DEPARTMENT OF TRANSPORTATION

National Highway Traffic Safety Administration

49 CFR Part 571

[Docket No. NHTSA–2024–0001]

RIN 2127–AM53

Federal Motor Vehicle Safety Standards; Seating Systems

AGENCY: National Highway Traffic Safety Administration (NHTSA), Department of Transportation (DOT).

ACTION: Advance notice of proposed rulemaking.

SUMMARY: Through this document, NHTSA fulfills the statutory mandate in section 24204 of the Infrastructure Investment and Jobs Act (IIJA), which directed the Secretary of Transportation to issue an advanced notice of proposed rulemaking to update Federal Motor Vehicle Safety Standard No. 207, ‘‘Seating systems.’’ NHTSA also partially grants rulemaking petitions submitted by Kenneth J. Saczalski of Environmental Research and Safety Technologists (ERST) and by Alan Cantor of ARCCA, Inc. (ARCCA), which sought changes to the Federal Motor Vehicle Safety Standards (FMVSS) petitioners stated would improve the safety of children during rear-end crashes. NHTSA denies a petition from the Center for Auto Safety (CAS), which sought to require additional warnings instructing adults regarding which rear seating position to place children.

DATES: Comments must be received no later than September 16, 2024. The Saczalski and Cantor petitions are granted in part and the CAS petition is denied as of July 16, 2024. See **ADDRESSES** and Section VIII. Public Participation for more information about submitting written comments and reviewing comments submitted by other interested parties.

ADDRESSES: You may submit written comments, identified by docket number or RIN, by any of the following methods:

- *Federal eRulemaking Portal:* Go to *https://www.regulations.gov.* Follow the online instructions for submitting comments.
- *Mail:* Docket Management Facility, U.S. Department of Transportation, 1200 New Jersey Avenue SE, Room W12–140, Washington, DC 20590–0001.
- *Hand Delivery or Courier:* 1200 New Jersey Avenue SE, West Building, Ground Floor, Room W12–140, Washington, DC, between 9 a.m. and 5 p.m. E.T., Monday through Friday, except Federal holidays. To be sure someone is there to help you, please call 202–366–9826 before coming.

Instructions: For detailed instructions on submitting comments and additional information on the rulemaking process, see the Public Participation heading of the **SUPPLEMENTARY INFORMATION** section of this document. Note that all comments received will be posted without change to *https://www.regulations.gov,* including any personal information provided. Please see the ‘‘Privacy Act’’ discussion in Section IX. Regulatory Analyses and Notices.

Confidential Business Information: If you claim that any of the information or documents provided to the agency constitute confidential business information within the meaning of 5 U.S.C. 552(b)(4), or are protected from disclosure pursuant to 18 U.S.C. 1905, you must submit supporting information together with the materials that are the subject of the confidentiality request, in accordance with part 512, by email or secure file transfer to the Office of the Chief Counsel, Litigation and Enforcement Division. Do not send a hardcopy of a request for confidential treatment to NHTSA's headquarters.

Your request must include a request letter that contains supporting information, pursuant to § 512.8. Your request must also include a certificate, pursuant to § 512.4(b) and part 512, appendix A.

You are required to submit one unredacted ‘‘confidential version’’ of the information for which you are seeking confidential treatment. Pursuant to § 512.6, the words ‘‘ENTIRE PAGE CONFIDENTIAL BUSINESS INFORMATION’’ or ‘‘CONFIDENTIAL BUSINESS INFORMATION CONTAINED WITHIN BRACKETS’’ (as applicable) must appear at the top of each page containing information claimed to be confidential. In the latter situation, where not all information on the page is claimed to be confidential, identify each item of information for which confidentiality is requested within brackets: ‘‘[ ].’’

You are also required to submit to the Office of the Chief Counsel one redacted ‘‘public version’’ of the information for which you are seeking confidential treatment. Pursuant to § 512.5(a)(2), the redacted ‘‘public version’’ should include redactions of any information for which you are seeking confidential treatment (*i.e.,* the only information that should be unredacted is information for which you are not seeking confidential treatment).

For questions about a request for confidential treatment, please contact Dan Rabinovitz in the Office of the Chief Counsel at *Daniel.Rabinovitz@dot.gov* or (202) 366–8534.

FOR FURTHER INFORMATION CONTACT: Mr. Tyler Brosten, Office of Crashworthiness Standards (Telephone: 202–366–1740; Email: *tyler.brosten@dot.gov,* Facsimile: 202–493–2739), or Mr. Eli Wachtel, Office of Chief Counsel (Telephone: 202–366–2992; Email: *eli.wachtel@dot.gov*). You may mail these officials at: National Highway Traffic Safety Administration, 1200 New Jersey Avenue SE, Washington, DC 20590.

