailers at speeds less than or equal to 35 mph that resulted in PCI may be preventable if intrusion into the passenger compartment was mitigated.[48]

[48] Some of the fatalities associated with PCI shown in Figure 6 may also be due to unrestrained status of the occupant.

VI. BENEFITS

For estimating the benefits of requiring applicable trailers to be equipped with CMVSS No. 223 certified guards, NHTSA estimated the annual number of fatalities and injuries in light vehicle crashes with PCI into the rear of trailers. In non-PCI crashes into the rear of trailers, the IIHS test data indicate that the passenger vehicle's restraint system, when used, would mitigate injury. Therefore, non-PCI crashes were not considered as part of the target population for estimating benefits.

<u>Fatal injuries</u>: Annually, there are 72 light vehicle occupant fatalities in crashes into the rear of trailers with rear impact guards with PCI. About 26 percent of fatal light vehicle crashes into the rear of trailers is at speeds 56 km/h (35 mph) or less. The agency estimates that 19 fatalities (=72 x0.26) are in crashes with relative velocity of 56 km/h (35 mph) or less. CMVSS No. 223 guards may not be able to mitigate all fatalities in crashes into the rear of trailers with relative velocity of 56 km/h or less because some crashes may be low overlap (30 percent or less) and some fatalities may be due to circumstances other than underride (i.e. unrestrained status of occupants, elderly and other vulnerable occupants). For the purpose of this analysis, NHTSA assumed that the incremental effectiveness of CMVSS No. 223 compliant guards over FMVSS No. 223 compliant guards in preventing fatalities in light vehicle impacts with PCI into the rear of trailers with crash speeds less than 56 km/h is 50 percent. Since only 26 percent of light vehicle crashes with PCI into the rear of trailers are at relative velocity less than or equal to 56 km/h, NHTSA estimated the overall effectiveness of upgrading to CMVSS No. 223 compliant guards to be 13 percent (=26% x 50%)

The target population of fatalities considered is representative of fatalities occurring in light vehicle crashes into the rear of trailers that result in PCI. As noted above, in estimating benefits, the agency assumed that the upgraded rear impact guards would mitigate fatalities and injuries in light vehicle impacts with PCI into the rear of trailers at impact speeds up to 56 km/h (35 mph), since the requirements of CMVSS No. 223 are intended to prevent PCI in impacts with speeds up to 56 km/h (35 mph). We recognize, however, that benefits may accrue from underride crashes at speeds higher than 56 km/h (35 mph), if, e.g., a vehicle's guard exceeded the minimum performance requirements of the FMVSS. NHTSA requests information that would assist the agency in quantifying the possible benefits of CMVSS No. 223 rear impact guards in crashes with speeds higher than 56 km/h (35 mph).

We note also that, while CMVSS No. 223 requirements are intended for mitigating PCI in light vehicle rear impacts at speeds less than or equal to 56 km/h (35 mph), CMVSS No. 223 certified rear impact guards may not be able to mitigate all fatalities in such crashes because some of the crashes may be low overlap (30 percent or less)[59] and because some fatalities are not as a result of PCI but are due to other circumstances (e.g. unrestrained status of occupants, elderly occupants) in which improved rear impact guards may not have prevented the fatalities.

The agency estimates that 93 percent of new trailers are already equipped with CMVSS No. 223 compliant guards. Assuming 13 percent effectiveness of these guards in fatal crashes with PCI into the rear of trailers, the agency estimates that about 0.66 life (= 72 x (1-0.93) x 0.13, rounded) would be saved annually by requiring all applicable trailers to be equipped with CMVSS No. 223 compliant guards.

<u>Serious Injuries</u>: According to the NASS CDS 1999-2006 data, there were a total of 22,251 front seat occupants with first row intrusion in front to rear end crashes where passenger vehicles underride the rear of a large truck with trailer. In addition, the data show that a total of 19,227 front seat occupants without first row intrusion. To estimate the benefits of Canadian standard compliant underride guards, we will first estimate the impact of shifting from a fleet with 100% FMVSS compliant guards to one with 100% Canadian standard compliant guards. This requires estimating a target population that reflects only FMVSS compliant underride guards. For this purpose, we have used data from the period 1999-2006. The Canadian standard became effective in 2007. Therefore, from 2007 forward a substantial portion of the on-road vehicle fleet would have underride guards that meet this standard. It is also likely that some portion of the on-road fleet had guards that met the Canadian standard prior to 2007 as manufacturers anticipated the standard and initiated production, but we do not have data to determine the actual transition experience of the on road fleet. To the extent that there were already Canadian standard compliant underride guards in the on-road fleet prior to 2007, their presence would have reduced the target population. Therefore, our assumption that the 1999-2006 fleet represents an injury profile for a fleet with FMVSS compliant underride guards provides a conservative estimate of the potential target population for such a fleet.

Table 16: NASS CDS 1999-2006, front seat occupants with first row intrusion in front to rear end crashes where passenger vehicles underride the rear of a large truck with trailer

Intrusion "Yes"	No injury	MAIS 1	MAIS 2	MAIS 3	MAIS 4	MAIS 5	Total
No.	7,173	11,114	2,082	635	757	490	22,251
Row %	32.24%	49.95%	9.36%	2.85%	3.40%	2.20%	n/a
Est. %	41.79%	21.86%	11.43%	5.98%	3.13%	1.64%	85.83%
Adj. est%	**48.69%**	**25.47%**	**13.32%**	**6.97%**	**3.65%**	**1.91%**	100.00%
Adj. est. no.	10,834	5,667	2,964	1,551	811	424	22,251

Table 17: NASS CDS 1999-2006, front seat occupants without first row intrusion in front to rear end crashes where passenger vehicles underride the rear of a large truck with trailer

Intrusion "No"	No injury	MAIS 1	MAIS 2	MAIS 3	MAIS 4	MAIS 5	Total
No.	12,127	5,852	981	175	113	29	19,277
Row %	62.91%	30.36%	5.09%	0.91%	0.59%	0.15%	n/a
Est. %	69.00%	19.77%	5.66%	1.62%	0.46%	0.13%	96.65%
Adj. est%	**71.39%**	**20.45%**	**5.86%**	**1.68%**	**0.48%**	**0.14%**	100.00%

The potential injury benefits would be realized when the total injuries (22,251) in the "intrusion" crashes are redistributed with the injury distribution of the "non-intrusion" crashes. The difference in injury counts would be the potential injury benefits.

Table 18: Redistribute of First row intrusion and Potential benefits without additional adjustment

Parameter	No injury	MAIS 1	MAIS 2	MAIS 3	MAIS 4	MAIS 5	Total
W/ intrusion, est.	10,834	5,667	2,964	1,551	811	424	22,251
Adj. est. (%)	71.39%	20.45%	5.86%	1.68%	0.48%	0.14%	100.00%
W/o intrusion	15,885	4,551	1,304	374	107	31	22,251
Benefits	-5,051	1,116	1,660	1,177	704	394	0

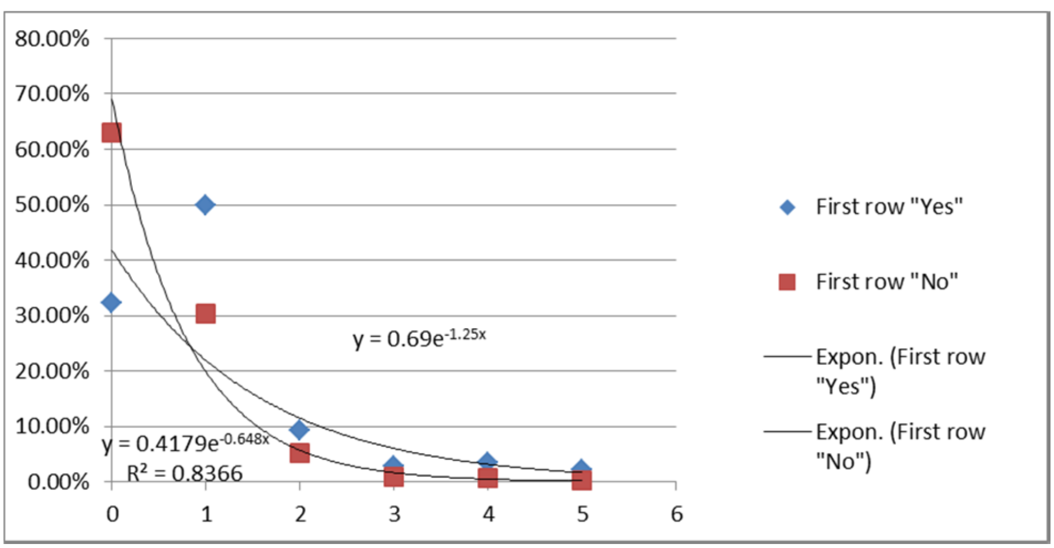


Figure 8. Injury distribution with and without intrusion, front row

Since Canadian standard underride guards would be effective in preventing intrusion at a delta-V of 35 mph or less whereas FMVSS compliant guards would be effective in preventing intrusion at a delta-V of 30 mph or less, we only considered crash at a delta-V range of 30 to 35 mph. According to the NASS CDS 2006-2008 data where front seat occupants of light vehicles that rear-end a vehicle, 32% of seriously injured occupants were in a delta-V range of 30 to 35mph.[49] In addition, the injury benefits were further adjusted with number of years in the CDS data, exemption status of trailers and compliance rate.

Table 19: Number of Injuries Adjusted with Delta-V Range of 30 - 35 mph

Benefits	MAIS 3	MAIS 4	MAIS 5
Benefits, all Delta-V's	1,177	704	394
Benefits, 30 – 35 mph	373	223	125

Table 20: Additional Adjustments for Injury Benefit Estimate

No. of years in the CDS data[50]	8
Exemption rate	35%
Compliance rate	93%
Non-exempted trailers	65%
Adjustment factor*	0.57%

*Adjustment factor = (1-exemption rate) x (1-compliance rate) / number of data years

With the additional adjustments, we estimated that a total of 4.1 serious injuries would be prevented annually with the proposed underride guard rule.

Table 21: Adjusted injury benefits, no discount, considering only serious injuries

Benefits	MAIS 3	MAIS 4	MAIS 5	Total
Benefits, 30 – 35 mph	373	223	125	721
Adjusted injury benefits	2.1	1.3	0.7	4.1

In summary, the proposed rule would save 0.66 life and 4.1 serious injuries annually.

[49] Due to limited data, the struck vehicle includes all vehicles including heavy trucks. In the crashes, the front of a passenger vehicle (the striking vehicle), which was going straight in a travel lane, strikes a motor vehicle (the struck vehicle) that was stopped or going straight in the same lane and direction as the striking vehicle and the struck vehicle driver did not steer to try to avoid the crash.

[50] NASS CDS 1999-2006

VII. COSTS AND LEADTIME

A. CMVSS Compliant Rear Guard Upgrade Impact

The agency conducted a study to develop cost and weight estimates for rear impact guards on heavy trailers.[51] In this study, the agency estimated the cost and weight of FMCSR 393.86(b) compliant rear impact guards, FMVSS No. 223 compliant rear impact guards, and CMVSS No. 223 compliant rear impact guards as shown in Table 15. All costs are presented in 2013 dollars.

In estimating the cost and weight of guards, an engineering analysis of the guard system for each trailer was conducted, including material composition, manufacturing and construction methods and processes, component size, and attachment methods. However, the researchers did not take into account the construction, costs, and weight changes in the trailer structure in order to withstand loads from the stronger guards. A limitation of this analysis is the fact that the authors did not evaluate the changes in design of the rear beam, frame rails, and floor of the trailer when replacing a rear impact guard compliant with FMCSR 393.86(b) with an FMVSS No. 224 compliant guard and then to a CMVSS No. 223 compliant guard.

The average cost of four Canadian compliant rear impact guards is $492 which is $229 more than an FMVSS No. 224 compliant guard. In comparing the Great Dane rear impact guards, the 2012 Great Dane guard (CMVSS No. 223 compliant) is $81.19 more expensive than the 2001 Great Dane guard (FMVSS No. 223 compliant).

[51] Cost and weight analysis for rear impact guards on heavy trucks, Docket No. NHTSA-2011-0066-0086, June 2013.

Table 22: Cost (2013 dollars) and weight of different types of rear impact guards

Type of Rear Impact Guard	Trailer Model Year/Make	*Guard Assembly*	*Installation Cost*	*Total Cost*	Weight (lb)
FMCSR 393.86(b)	*1993 Great Dane*	$65.31	$41.92	$107.23	78
FMVSS No. 224	*2001 Great Dane*	$153.22	$109.75	$262.86	172
CMVSS No. 223	*2012 Great Dane*	$191.17	$153.25	$344.05	193
	2012 Manac	$302.05	$248.74	$550.08	307
	2012 Stoughton	$248.02	$222.37	$470.91	191
	2012 Wabash	$447.05	$155.21	$601.84	243

The incremental cost of equipping CMVSS No. 223 compliant rear impact guards on applicable new trailers (those that are required to be equipped with FMVSS No. 223 compliant rear impact guards) is $229. There are 243,873 trailers sold in 2013[52] among which 65 percent (see Table 17) are required to be equipped with rear impact guards, of which 93 percent are already equipped with CMVSS No. 223 compliant guards. The annual incremental fleet cost of equipping all applicable trailers with CMVSS No. 223 rear impact guards is approximately $2.5 million (=243,873x0.65x(1.0-0.93)x229).

Table 23: Cost per Trailer and Total Cost (Cost in 2013 dollars)

CMVSS Guard	FMVSS Guard	Difference in Cost per Guard	% of Trailers That Requires Guard	Non Compliance	Total Number of Trailers Sold	Applicable Trailers	Total Incremental cost
$491.72	$262.86	$228.86	65%	7%	243,873	11,096	$2,539,481

52 http://trailer-bodybuilders.com/trailer-output/2014-trailer-production-figures-table

B. Fuel Economy Impact

The average weight of 4 Canadian compliant guards is estimated to be 233.5 pounds and the single FMVSS compliant guard (2001 Great Dane) is estimated to be 172 pounds as shown in Table 15. Upgrading from the FMVSS compliant guard to the CMVSS compliant guard would add an incremental weight of 48.9 pounds to the FMVSS compliant guard, thereby reducing the overall fuel economy during the lifetime of heavy trucks. So for the fuel cost analysis, the increase in weight due to equipping a Canadian compliant guard is estimated 48.9 pounds per vehicle.

Table 24: Average Weight of Underride Guards

Make	standard	weight (lbs)	Sales, 2013	Weighted sales	Weighted average weight
2001 great dane	FMVSS	172	--	n/a	n/a
2012 great dane	FMVSS/CMVSS	193	44,000	40.52%	78
2012 manac	FMVSS/CMVSS	307	6,600	6.08%	19
2012 stoughton	FMVSS/CMVSS	191	12,000	11.05%	21
2012 wabash	FMVSS/CMVSS	243	46,000	42.36%	103
Total			108,600	100%	221

Table 25: Average Increase in Weight, CMVSS (Canadian) and FMVSS Guards

average weight of cmvss guard (lbs.)	233.5
maximum weight increase:	135
average weight increase (lbs)	48.9
minimum weight increase(lbs)	19

A standard formula for estimating the impact of marginal weight increases on fuel economy is:

(Base vehicle weight/[vehicle weight + added weight])^0.8 * Baseline fuel economy

This formula is based on light vehicle data however it is the best available method for estimating changes in fuel economy due to weight increases at this time. Assuming that it does apply, we can estimate the impact that a weight increase would have on fuel economy. First, we assume that the average in-use weight of a loaded heavy truck is estimated to be 55,000 pounds. Second, the average baseline miles per gallon (mpg) of a heavy truck is estimated to be 5.8 mpg.[53] Third, the projected price of diesel fuel was taken from reference case of the Annual Energy Outlook in 2013 dollars starting in 2017, the assumed effectiveness year in this Preliminary Regulatory Evaluation. The analysis uses a 3 percent and a 7 percent discount rate.