SUPPLEMENTARY INFORMATION:

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I. Introduction

As part of its safety mission, NHTSA issues Federal Motor Vehicle Safety Standards (FMVSSs)[1] and other regulations for new motor vehicles and motor vehicle equipment to save lives, prevent injuries, and reduce economic costs due to road traffic crashes. All FMVSSs must meet the requirements of the National Traffic and Motor Vehicle Safety Act of 1966 (the ''Safety Act'').[2] That is, they must ''be practicable, meet the need for motor vehicle safety, and be stated in objective terms.''[3] On November 14, 2021, the Infrastructure, Investment and Jobs Act (IIJA; Pub. L. 117–58[4]) was passed. Section 24204 of IIJA, ''Motor Vehicle Seat Back Safety Standards,'' directs the Secretary of Transportation to issue an advance notice of proposed rulemaking (ANPRM) within two years to update 49 CFR 571.207. The publication of this ANPRM fulfills this statutory mandate.

FMVSS No. 207 establishes requirements for seats, seat attachment assemblies, and their installation in passenger cars, multipurpose passenger vehicles, trucks designed to carry at least one person, and buses.[5] The standard, among other things, sets minimum requirements for the strength of the seat back and its associated restraining devices and adjusters.[6] While in its rearmost position, a seat back must withstand a rearward moment (torque) of 373 Newton-meters (Nm) (3,300 Inch-pounds (in-lb)), applied by a horizontal force measured vertically from the seating reference point.[7] The standard also contains a test procedure. The test specifies an application of a rearward force on the uppermost cross member of the seat back structure, that results in a moment applied to the attachment (often the recliner mechanism) of the seat back and the remainder of the seat structure.

Although FMVSS No. 207 sets the minimum seat back strength requirement, since 1968 the *de facto* minimum requirement for seat back strength has effectively been set by FMVSS No. 202 (now 202a), ''Head restraints.''[8] This standard requires head restraints and establishes requirements for them to reduce the severity of neck injuries in rear impact crashes. Currently, FMVSS No. 202a requires a fully extended head restraint to withstand an 890 Newtons (N) (200 pound force (lb-f)) rearward load for 5 seconds applied 65 millimeters (mm) (2.5 inches (in)) below its top when adjusted to its highest position, which must be at least 800 mm.[9] This creates an effective torque requirement on the seat back of 654 Nm (5,790 in-lb), where 654 = 890*(0.8–0.065), significantly higher than the 373 Nm (3,300 in-lb) required by FMVSS No. 207.

In addition to the requirement in IIJA, this ANPRM addresses three petitions for rulemaking NHTSA received requesting various amendments to the FMVSS related to the deformation of seat backs in rear impacts.[10] Two of the petitioners, Kenneth J. Saczalski of ERST. and Alan Cantor of ARCCA requested that the agency increase the strength requirements for seat backs in the front row. They argue that seats that comply with the current standard may yield excessively during a crash, which can lead to spinal cord and brain injuries due to contact between the seated occupant's head and vehicle structures in the rear seat compartment. In addition, they state that under the current standard, in certain higher speed rear end crashes, a seat could yield to the point that the seat becomes fully reclined (hereinafter described as ''seat back failure''). This may cause a belted occupant in the front seat to slide underneath the seat belt, leading to ejection into the rear seat space or outside the vehicle. (The petitioners refer to this phenomenon as ''ramping.'') Ramping poses injury risk to occupants seated directly behind the occupied front seat. In addition, the petitioners have asked NHTSA to revise other FMVSSs in ways that they stated would mitigate the injurious effects of excessively yielding seat backs. This ANPRM seeks to further develop the

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[1] The FMVSS are codified in 49 CFR part 571.

[2] 49 U.S.C. 30101.

[3] 49 U.S.C. 30111(a). The Secretary must also (1) ''consider relevant available motor vehicle safety information; (2) consult with the agency established under the Act of August 20, 1958 (Pub. L. 85–684, 72 Stat. 635), and other appropriate State or interstate authorities (including legislative committees); (3) consider whether a proposed standard is reasonable, practicable, and appropriate for the particular type of motor vehicle or motor vehicle equipment for which it is prescribed; and (4) consider the extent to which the standard will carry out'' the purpose of the Safety Act. 49 U.S.C. 30111(b). The purpose of the Safety Act is to ''reduce traffic accidents and deaths and injuries resulting from traffic accidents.'' 49 U.S.C. 30101.

[4] Public Law 117–58.

[5] 49 CFR 571.207 S1 and S2.

[6] FMVSS No. 207 also contains provisions dictating the strength of seat attachments to the vehicle in both the front and rear directions. For the purposes of this ANPRM, ''strength'' with respect to seat backs refers to the maximum rearward moment or force a seat back is able to withstand. ''Stiffness'' refers to the resistance of the seat back to any (or a specified) amount of deformation and deflection. Stated another way, ''stiffness'' can be thought of as the increase in resistive force or moment per unit deformation or rotation. Rigidity is the characteristic of a structure, such as a seat back, exhibiting relatively limited deformation when exposed to a force. Rigid and yielding seat back structures are opposites.

[7] 49 CFR 571.207 S4.

[8] The head restraint and seat back are interconnected parts of the seating system.

[9] 49 CFR 571.202(a) S4.2.7.

[10] These petitions, dated October 28, 2014 (Environmental Research and Safety Technologists, Inc.), and September 28, 2015 (ARCCA), are available in the rulemaking docket at *https://www.regulations.gov/*.

record on occupant protection in rear impacts to inform a potential future rulemaking. As explained in section V., this document grants these petitions in part.