Adding 48.9 pounds changes the average fuel economy of that vehicle from 5.8 mpg to 5.7959 mpg. Over the life time of a heavy truck, the vehicle would use 418,545 gallons at 5.8 mpg and would use 418,843 gallons at 5.7959 mpg, so adding 48.9 pounds results in 298 additional gallons of diesel fuel used per vehicle for the life time of a vehicle. The estimated impact on a year to year basis is shown in Table 26.

[53] U.S. Department of Transportation Federal Highway Administration, Office of Highway Policy Information, Highway Statistics Series, http://www.fhwa.dot.gov/policyinformation/statistics/2012/vm1.cfm

Table 26: Undiscounted Value of Lifetime Fuel Economy Impact Per Vehicle in 2013 dollars

*The survival rate is based on heavy truck data

Year	Survival Probability	Exposure VMT	Aggregate Exposure	Fuel Price	Fuel Economy		Fuel Consumption		Value of Fuel Consumption	
					base	new	base	new	base	new
1	1	240,737	240,737	$3.55	5.8	5.7959	41,506	41,536	147,316	147,421
2	0.993	226,110	224,527	$3.59	5.8	5.7959	38,712	38,739	138,840	138,939
3	0.981	212,378	208,343	$3.66	5.8	5.7959	35,921	35,947	131,630	131,724
4	0.9642	199,486	192,344	$3.73	5.8	5.7959	33,163	33,186	123,584	123,672
5	0.9432	187,381	176,738	$3.80	5.8	5.7959	30,472	30,494	115,685	115,767
6	0.9181	176,017	161,601	$3.87	5.8	5.7959	27,862	27,882	107,900	107,977
7	0.8894	165,346	147,059	$3.93	5.8	5.7959	25,355	25,373	99,534	99,605
8	0.8575	155,327	133,193	$3.98	5.8	5.7959	22,964	22,981	91,317	91,382
9	0.823	145,919	120,091	$4.04	5.8	5.7959	20,705	20,720	83,572	83,632
10	0.786	137,085	107,749	$4.08	5.8	5.7959	18,577	18,591	75,874	75,928
11	0.7473	128,789	96,244	$4.14	5.8	5.7959	16,594	16,606	68,761	68,810
12	0.7071	120,999	85,558	$4.18	5.8	5.7959	14,751	14,762	61,638	61,682
13	0.666	113,683	75,713	$4.23	5.8	5.7959	13,054	13,063	55,157	55,196
14	0.6244	106,813	66,694	$4.27	5.8	5.7959	11,499	11,507	49,063	49,098
15	0.5826	100,360	58,470	$4.32	5.8	5.7959	10,081	10,088	43,512	43,543
16	0.5411	94,300	51,026	$4.37	5.8	5.7959	8,798	8,804	38,431	38,458
17	0.5003	88,609	44,331	$4.42	5.8	5.7959	7,643	7,649	33,809	33,833
18	0.4604	83,263	38,334	$4.50	5.8	5.7959	6,609	6,614	29,710	29,731
19	0.4217	78,242	32,995	$4.53	5.8	5.7959	5,689	5,693	25,791	25,809
20	0.3845	73,526	28,271	$4.58	5.8	5.7959	4,874	4,878	22,307	22,323
21	0.349	69,096	24,115	$4.61	5.8	5.7959	4,158	4,161	19,169	19,182
22	0.3152	64,935	20,468	$4.65	5.8	5.7959	3,529	3,531	16,415	16,427
23	0.2835	61,026	17,301	$4.72	5.8	5.7959	2,983	2,985	14,086	14,096
24	0.2537	57,354	14,551	$4.80	5.8	5.7959	2,509	2,511	12,046	12,055
25	0.226	53,905	12,183	$4.84	5.8	5.7959	2,100	2,102	10,156	10,163
26	0.2004	50,664	10,153	$4.87	5.8	5.7959	1,751	1,752	8,523	8,529
27	0.1769	47,620	8,424	$4.90	5.8	5.7959	1,452	1,453	7,121	7,126
28	0.1554	44,759	6,956	$4.94	5.8	5.7959	1,199	1,200	5,921	5,925
29	0.1359	42,072	5,718	$4.97	5.8	5.7959	986	986	4,901	4,905
30	0.1183	39,547	4,678	$5.01	5.8	5.7959	807	807	4,039	4,041
31	0.1025	37,175	3,810	$5.04	5.8	5.7959	657	657	3,312	3,315
32	0.0884	34,945	3,089	$5.08	5.8	5.7959	533	533	2,704	2,706
33	0.0759	32,851	2,493	$5.11	5.8	5.7959	430	430	2,198	2,199
34	0.0649	30,883	2,004	$5.15	5.8	5.7959	346	346	1,779	1,780
35	0.0552	29,033	1,603	$5.18	5.8	5.7959	276	277	1,433	1,434
Total			2,427,562				418,545		1,657,237	1,658,415

Table 27 shows the estimated incremental weight increase and the impact on fuel cost per vehicle at the 3 percent and 7 percent discount rate.

Table 27: Present Discounted Value of Increased Lifetime Fuel Costs per Vehicle (in 2013 dollars)

Impact Guard	Weight Increase (lb), avg.	Fuel Economy (mpg)		Incremental Increase in Lifetime Fuel Costs		
		Base	New	Undiscounted	3%	7%
Upgrade From FMVSS To CMVSS	48.9	5.8	5.7959	$1,178.30	$1,042.21	$927.68

The total fuel costs depend on the incremental weight increase and the discount rate applied. These are derived by taking the vehicle lifetime fuel cost in Table 26 and multiplying by the number of applicable vehicles.[54] In addition, we adjusted with the estimate fuel cost with the 93% compliance and 35% exemption rates.

Table 28: Unit Incremental Fuel Cost per Vehicle, in 2013 dollars

Adjustment	Not discounted	3%	7%
w/o adjustment	$1,178.30	$1,042.21	$927.68
w/ adjustment	$53.61	$47.42	$42.21

With 194,715 Class annual production, the total fuel cost was estimated to be $9.23 million and $8.22 million discounted at 3% and 7%, respectively, as shown in Table 29.

Table 29: Total Incremental Fuel Costs (2013 Dollars) in Millions

Impact Guard	Costs per Vehicle		Number of Applicable Vehicles	Total Incremental Increase Lifetime Fuel Costs		
	3%	7%		Undiscounted	3%	7%
Upgrade From FMVSS To CMVSS	$47.42	$42.21	194,715	$10.44	$9.23	$8.22

[54] From Ward's Automotive Yearbook 2014 Ward's Automotive Group ISBN Number 978-0-910589-31-4 U.S. Truck Sales by GVW by Month, 2012 page 207

VIII. COST EFFECTIVENESS AND BENEFIT-COST

This chapter provides cost-effectiveness and benefit-cost analysis of the proposed trailer underride guard requirements. The Office of Management and Budget (OMB) requires all agencies to perform cost-effectiveness and benefit-cost analyses in support of rules, effective January 1, 2004.[55]

Cost-effectiveness measures the net cost per equivalent life saved (i.e., per equivalent fatality), while benefit-cost measures the net benefit, which is the difference between benefits and net costs in monetary values. Injury benefits are expressed as fatal equivalents in cost-effectiveness analysis and are further translated into monetary value in benefit-cost analysis. Fatal equivalents represent the savings throughout the vehicle's lifetime and are discounted to reflect their present values (2013 dollars).

A. Fatal Equivalents

To calculate a cost per equivalent fatality, nonfatal injuries must be expressed in terms of fatalities. This is done by comparing the values of preventing nonfatal injuries to the value of preventing a fatality. Value of Statistical Life (VSL) is used to determine the relative ratio of nonfatal injuries to fatalities (i.e., relative injury factor). VSL measurements inherently include a value for lost quality of life plus a valuation of lost material consumption that is represented by measuring consumers' after-tax lost productivity. The societal economic costs including medical care, emergency services, insurance administrative costs, workplace costs, and legal costs were

[55] See OMB Circular A-4.

treated as part of savings that would reduce the regulatory costs. Therefore, societal economic costs were excluded from the determination of the relative injury factors. Table 30 shows the relative injury factors.

Table 30: Relative Injury Factor*

Injury	MAIS 1	MAIS 2	MAIS 3	MAIS 4	MAIS 5	Fatality
Factor	0.0030	0.0470	0.1050	0.2660	0.5930	1.000

* Source: Appendix B

Fatal equivalents are derived by applying the relative injury factor shown in Table 30 to the estimated injury benefits. As discussed earlier, benefits are realized throughout a vehicle's life. Thus, fatal equivalents are required to be discounted at 3 and 7 percent. Table 31 shows the undiscounted and discounted fatal equivalents examined in the benefit chapter.

As shown, undiscounted, the proposed rule would save 1.6 fatal equivalents when all applicable trailers are equipped with the proposed underride guards. At a 3 percent discount rate, the proposed rule would save 1.4 fatal equivalents. At a 7 percent discount rate, the proposed rule would save 1.3 fatal equivalents.

Table 31: Equivalent lives saved (ELS), Tractor Truck Trailer Underrides

Inj. Level	Rel. Val. per Inj.	Total ELS		
		No discount	3%	7%
		1.0000	0.8845	0.7873
MAIS3	0.1050	0.2228	0.1970	0.1754
MAIS4	0.2660	0.3376	0.2986	0.2685
MAIS5	0.5930	0.4207	0.3721	0.3312
Fatal	1.0000	0.6552	0.5795	0.5158
Total		1.6362	1.4472	1.2882
Total, rounded		1.6	1.4	1.3

B. Cost-Effectiveness

The cost-effectiveness analysis derives the net cost per equivalent life saved which is equal to the net cost divided by the total fatal equivalents. The net cost of the proposed rule would be the regulatory cost minus the societal economic savings. Table 34 shows the cost effectiveness.

Table 32: Societal economic benefits (in Millions of 2013 dollars)

			No-discount	3%	7%
Injury	No.	Value	1.0000	0.8845	0.7873
MAIS 3	2	$157,649	$0.33	$0.30	$0.26
MAIS 4	1	$364,748	$0.46	$0.41	$0.36
MAIS 5	1	$956,960	$0.68	$0.60	$0.53
Fatal	0.6552	$1,159,136	$0.76	$0.67	$0.60
Total			$2.24	$1.98	$1.76

Table 33: Net cost (in Millions of 2013 dollars)

	No-discount	3%	7%
Total cost	$12.98	$11.77	$10.76
Societal benefits	$2.24	$1.98	$1.76
Net Cost	$10.74	$9.80	$9.00

Table 34: Net Costs per ELS*(Millions of 2013 dollars)

Net cost ELS	No-discount	3%	7%
Net Cost	$10.74	$9.80	$9.00
ELS	1.6362	1.4299	1.2574
Net Cost per ELS	$6.57	$6.85	$7.16

* Net costs = Regulatory cost – Societal economic savings

C. Net Benefits

Benefit-cost analysis derives the net benefits which is the difference between the injury benefits and the net costs of the rule in monetary values. Thus, benefit-cost analysis differs from cost-effectiveness analysis in that it requires that benefits be assigned a monetary value, and that this value be compared to the net cost to derive a net benefit.

Table 35 summarizes the net benefits of the proposed rule. As shown, at a 3 percent discount rate, the net benefits of the proposed rule would be $3.52 million. At a 7 percent discount rate, the net benefits of the proposed rule would be $2.85 million in 2013 dollars.

Table 35: Net Benefits* (in Millions of 2013 dollars)

Benefit and Cost	No-discount	3%	7%
VSL benefit	$15.05	$13.31	$11.85
Net Cost	$10.74	$9.80	$9.00
Net Benefit	$4.31	$3.52	$2.85

D. Summary

Table 36 summarizes the regulatory cost and net benefit statistics of the proposed rule at the 3 and 7 discount rates. The proposed rule is cost beneficial with $3.52 million and $2.85 million net benefits at 3% and 7%, respectively.

Table 36: Cost-Effectiveness and Net Benefits (2013 dollars), in million

Discount	Regulatory cost	Societal Economic Savings	VSL savings	Total benefits	Net benefits
3%	$11.77	$1.98	$13.31	$15.29	$3.52
7%	$10.76	$1.76	$11.85	$13.61	$2.85

* Costs are not discounted, since they occur at the time of purchase, whereas benefits occur over the vehicle’s lifetime and are discounted back to the time of purchase.
(1) Total Benefit = Societal Economic Benefit + VSL Benefit
(2) Net Benefit = Total Benefit – Regulatory Cost

IX. SENSITIVITY ANALYSIS

This chapter discusses the change in costs and benefits that result from different assumptions used in the analysis. When inputs that affect the analysis are uncertain, the agency makes its best judgment about the probable values or range of values that will occur. This analysis will examine alternatives to these selections to illustrate how sensitive the results are to the values initially selected. This process involves altering input values and interpreting and presenting the results. This is helpful not only because of the uncertainty inherent in estimations and predictions but also it provides insight into values chosen to represent abstract concepts.

In the fatal benefit analysis, we assumed that the proposed underride guard would be 50% effective in preventing fatalities at a delta-V of 35 mph or less. In this sensitivity chapter, in addition to the 50% assumed effectiveness, we examined 0% and 100% effectiveness as lower and upper ranges in fatal crashes. The sensitivity analysis shows that the proposed rule would not be cost effective when we assume that the enhanced underride guards (i.e., Canadian standard compliant guards) provide no additional occupant protections over FMVSS compliant guards in fatal crashes (i.e., 0% effective).

Table 37: Net Cost, Net Benefit and Net Cost per ELS with 0%, 50% and 100% Fatal Effectiveness (in Millions of 2013 dollars)

Parameter	3%			7%		
Fatal Effectiveness	0%	50%	100%	0%	50%	100%
Net cost	$10.47	$9.80	$9.12	$9.60	$9.00	$8.40
Net Cost per ELS	$12.06	$6.77	$4.50	$12.42	$6.99	$4.66
Net Benefit	-$1.18	$5.50	$12.17	-$1.33	$4.61	$10.55

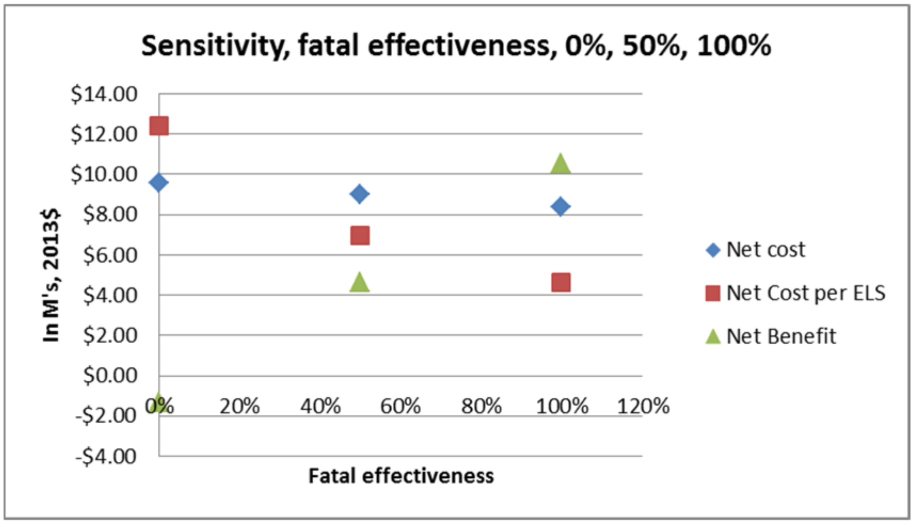


Figure 9. Net cost, Net cost per ELS and Net benefit with 0%, 50% and 100% Fatal Effectiveness

X. ALTERNATIVES

As an alternative to requiring only new underride guards, we analyzed the cost effectiveness and the practicability of retrofitting a Canadian standard compliant guard for current trailers. For the analysis, these trailers were assumed to be equipped with a guard compliant with FMVSS.