The third petitioner, CAS, requested the addition of warning language to child restraint system labels and owner's manuals to warn parents against placing a child behind an occupied front seat.[11] As explained in section V.H., this document denies this petition.

IIJA requires that NHTSA issue an ANPRM to update FMVSS No. 207. Congress stated, however, that an update must be consistent with the considerations described in 49 U.S.C. 30111(b) of the Safety Act and issued pursuant to the Safety Act. Therefore, it must be practicable, meet the need for safety, and be stated in objective terms as provided in 49 U.S.C. 30111(a). This ANPRM discusses issues that have historically contributed to the complexities of regulatory action on seating systems.

As outlined in the regulatory and research review below, a major challenge in NHTSA's efforts to set standards for rear impact protection relates to the determination of whether a seat should yield, thereby reducing forces acting on the seat occupant, or be stiffer, and thus prevent rare occurrences like ramping or interaction with other occupants. Finding the appropriate balance inherent in rear impact protection is a theme and central debate in much of the research and analysis conducted on this issue.

Complicating this question is the dramatic difference in frequency between relatively common and generally minor cervical spine injuries (such as whiplash) caused by forces acting on a seat occupant that can occur even in low-speed rear impacts and severe injuries, which are rare. Studies suggest that no more than 1% of rear impacts cause any type of serious or higher severity injury,[12] which are mostly associated with impacts with vehicle structures, not other occupants.[13] [14] In contrast, cervical spine injuries, such as whiplash, are highly common injuries in rear impacts and occur at many different speeds, including at low speed, with some estimates of over 100,000 injuries annually in the United States. Additionally, despite decades of industry and agency research into whiplash, the understanding of the biological mechanisms that cause these injuries remain limited. This has restricted NHTSA's ability to develop objective updated performance standards for seat backs, such as updated strength requirements or a comprehensive dynamic test for rear impact protection. In particular, factors like test speed and what metrics of seat back and head restraint performance to test (*i.e.,* strength only vs. anthropomorphic test dummy injury metrics) remain unclear. These and other related issues present a challenge to updating FMVSS No. 207 in a manner that is objective, practicable, and meets the need for safety.

This ANPRM is part of NHTSA's ongoing effort to meet this challenge. Here, we detail a unified approach to occupant protection in rear impacts. Although IIJA mentions only FMVSS No. 207, NHTSA is considering integrating FMVSS Nos. 207 and 202a because of the clear connection between head rests and seat backs. An integrated approach would enable NHTSA to comprehensively evaluate the performance of the seating system for rear impact protection and better balance considerations relevant to both high speed (severe injuries) and low-speed (whiplash injury prevention) impacts. As part of this approach, NHTSA is considering a quasi-static test or a dynamic test requirement with at least two (low and high) impact severity ranges. This ANPRM discusses many considerations associated with each approach and seeks comment on them, including choice of anthropomorphic test device (ATD), performance criteria (such as ATD metrics), test severities, and crash pulse delivery methods.

This ANPRM has four main areas of focus. In section II, NHTSA details the safety problem in rear impact occupant protection. In section III, NHTSA describes the regulatory and research history of seat backs, and in section IV, NHTSA summarizes a literature review in this area to provide context for the ANPRM.[15] In section V, NHTSA discusses the Cantor, Saczalski, and CAS petitions. Finally, in section VI, NHTSA describes the unified approach with regard to FMVSS No. 207 and FMVSS No. 202a, and in section VII, NHTSA describes its research efforts in this area and the knowledge gaps that may need to be filled prior to implementing this unified approach. Throughout the document, we seek comment on a variety of topics to inform a determination about what upgrade, if any, to FMVSS No. 207 (and FMVSS No. 202a) can meet the requirements of the Safety Act with the aim of improving occupant protection in rear impact collisions.

II. Occupant and Seat Back Dynamics and Field Data on Rear Impact Crashes

Controlled interaction of the occupant with the seat back is the primary countermeasure to injury in motor vehicle rear collisions. In these crashes, the seat back supports the occupant during sudden forward acceleration, when a range of injury risks may be generated. Because it is necessary to provide a broad range of injury protections, the rear impact protection issue has been framed as both a balance and competition between high and low-severity protection measures. To introduce the issue, this section begins with a brief discussion of rear impact seat back dynamics and follows with a survey of field data regarding rear impacts.

In front row seats, the seat back frame is typically connected to the lower seat structure, or pan, by a mechanical joint. When a seat back is subjected to an inertial load from the occupant during a rear collision, the seat back frame rotates and bends rearward around this joint. When asymmetric loading on the seat back occurs, this dynamic can result in twisting of the seat back around its longitudinal axis. The force acting on the seat back is proportional to the occupant's mass and forward acceleration. As the seat back rotates rearward, the force applied to the seat back becomes less perpendicular to the seat back plane as the applied force is further defined by transverse forces made up of seat back-occupant friction and pocketing,[16] seat belt restraints, and other factors that maintain occupant seat retention.[17] These actions have long been understood to absorb energy, reduce forces acting on the seat occupant, and disperse acceleration of

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[11] This petition, dated March 9, 2016, is also available in the rulemaking docket at *https://www.regulations.gov/.*

[12] The severity of injury is ranked in accordance with the Abbreviated Injury Scale (AIS). An AIS level 3 injury is a serious injury, level 4 a severe injury, and levels 5 and 6 are critical and fatal injuries, respectively. *www.aaam.org.*

[13] Prasad, Priya, et al. ''Relationships between passenger car seat back strength and occupant injury severity in rear end collisions: Field and laboratory studies.'' *SAE transactions* (1997): 3935–3967.