Costs: In the costs chapter, we included the lifetime fuel cost for equipping a Canadian standard compliant guard on trailers. However, for simplicity, will not include the lifetime fuel cost for retrofitting a Canadian compliant guard on trailers in this retrofitting analysis.

The average estimated cost of 4 Canadian standard compliant guards is $492 which is $229 more than a FMVSS compliant guard (2001 Great Dane rear impact guard). With the incremental cost of $229 without considering labor costs involved in retrofitting, if all trailers meet the Canadian standard by 2007, it is possible to determine what percentage of trailers would need to be retrofit in a particular year[56]. For the retrofit analysis, we assume that all applicable trailers[57] manufactured since 2007 meet the Canadian standard. We also assume that all applicable trailers manufactured prior to 2007 comply with FMVSS and do not comply with the Canadian standard.

It is estimated that the total number of trailers manufactured prior to 2007 is approximately 3,402,300, of which 65% are required to be equipped with a rear impact guard. There is an estimated 2,211,495 trailers that are required to be equipped with a FMVSS compliant guard in 2017. Thus the total cost of retrofitting a Canadian standard compliant guard on the 2,211,495 trailers is estimated to be approximately $506 million ($506,432,391).

[56] MY2017, assumed effective year of the proposal
[57] Applicable trailers are those that are required to be equipped with a FMVSS compliant guard and account for 65% of all trailers.

Table 38: Cost for Retrofitting, in 2013 dollars

1974 to 2006 sales on road in 2017	3,402,300
percent of trailers with a required guard	0.65
trailers that need to retrofit	2,211,495
incremental cost from FMVSS to CMVSS guard	$229.00
total cost for retrofitting	$506,432,391

Table 39: Cost (2013 dollars) and Weight of Different Types of Rear Impact Guards

Type of Rear Impact Guard	Trailer Model Year/Make	*Guard Assembly*	*Installation Cost*	*Total Cost*	Weight (lb)
FMCSR 393.86(b)	*1993 Great Dane*	$65.31	$41.92	$107.23	78
FMVSS No. 224	*2001 Great Dane*	$153.22	$109.75	$262.86	172
CMVSS No. 223	*2012 Great Dane*	$191.17	$153.25	$344.05	193
	2012 Manac	$302.05	$248.74	$550.08	307
	2012 Stoughton	$248.02	$222.37	$470.91	191
	2012 Wabash	$447.05	$155.21	$601.84	243

Benefits: The agency examined potential safety impacts when current trailers are retrofitted to meet the proposed requirements.

In the benefit chapter, with the 93% compliance rate, we estimated that a total of 4.1 seriously injuries (i.e., MASI 3-5) would be prevented, annually. When none of the trailers are in compliance with the proposed rule, a total of 58.6 seriously injuries would be prevented. In 2017, we expect that 5,638,282 trailers would be on road. Among the 5,638,282 trailers, 3,402,300 trailers would be sold in 1974 – 2006. Therefore, 60% (3,402,300/5,638,282 = 60%) of the trailers in 2017 would not be equipped Canadian guards. When the 3,402,300 pre-2007 trailers (or 60% of all trailers on road in 2017 or 40% compliant trailers) are replaced with Canadian guards, hypothetically, we expect a total of 35 (35.1) serious injuries would be prevented. In other words, when compared to the current requirement, the injury benefit would increase by 8.6 times.

Table 40: Estimated Annual Serious Injuries Prevented

Compliant rate	MAIS 3	MAIS 4	MAIS 5	Total	ratio
93%	2.1	1.3	0.7	4.1	1.0
0%	30.3	18.1	10.1	58.6	14.3
40%	18.2	10.9	6.1	35.1	8.6

In the benefit chapter, with the 93% current compliance rate, we estimated that the proposed rule would prevent one life (0.65). If we assume that the fatal benefit would increase by 8.6 (35.1/4.1) times, a total of 6 lives (0.65 x 8.6 = 5.6).

Table 41: Potential Benefit with Retrofitting Trailers

MAIS 3	MAIS 4	MAIS 5	Fatal
18.2	10.9	6.1	5.6

Table 42: ELS Potential Benefit with Retrofitting Trailers

No discount	3%	7%
14.0	12.4	11.0

With the estimated $506 million of regulatory cost and excluding fuel cost, the net benefit is estimated to be -$375 million and -$390 million at 3% and 7%, respectively.

Table 43: Net Benefit with Retrofitting Trailers (in Millions of 2013 dollars)

Discount	Regulatory cost	Societal Econ. Savings	VSL savings	Total benefits	Net benefits
3%	$506.43	$16.95	$114.18	$131.14	-$375.29
7%	$506.43	$15.09	$101.63	$116.73	-$389.70

XI. REGULATORY FLEXIBILITY ACT AND UNFUNDED MANDATES REFORM ACT ANALYSIS

A. Regulatory Flexibility Act

The Regulatory Flexibility Act of 1980 (5 U.S.C. §601 et seq.) requires agencies to evaluate the potential effects of their proposed and final rules on small businesses, small organizations and small governmental jurisdictions. In compliance with the Regulatory Flexibility Act, 5 U.S.C. 60l et seq., NHTSA has evaluated the effects of this final rule on small entities. The head of the agency has certified that this rule will not have a significant economic impact on a substantial number of small entities.

The factual basis for the certification (5 U.S.C. 605(b)) is set forth below. Although the agency is not required to issue an initial regulatory flexibility analysis, we discuss below many of the issues that an initial regulatory flexibility analysis would address.

5 U.S.C §603 requires agencies to prepare and make available for public comments initial and final regulatory flexibility analysis (RFA) describing the impact of proposed and final rules on small entities. Section 603(b) of the Act specifies the content of a RFA. Each RFA must contain:

1. A description of the reasons why action by the agency is being considered;
2. A succinct statement of the objectives of, and legal basis for the proposal;
3. A description of and, where feasible, an estimate of the number of small entities to which the proposal will apply;

4. A description of the projected reporting, recording keeping and other compliance requirements of the proposal including an estimate of the classes of small entities which will be subject to the requirement and the type of professional skills necessary for preparation of the report or record;
5. An identification, to the extent practicable, of all relevant Federal rules which may duplicate, overlap or conflict with the proposal;
6. Each initial regulatory flexibility analysis shall also contain a description of any significant alternatives to the proposal which accomplish the stated objectives of applicable statutes and which minimize any significant economic impact of the proposal on small entities.

1. Description of the reason why action by the agency is being considered

NHTSA is proposing this action to improve the safety of light duty vehicle occupants by strengthening requirements of rear impact guards for trailers and semi-trailers. NHTSA is proposing this action in response to a petition for rulemaking from the Insurance Institute for Highway Safety and from Ms. Marianne Karth and the Truck Safety Coalition to improve underride protection in crashes into the rear of trailers. This proposed action requires all new applicable trailers and semitrailers in the United States to be equipped with rear impact guards with improved strength and energy absorption capability currently required in Canada. This action also adopts CMVSS No. 223 specifications regarding the location of aerodynamic fairings so they do not pose a safety hazard in crashes into the rear of trailers. Currently, 93 percent of new trailers and semitrailers in the United States comply with CMVSS No. 223 requirements.

2. Objectives of, and legal basis for, the proposal

Under 49 U.S.C. 322(a), the Secretary of Transportation (the "Secretary") has authority to prescribe regulations to carry out the duties and powers of the Secretary. One of the duties of the Secretary is to administer the National Traffic and Motor Vehicle Safety Act, as amended (49 U.S.C. 30101 et seq.). The Secretary is authorized to issue federal motor vehicle safety standards (FMVSS) that are practicable, meet the need for motor vehicle safety, and are stated in objective terms[58]. The Secretary has delegated the responsibility for carrying out the National Traffic and Motor Vehicle Safety Act to NHTSA[59]. NHTSA is proposing this rule under the Authority of 49 U.S.C. 322, 30111, 30115, 30117, and 30166; delegation of authority at 49 CFR 1.95. This proposal is needed to improve the safety of occupants in light duty vehicles.

3. Description and estimate of the number of small entities to which the proposal will apply

Business entities are defined as small businesses using the North American Industry Classification system (NAICS) code, for the purpose of receiving Small Business Administration assistance. One of the criteria for determining size, as stated in 13 CFR 121.201, is the number of employees in the firm. For establishments primarily engaged in manufacturing or assembling automobiles, light and heavy duty trucks, buses, motor homes, new tires, or motor vehicle body manufacturing (NAICS code 336211), the firm must have less than 1,000 employees to be classified as a small business.

The trailer manufacturing industry is fragmented, and NHTSA believes that there are hundreds of trailer manufacturers that can be classified as small businesses. The propose rule will affect a

[58] 49 U.S.C. 30111(a).
[59] 49 U.S.C. 105 and 322; delegation of authority at 49 CFR 1.50.

substantial number of small trailer manufacturing businesses. While a substantial number of small trailer manufacturing businesses will be affected by the proposed rule, the agency believes that the proposed rule will not have a significant economic impact on a substantial number of small trailer manufacturers. This NPRM proposes changes to the strength requirements applying to underride guards, but would not be amending the method by which small trailer manufacturers can certify compliance with FMVSS Nos. 223 and 224.

FMVSS No. 223, an equipment standard, specifies strength and energy absorption requirements in quasi-static force tests of rear impact guards sold for installation on new trailers and semitrailers. FMVSS No. 224, a vehicle standard, requires new trailers and semitrailers with a GVWR of 4,536 kg (10,000 lb) or more to be equipped with a rear impact guard meeting FMVSS No. 223. NHTSA established the two-standard approach to provide underride protection in a manner that imposes reasonable compliance burdens on small trailer manufacturers.

Under FMVSS No. 223, the guard may be tested for compliance while mounted to a test fixture or to a complete trailer. FMVSS No. 224 requires that the guard be mounted on the trailer or semitrailer in accordance with the instructions provided with the guard by the guard manufacturer. Under this approach, a small manufacturer that produces relatively few trailers can certify its trailers to FMVSS No. 224 without feeling compelled to undertake destructive testing of what could be a substantial portion of its production. The two-standard approach was devised to provide small manufacturers a practicable and reasonable means of meeting the safety need served by an underride guard requirement. This NPRM does not propose changing the method of certifying compliance to the underride guard requirements of FMVSS Nos. 223 and 224.

4. A description of the projected reporting, record keeping and other compliance requirements of the proposal including an estimate of the classes of small entities which will be subject to the requirement and the type of professional skills necessary for preparation of the report or record.

The proposed rule requires manufacturers to equip their trailers with a Canadian standard compliant guard and to certify that their products comply with the standard. The proposed rule includes no reporting requirements for trailer manufacturers.

5. An identification, to the extent practicable, of all relevant Federal rules which may duplicate, overlap, or conflict with the proposal

The proposal amends and upgrades FMVSS No. 223. There are no duplicate or overlapping Federal rules in this area.

6. A description of any significant alternatives to the proposal which accomplish the stated objectives of applicable statutes and which minimize any significant economic impact of the final rule on small entities.

We believe this proposal will not have a significant economic impact on small entities. No alternatives were considered that could further limit the impacts on small entities. Alternatives have been discussed in Chapter X for retrofitting a Canadian compliant impact guard on applicable trailers.

B. Unfunded Mandates Reform Act

The Unfunded Mandates Reform Act of 1995 (Public Law 104-4) requires agencies to prepare a written assessment of the costs, benefits, and other effects of proposed or final rules that include a Federal mandate likely to result in the expenditures by States, local or tribal governments, in the aggregate, or by the private sector, of more than $100 million annually (adjusted annually for inflation with base year of 1995). Adjusting this amount by the implicit gross domestic product price deflator for 2013 results in $142 million (106.733/75.324 = 1.42). The assessment may be included in conjunction with other assessments, as it is here.

This proposal would not result in expenditures by State, local or tribal governments of more than $142 million annually. The proposal also would not result in an expenditure of more than that magnitude by trailer manufacturers. The estimated annual total expenditure for manufacturers is expected to be approximately $2.5 million. These effects have been discussed previously in this Preliminary Regulatory Evaluation (see Costs, Benefits, and Cost Effectiveness Chapters).

Appendix A
Discount Factor

<u>Heavy trucks</u>							Discount rate 3%		Discount rate 7%	
Year	Adjusted VSL millions	Survival Probability	Exposure (VMT)	Aggregate Exposure	Exposure Proportion	Pre-Discounting Aggregate VSL	Mid-Year Discount Factor (3%)	Discounted Aggregate VSL	Mid-Year Discount Factor (7%)	Discounted Aggregate VSL
2017	$9.20	1.0000	240,737	240,737	0.099168	0.912	1.07670	0.98	1.18429	1.08
2018	$9.20	0.993	226,110	224,527	0.092491	0.851	1.04534	0.89	1.10682	0.94
2019	$9.20	0.981	212,378	208,343	0.085824	0.790	1.01489	0.80	1.03441	0.82
2020	$9.20	0.9642	199,486	192,344	0.079233	0.729	0.98533	0.72	0.96674	0.70
2021	$9.20	0.9432	187,381	176,738	0.072805	0.670	0.95663	0.64	0.90349	0.61
2022	$9.20	0.9181	176,017	161,601	0.066569	0.612	0.92877	0.57	0.84439	0.52
2023	$9.20	0.8894	165,346	147,059	0.060579	0.557	0.90172	0.50	0.78914	0.44
2024	$9.20	0.8575	155,327	133,193	0.054867	0.505	0.87545	0.44	0.73752	0.37
2025	$9.20	0.823	145,919	120,091	0.049470	0.455	0.84995	0.39	0.68927	0.31
2026	$9.20	0.786	137,085	107,749	0.044386	0.408	0.82520	0.34	0.64418	0.26
2027	$9.20	0.7473	128,789	96,244	0.039646	0.365	0.80116	0.29	0.60203	0.22
2028	$9.20	0.7071	120,999	85,558	0.035244	0.324	0.77783	0.25	0.56265	0.18
2029	$9.20	0.666	113,683	75,713	0.031189	0.287	0.75517	0.22	0.52584	0.15
2030	$9.20	0.6244	106,813	66,694	0.027474	0.253	0.73318	0.19	0.49144	0.12
2031	$9.20	0.5826	100,360	58,470	0.024086	0.222	0.71182	0.16	0.45929	0.10
2032	$9.20	0.5411	94,300	51,026	0.021019	0.193	0.69109	0.13	0.42924	0.08
2033	$9.20	0.5003	88,609	44,331	0.018262	0.168	0.67096	0.11	0.40116	0.07
2034	$9.20	0.4604	83,263	38,334	0.015791	0.145	0.65142	0.09	0.37492	0.05
2035	$9.20	0.4217	78,242	32,995	0.013592	0.125	0.63245	0.08	0.35039	0.04
2036	$9.20	0.3845	73,526	28,271	0.011646	0.107	0.61402	0.07	0.32747	0.04
2037	$9.20	0.349	69,096	24,115	0.009934	0.091	0.59614	0.05	0.30604	0.03
2038	$9.20	0.3152	64,935	20,468	0.008431	0.078	0.57878	0.04	0.28602	0.02