[14] Parenteau, Chantal S., and David C. Viano. ''Serious head, neck and spine injuries in rear impacts: frequency and sources.'' *IRC–21–10, IRCOBI Conference.* 2021.

[15] The research in the public domain on the area of seat back strength is extensive, and this document does not attempt to fully synthesize it.

[16] Pocketing refers to displacement of the occupant's torso into the relatively pliable interior of a seat back.

[17] Seat retention refers to the occupant restraint system's ability to keep the occupant coupled to the seat.

the occupant over time.[18] [19] When the force applied to the seat back exceeds the material's elastic limit, it begins to deform in a way that permanently bends the seat (plastic deformation). For some rear impacts, this deformation may exceed the seat structure's ability to substantially oppose the applied force, resulting in seat back failure due to significant material bending or fracture, at which point the seat back is said to fail. At the point of seat back failure or significant seat back deformation, seat occupants in rearward seat rows may be exposed to injury risk due to contact with the front seat back or front occupants. Paradoxically, the restraining force applied by the front seat on its occupant can lead to injury, just as a seat belt can injure an occupant in a frontal crash. The following subsection examines field data to further lay out the current understanding of the risks to vehicle occupants in rear impacts. Later sections will provide additional discussion on the literature regarding rear impact injuries and protection. The literature outlines a continued debate around how best to protect occupants, the uncertain understanding of how certain injuries occur in rear impacts, and varied approaches and developments in technology for rear impact protection.

A. FARS and CRSS Data Analysis

In general, rear collisions result in fewer fatalities and serious injuries when compared to other impact directions. Table II.1 shows overall crash statistics for the sum of light vehicles (passenger cars and light trucks) in year 2020 organized by impact directions and injury severities. NHTSA compiled this data set in the 2020 Traffic Safety Facts from FARS (Fatality Analysis Reporting System) and CRSS (Crash Report Sampling System).[20] We note that the data include all vehicle rows. The data show that rear impacted light vehicles accounted for 24.1% of crashed light vehicles and 21.8% of vehicles with injured occupants, but only 7.2% of vehicles with fatalities in 2020.

TABLE II.1—PASSENGER CARS AND LIGHT TRUCKS INVOLVED IN CRASHES, BY INITIAL POINT OF IMPACT, CRASH SEVERITY, AND CRASH TYPE FOR YEAR 2020

Crash type by initial point of impact	Crash severity							
	Fatal		Injury		Property damage only		Total	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Single-Vehicle Crashes:								
Front	10,883	67.9	358,800	77.1	791,913	73.1	1,161,597	74.2
Left Side	890	5.6	21,960	4.7	54,317	5.0	77,167	4.9
Right Side	886	5.5	33,795	7.3	85,283	7.9	119,965	7.7
Rear	222	1.4	16,334	3.5	84,915	7.8	101,473	6.5
Noncollision	1,714	10.7	27,237	5.9	40,898	3.8	69,849	4.5
Other/Unknown	1,430	8.9	7,157	1.5	25,991	2.4	34,580	2.2
Total	16,025	100.0	465,285	100.0	1,083,319	100.0	1,564,629	100.0
Multiple-Vehicle Crashes:								
Front	15,987	62.9	1,183,348	54.3	2,354,919	49.3	3,554,254	50.9
Left Side	3,221	12.7	224,185	10.3	522,635	10.9	750,041	10.7
Right Side	2,649	10.4	206,256	9.5	486,970	10.2	695,875	10.0
Rear	2,772	10.9	561,310	25.8	1,395,634	29.2	1,959,717	28.1
Noncollision	76	0.3	702	0.0	2,474	0.1	3,253	0.0
Other/Unknown	704	2.8	2,787	0.1	17,515	0.4	21,007	0.3
Total	25,409	100.0	2,178,589	100.0	4,780,149	100.0	6,984,146	100.0
All Crashes:								
Front	26,870	64.9	1,542,149	58.3	3,146,832	53.7	4,715,850	55.2
Left Side	4,111	9.9	246,145	9.3	576,953	9.8	827,209	9.7
Right Side	3,535	8.5	240,051	9.1	572,254	9.8	815,839	9.5
Rear	2,994	7.2	577,646	21.8	1,480,551	25.3	2,061,189	24.1
Noncollision	1,790	4.3	27,939	1.1	43,372	0.7	73,101	0.9
Other/Unknown	2,134	5.2	9,945	0.4	43,507	0.7	55,586	0.7
Total	41,434	100.0	2,643,874	100.0	5,863,467	100.0	8,548,775	100.0

Of the over 2 million rear impacted light vehicles in 2020, only 0.15% (2994/2,061,189) involved fatalities, as compared with 0.57% (26,870/4,715,850) of the 4.7 million front impacted light vehicles and 0.47% (7646/1,643,048) of the 1.6 million side impacted light vehicles involved fatalities; a fatal rear collision is typically associated with a high ΔV[21] collision.[22] However, the injury rate in light vehicles that underwent a rear collision in 2020 is comparable to other crash directions, as 30% of rear impacted light vehicles involved injury, while 33% of frontal and 30% of side impacted light vehicles involved injury.