2039	$9.20	0.2835	61,026	17,301	0.007127	0.066	0.56192	0.04	0.26731	0.02
2040	$9.20	0.2537	57,354	14,551	0.005994	0.055	0.54555	0.03	0.24982	0.01
2041	$9.20	0.226	53,905	12,183	0.005019	0.046	0.52966	0.02	0.23348	0.01
2042	$9.20	0.2004	50,664	10,153	0.004182	0.038	0.51424	0.02	0.21821	0.01
2043	$9.20	0.1769	47,620	8,424	0.003470	0.032	0.49926	0.02	0.20393	0.01
2044	$9.20	0.1554	44,759	6,956	0.002865	0.026	0.48472	0.01	0.19059	0.01
2045	$9.20	0.1359	42,072	5,718	0.002355	0.022	0.47060	0.01	0.17812	0.00
2046	$9.20	0.1183	39,547	4,678	0.001927	0.018	0.45689	0.01	0.16647	0.00
2047	$9.20	0.1025	37,175	3,810	0.001569	0.014	0.44358	0.01	0.15558	0.00
2048	$9.20	0.0884	34,945	3,089	0.001272	0.012	0.43066	0.01	0.14540	0.00
2049	$9.20	0.0759	32,851	2,493	0.001027	0.009	0.41812	0.00	0.13589	0.00
2050	$9.20	0.0649	30,883	2,004	0.000826	0.008	0.40594	0.00	0.12700	0.00
2051	$9.20	0.0552	29,033	1,603	0.000660	0.006	0.39412	0.0024	0.11869	0.00
				2427564						
				2427564		9.20		8.14		7.24
								0.8845	$0.00	0.7873

Appendix B
VSL Value

Comprehensive Costs and Relative Value Factors Reflecting $9.2 million								
[Police Reported] Value of a Statistical Life (VSL) for 2018, in 2013 Economics								
CPI	Factor	MAIS0	MAIS 1	MAIS 2	MAIS 3	MAIS 4	MAIS 5	Fatal
1.094476	Medical	$0	$3,063	$12,535	$53,213	$149,196	$420,578	$12,386
1.068336	EMS	$40	$116	$237	$444	$895	$913	$964
1.060018	Market Prod	$0	$2,890	$20,521	$68,199	$149,267	$357,869	$989,274
1.060018	Household Produce	$48	$914	$7,532	$24,050	$39,794	$101,133	$307,310
1.068336	Ins. Adm.	$153	$3,523	$4,977	$16,421	$30,157	$77,481	$30,257
1.060018	Workplace	$49	$361	$2,803	$6,123	$6,743	$11,757	$12,490
1.068336	Legal	$0	$1,263	$3,580	$13,249	$28,490	$88,362	$113,765
1.060018	Travel Delay	$1,501	$1,511	$1,537	$1,580	$1,602	$1,621	$6,063
1.068336	Property	$2,876	$8,503	$9,091	$17,122	$17,444	$16,123	$11,978
	Damage							
1.060018	QALYs*	$0	$24,061	$376,953	$842,130	$2,133,396	$4,756,030	$8,020,287
Injury Subtotal		$290	$36,191	$429,138	$1,023,829	$2,537,938	$5,814,123	$9,486,733
QALY* Relatives		0	0.003	0.047	0.105	0.266	0.593	1
Economic Impact Costs		$4,619	$18,681	$37,184	$116,209	$252,161	$659,113	$304,774
(Medical, EMS, Ins. Adm., Workplace, Legal, 12.5% of Market Productivity)								
*QALYs: Quality-Adjusted Life-Years								

Appendix C
Trailer sales and survivability
(New Trailer Output was based on trailer-body web site
http://trailer-bodybuilders.com/trailer-output as of May 2012
New trailer data from 1998-2012. Represents 90% of total sales)

		Year	**1974**	**1975**	**1976**	**1977**	**1978**
Total trailer Sales by Year			*226500*	*226500*	*226500*	*226500*	*226500*
Survivability	**Year**	**Sum in fleet**					
1.0000	1974	226500	226500				
1.0000	1975	453000	226500	226500			
1.0000	1976	679500	226500	226500	226500		
1.0000	1977	906000	226500	226500	226500	226500	
1.0000	1978	1132500	226500	226500	226500	226500	226500
0.9950	1979	1357868	225368	226500	226500	226500	226500
0.9900	1980	1582103	224235	225368	226500	226500	226500
0.9850	1981	1805205	223103	224235	225368	226500	226500
0.9800	1982	2027175	221970	223103	224235	225368	226500
0.9750	1983	2248013	220838	221970	223103	224235	225368
0.9530	1984	2463867	215855	220838	221970	223103	224235
0.9310	1985	2674739	210872	215855	220838	221970	223103
0.9090	1986	2880627	205889	210872	215855	220838	221970
0.8870	1987	3081533	200906	205889	210872	215855	220838
0.8650	1988	3277455	195923	200906	205889	210872	215855
0.8330	1989	3466130	188675	195923	200906	205889	210872
0.8010	1990	3647556	181427	188675	195923	200906	205889
0.7690	1991	3821735	174179	181427	188675	195923	200906
0.7370	1992	3988665	166931	174179	181427	188675	195923
0.7050	1993	4148348	159683	166931	174179	181427	188675
0.6630	1994	4298517	150170	159683	166931	174179	181427
0.6210	1995	4439174	140657	150170	159683	166931	174179
0.5790	1996	4570317	131144	140657	150170	159683	166931
0.5370	1997	4691948	121631	131144	140657	150170	159683
0.4950	1998	4883817	112118	121631	131144	140657	150170
0.4630	1999	5099100	104870	112118	121631	131144	140657
0.4310	2000	5260322	97621	104870	112118	121631	131144
0.3990	2001	5268595	90373	97621	104870	112118	121631
0.3670	2002	5285307	83125	90373	97621	104870	112118
0.3350	2003	5327909	75877	83125	90373	97621	104870
0.3030	2004	5422589	68629	75877	83125	90373	97621

0.2710	2005	5528754	61381	68629	75877	83125	90373
0.2390	2006	5669696	54133	61381	68629	75877	83125
0.2070	2007	5732246	46885	54133	61381	68629	75877
0.1750	2008	5706090	39637	46885	54133	61381	68629
0.1530	2009	5597766	34654	39637	46885	54133	61381
0.1310	2010	5530483	29671	34654	39637	46885	54133
0.1090	2011	5563070	24688	29671	34654	39637	46885
0.0870	2012	5614207	19705	24688	29671	34654	39637
0.0650	2013	5625975	14722	19705	24688	29671	34654
0.0530	2014	5634159	12004	14722	19705	24688	29671
0.0410	2015	5638665	9286	12004	14722	19705	24688
0.0290	2016	5639724	6568	9286	12004	14722	19705
0.0170	2017	5638282	3850	6568	9286	12004	14722
0.0050	2018	5634742	1132	3850	6568	9286	12004
	2019	5631063	0	1132	3850	6568	9286
	2020	5627850	0	0	1132	3850	6568
	2021	5624377	0	0	0	1132	3850

(Continued)