The count of occupant injury and fatality for different collision directions is classified by vehicle type for year 2020 in table II.2 Traffic Safety Facts from FARS and CRSS. Restricting the discussion to light vehicles (passenger cars and light trucks), 6.1% of passenger car occupants and 4.6% of light truck occupants killed were due to rear

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[18] Anderson JO. Dynamics of Occupants in Automotive Accidents Involving Rear Impacts. Warren, MI: Research Laboratories General Motors Corporation; 1961. Report No. R–34–1295.

[19] Severy DM, Mathewson J, Bechtol O. Controlled automobile rear-end collisions and investigation of related engineering and medical phenomena. Can Serv Med J. 1955;11:727–759.

[20] National Center for Statistics and Analysis. (2022, October). Traffic Safety Facts 2020: A compilation of motor vehicle crash data (Report No. DOT HS 813 375). National Highway Traffic Safety Administration.

[21] ΔV is defined as the maximum change in velocity of the struck vehicle after impact.

[22] Wang, J.-S. (2022, May). MAIS(05/08) injury probability curves as functions of ΔV (Report No. DOT HS 813 219) National Highway Traffic Safety Administration.

impacts. The combined light vehicle total was 5.4%. In contrast to the light vehicle fatality rate, the percentage of fatalities in rear impacted large trucks was only 2.9%. This would be consistent with the expectation that rear impact ΔV for large trucks would be on average smaller than for light vehicles.[23]

TABLE II.2—VEHICLE OCCUPANTS KILLED AND INJURED, BY INITIAL POINT OF IMPACT AND VEHICLE TYPE FOR YEAR 2020

Injury severity/initial point of impact	Vehicle type							
	Passenger cars	Light trucks	Large trucks	Buses	Other/ unknown	Subtotal	Motorcycles	Total
Occupants Killed:								
Front	7,724	5,997	523	6	273	14,523	3,444	17,967
Left Side	1,849	1,129	35	1	53	3,067	300	3,367
Right Side	1,633	840	50	0	52	2,575	259	2,834
Rear	822	474	24	1	70	1,391	242	1,633
Other	160	106	16	2	12	296	32	328
Noncollision	581	1,309	146	2	280	2,318	858	3,176
Unknown	703	497	37	4	125	1,366	444	1,810
Total	13,472	10,352	831	16	865	25,536	5,579	31,115
Occupants Injured:								
Front	696,221	440,711	21,175	1,958	3,023	1,163,087	41,952	1,205,039
Left Side	121,449	74,875	4,058	2,623	596	203,600	6,623	210,222
Right Side	109,313	77,510	4,429	920	447	192,620	5,863	198,483
Rear	273,123	194,857	9,136	1,096	698	478,909	4,765	483,675
Other	5,600	3,584	1,228	0	38	10,451	289	10,740
Noncollision	15,248	21,698	4,895	1	2,012	43,854	23,010	66,864
Unknown	381	274	13	23	34	725	26	751
Total	1,221,335	813,509	44,934	6,620	6,849	2,093,246	82,528	2,175,774

Further, according to the 2020 Traffic Safety Facts, 22.3% of passenger vehicle injuries occurred in rear impacts (light trucks = 24.0%, heavy trucks = 20.3%). For each vehicle type, the proportion of fatalities for rear impacts is significantly lower than the corresponding proportion of injuries for rear impacts, compared to other initial impact directions. The rear impact proportion of fatalities in light trucks and heavy trucks is lower than in passenger cars, but the rear impact proportion of injuries in light trucks is slightly greater than in passenger cars and heavy trucks. The disparity in rear collision proportion of injuries for different vehicle types is discussed in the literature review below.

B. CISS Data Analysis

NHTSA also examined the Crash Investigation Sampling System (CISS) data files for the years 2017–2020 to determine the number of rear impacts compared to other crash modes and determine the injury risk (number of injured occupants divided by the number of exposed occupants) of vehicle occupants in rear impacts. These data are limited because CISS currently reports only police reported, tow-away crashes, and, as will be explained later, most rear impacts are not tow-aways. The data were divided into different crash types: rollover, frontal, side, rear, other, and unknown. In addition, for rear impacts, the data were segmented by the change in velocity of the impacted vehicle (ΔV). All data presented here are weighted to represent national estimates. The maximum abbreviated injury scale[24] (MAIS) for each injured occupant is presented so that an occupant with multiple injuries is counted only once in the analysis. An occupant was counted as having a whiplash injury (MAIS 1 neck injury) even if they had other AIS 1 injuries. Crashes with fire have been excluded from the sample. If an occupant had a whiplash injury but also had a MAIS 2+ injury, they were not added to the whiplash injury count. As was the case for the FARS and CRSS data above, we have not restricted the data by seating row.

The total annualized number of involved individuals was estimated to be 4.5 million, including crash types categorized as ''unknown'' and ''other.'' Rear impact crashes accounted for only 373,237 or 8.3% of all tow-away crash involving individuals in the CISS database (Figure II.1). Only rollover crashes yield fewer occupants involved in tow-away crashes. Looking at the proportion of occupants with serious and higher severity injuries (MAIS 3–6) by crash type, we see that MAIS 3–6 are underrepresented in rear impacts (4.3% = 3,814/88,437) and overrepresented in rollover (19.7% = 17,415/88,437). By contrast whiplash injury is overrepresented in rear impacts (15.8% = 31,206/197,060) as compared to the number of towed rear impacts.

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[23] ΔV is inversely proportional to the struck vehicle weight. Large trucks (including single-unit trucks and truck tractors) have a gross vehicle weight rating (GVWR) greater than 10,000 pounds. Passenger cars and light trucks (including pickups, vans, and utility vehicles) have a GVWR not greater than 10,000 pounds.

[24] The severity of injury is reported in CISS 2017–2020 using the 2015 Abbreviated Injury Scale, where AIS 1 are minor injuries, and the 2–6 categories are moderate, serious, severe, critical, and fatal injuries, respectively.

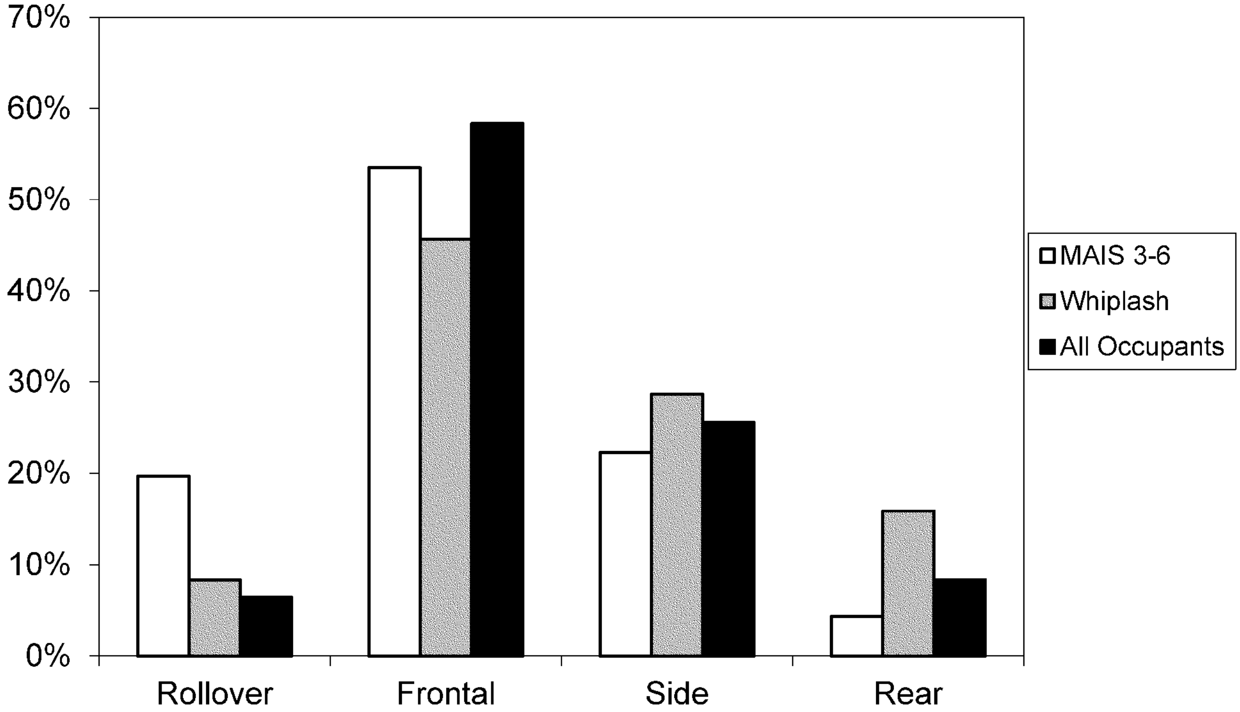

Figure II.1: Proportion of Injured and All Occupants (including uninjured) by Impact Type (2017 – 2020 CISS)

Figure II.2 and Figure II.3 show the risk of MAIS 3–6 and whiplash injury[25] for each towed crash mode. The risk of MAIS 3–6 injury in rear impacts is 1.0% (= 3,814/373,237), which is about 60% of the next highest risk (1.7% for side). The whiplash injury risk in rear impacts is approximately 8.4% (= 31,206/373,237), which is about 1.5 times the next highest risk (5.7% for rollover). These whiplash injury rates do not consider non-towed crashes, where the majority of whiplash injuries are known to occur.[26]