1979	**1980**	**1981**	**1982**	**1983**	**1984**	**1985**	**1986**	**1987**	**1988**	**1989**
226500	*226500*	*226500*	*226500*	*226500*	*226500*	*226500*	*226500*	*226500*	*226500*	*226500*
226500										
226500	226500									
226500	226500	226500								
226500	226500	226500	226500							
226500	226500	226500	226500	226500						
225368	226500	226500	226500	226500	226500					
224235	225368	226500	226500	226500	226500	226500				
223103	224235	225368	226500	226500	226500	226500	226500			
221970	223103	224235	225368	226500	226500	226500	226500	226500		

220838	221970	223103	224235	225368	226500	226500	226500	226500	226500	
215855	220838	221970	223103	224235	225368	226500	226500	226500	226500	226500
210872	215855	220838	221970	223103	224235	225368	226500	226500	226500	226500
205889	210872	215855	220838	221970	223103	224235	225368	226500	226500	226500
200906	205889	210872	215855	220838	221970	223103	224235	225368	226500	226500
195923	200906	205889	210872	215855	220838	221970	223103	224235	225368	226500
188675	195923	200906	205889	210872	215855	220838	221970	223103	224235	225368
181427	188675	195923	200906	205889	210872	215855	220838	221970	223103	224235
174179	181427	188675	195923	200906	205889	210872	215855	220838	221970	223103
166931	174179	181427	188675	195923	200906	205889	210872	215855	220838	221970
159683	166931	174179	181427	188675	195923	200906	205889	210872	215855	220838
150170	159683	166931	174179	181427	188675	195923	200906	205889	210872	215855
140657	150170	159683	166931	174179	181427	188675	195923	200906	205889	210872
131144	140657	150170	159683	166931	174179	181427	188675	195923	200906	205889
121631	131144	140657	150170	159683	166931	174179	181427	188675	195923	200906
112118	121631	131144	140657	150170	159683	166931	174179	181427	188675	195923
104870	112118	121631	131144	140657	150170	159683	166931	174179	181427	188675
97621	104870	112118	121631	131144	140657	150170	159683	166931	174179	181427
90373	97621	104870	112118	121631	131144	140657	150170	159683	166931	174179
83125	90373	97621	104870	112118	121631	131144	140657	150170	159683	166931
75877	83125	90373	97621	104870	112118	121631	131144	140657	150170	159683
68629	75877	83125	90373	97621	104870	112118	121631	131144	140657	150170
61381	68629	75877	83125	90373	97621	104870	112118	121631	131144	140657
54133	61381	68629	75877	83125	90373	97621	104870	112118	121631	131144
46885	54133	61381	68629	75877	83125	90373	97621	104870	112118	121631
39637	46885	54133	61381	68629	75877	83125	90373	97621	104870	112118
34654	39637	46885	54133	61381	68629	75877	83125	90373	97621	104870
29671	34654	39637	46885	54133	61381	68629	75877	83125	90373	97621
24688	29671	34654	39637	46885	54133	61381	68629	75877	83125	90373
19705	24688	29671	34654	39637	46885	54133	61381	68629	75877	83125
14722	19705	24688	29671	34654	39637	46885	54133	61381	68629	75877
12004	14722	19705	24688	29671	34654	39637	46885	54133	61381	68629
9286	12004	14722	19705	24688	29671	34654	39637	46885	54133	61381
6568	9286	12004	14722	19705	24688	29671	34654	39637	46885	54133

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				real production = 90% of total		275627	303222

1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
226500	*226500*	*226500*	*226500*	*226500*	*226500*	*226500*	*226500*	*306252*	*336913*
226500									
226500	226500								
226500	226500	226500							
226500	226500	226500	226500						
226500	226500	226500	226500	226500					
225368	226500	226500	226500	226500	226500				
224235	225368	226500	226500	226500	226500	226500			
223103	224235	225368	226500	226500	226500	226500	226500		
221970	223103	224235	225368	226500	226500	226500	226500	306252	
220838	221970	223103	224235	225368	226500	226500	226500	306252	336913
215855	220838	221970	223103	224235	225368	226500	226500	306252	336913
210872	215855	220838	221970	223103	224235	225368	226500	306252	336913
205889	210872	215855	220838	221970	223103	224235	225368	306252	336913
200906	205889	210872	215855	220838	221970	223103	224235	304721	336913
195923	200906	205889	210872	215855	220838	221970	223103	303190	335229
188675	195923	200906	205889	210872	215855	220838	221970	301658	333544
181427	188675	195923	200906	205889	210872	215855	220838	300127	331860
174179	181427	188675	195923	200906	205889	210872	215855	298596	330175
166931	174179	181427	188675	195923	200906	205889	210872	291858	328491
159683	166931	174179	181427	188675	195923	200906	205889	285121	321078
150170	159683	166931	174179	181427	188675	195923	200906	278383	313666

140657	150170	159683	166931	174179	181427	188675	195923	271646	306254
131144	140657	150170	159683	166931	174179	181427	188675	264908	298842
121631	131144	140657	150170	159683	166931	174179	181427	255108	291430
112118	121631	131144	140657	150170	159683	166931	174179	245308	280649
104870	112118	121631	131144	140657	150170	159683	166931	235508	269868
97621	104870	112118	121631	131144	140657	150170	159683	225708	259086
90373	97621	104870	112118	121631	131144	140657	150170	215908	248305
83125	90373	97621	104870	112118	121631	131144	140657	203045	237524
75877	83125	90373	97621	104870	112118	121631	131144	190183	223374
68629	75877	83125	90373	97621	104870	112118	121631	177320	209223
61381	68629	75877	83125	90373	97621	104870	112118	164457	195073

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261090	129960	144078	174261	228151	245297	282750	218422	146182	78526	121128
2000	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
290100	*144400*	*160087*	*193623*	*253501*	*272552*	*314167*	*242691*	*162424*	*87251*	*134587*

290100										
290100	144400									
290100	144400	160087								
290100	144400	160087	193623							
290100	144400	160087	193623	253501						
288650	144400	160087	193623	253501	272552					
287199	143678	160087	193623	253501	272552	314167				
285749	142956	159286	193623	253501	272552	314167	242691			
284298	142234	158486	192655	253501	272552	314167	242691	162424		
282848	141512	157685	191687	252234	272552	314167	242691	162424	87251	
276465	140790	156885	190719	250966	271189	314167	242691	162424	87251	134587
270083	137613	156085	189751	249699	269827	312596	242691	162424	87251	134587
263701	134436	152563	188783	248431	268464	311025	241478	162424	87251	134587
257319	131260	149041	184523	247164	267101	309454	240264	161612	87251	134587
250937	128083	145519	180263	241587	265738	307883	239051	160800	86815	134587
241653	124906	141997	176004	236010	259742	306313	237837	159988	86379	133914
232370	120285	138475	171744	230433	253746	299401	236624	159176	85942	133241
223087	115664	133352	167484	224855	247750	292489	231285	158364	85506	132568
213804	111044	128229	161288	219278	241754	285578	225945	154790	85070	131895
204521	106423	123107	155092	211166	235758	278666	220606	151217	83150	131222
192336	101802	117984	148896	203054	227036	271754	215267	147644	81231	128261
180152	95737	112861	142700	194942	218314	261701	209928	144070	79311	125300

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214634	234870									
2011	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
238482	*260967*	*226500*	*226500*	*226500*	*226500*	*226500*	*226500*	*226500*	*226500*	*226500*

238482										
238482	260967									
238482	260967	226500								
238482	260967	226500	226500							
238482	260967	226500	226500	226500						
237290	260967	226500	226500	226500	226500					
236097	259662	226500	226500	226500	226500	226500				

234905	258357	225368	226500	226500	226500	226500	226500			
233713	257052	224235	225368	226500	226500	226500	226500	226500		
232520	255747	223103	224235	225368	226500	226500	226500	226500	226500	
227274	254443	221970	223103	224235	225368	226500	226500	226500	226500	226500