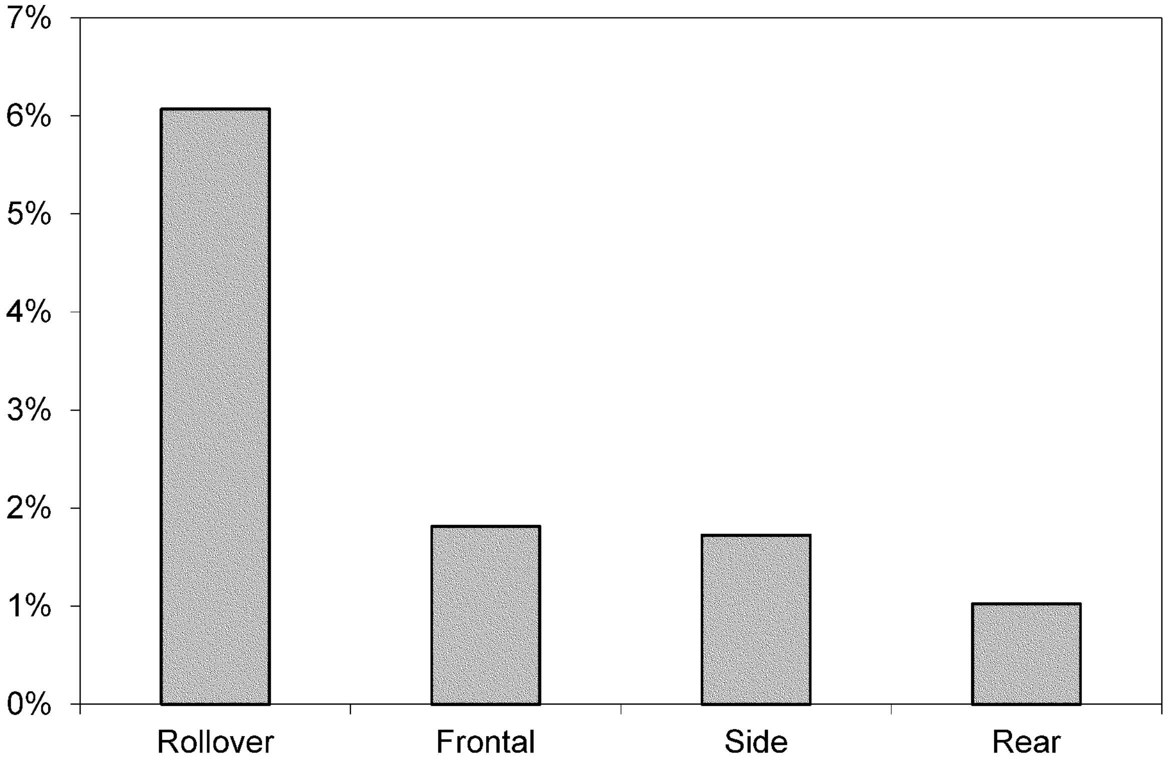

Figure II.2: Risk of MAIS 3 – 6 Injury by Impact Type (2017 – 2020 CISS)

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[25] Risk of MAIS 3–6 injuries in a crash mode is equal to the number of occupants with MAIS 3–6 injuries in that crash mode divided the total number of occupants (injured and uninjured) in that crash mode. Similar computation is done to determine risk of whiplash injuries.

[26] Final Regulatory Impact Analysis for FMVSS No. 202 Head Restraints for Passenger Vehicles, Docket NHTSA–2004–19807.

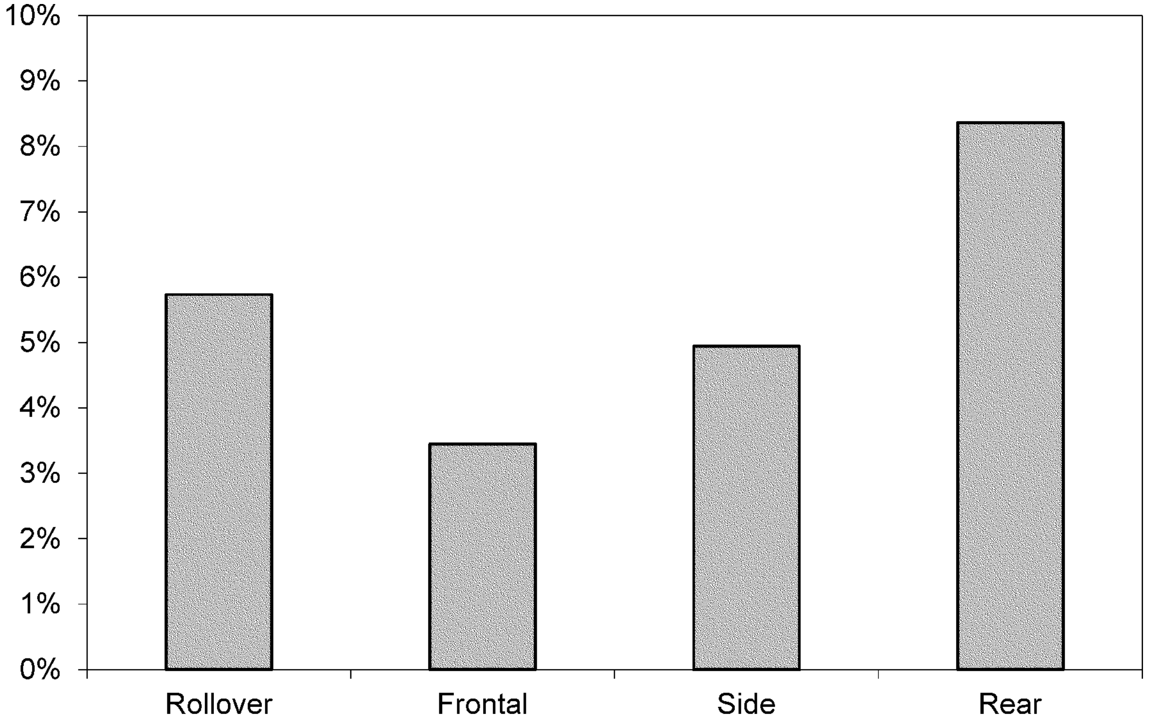

Figure II.3: Risk of Whiplash Injury by Impact Type (2017 – 2020 CISS)

Figure II.4 shows the distribution of towed rear impacts by the change in velocity of the rear impacted vehicle. Most of the crashes are in the 11–20 kilometers per hour (km/h) (6.8–12.4 miles per hour (mph)) ΔV range. Table II.3 provides tabulated annual occupant injuries in rear collisions according to injury severity and ΔV. For occupants in a known ΔV rear impact crash, the majority of injuries are estimated to be no injury (MAIS 0) in all ΔV ranges. The most probable known ΔV range for injury of any type is the 11–20 km/h (6.8–12.4 mph) category, which is consistent with this being the most common impact speed range. More than three-quarters of MAIS 3+ rear impact injuries occur above 31 km/h (19.3 mph). Figure II.5 gives the risk of MAIS 2 and MAIS 3+ injuries as a function of impact ΔV in towed rear crashes. The highest risk for MAIS 2 injuries is 8.4% (= 891/10,630) for 51+ km/h (31.7+ mph) ΔV crashes. The highest risk for MAIS 3+ is 7.0% (= 1,572/22,425) for the 31–40 km/h (19.3–24.9 mph) ΔV range. Figure II.6 shows that for whiplash, the highest risk is 11.7% (= 2,624/22,425) for injury in towed crashes occurring in the 26–35 km/h (16.2–21.8 mph) range. The risk at 51+ km/h is similar at 11.1% (= 1,183/10,630) and at other speeds is between 2.8% and 9.7%.

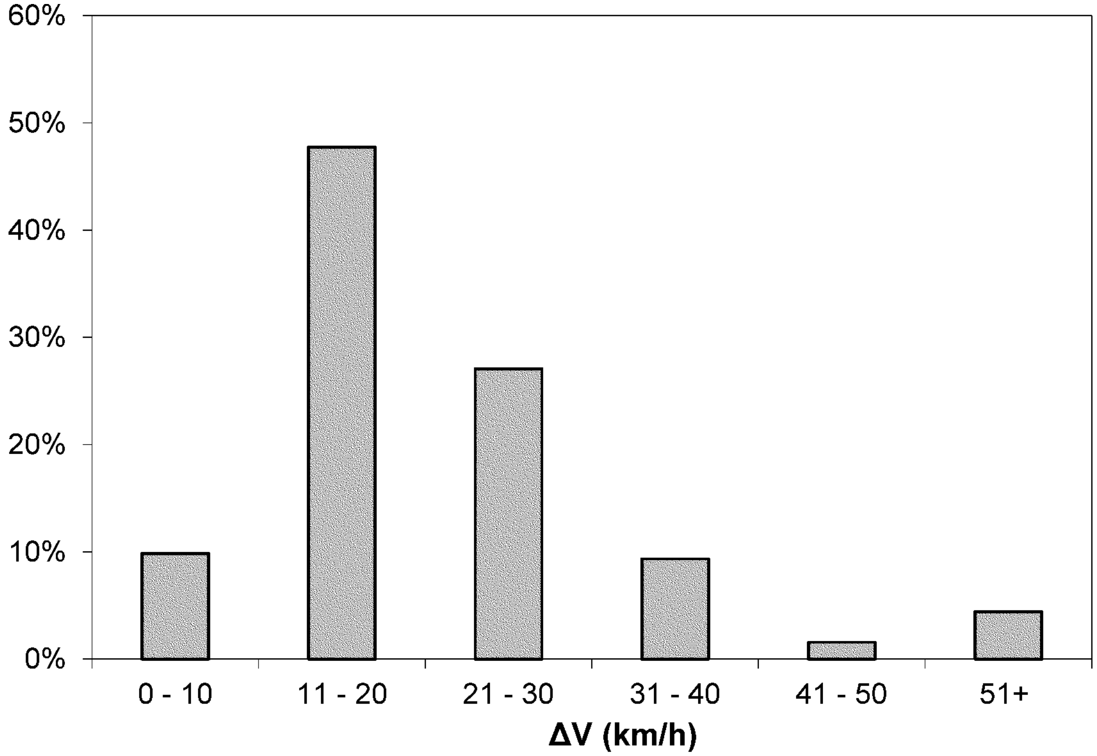

Figure II.4: Distribution of Towed Rear Impacts by ΔV (2017 - 2020 CISS)

TABLE II.4—ANNUAL REAR IMPACT INJURY BY ΔV

[2017–2020 CISS]

ΔV (km/h)	MAIS 0	Whiplash	MAIS 1 no whiplash	MAIS 2	MAIS 3–6	Total
Unknown	101,022	12,637	13,950	4,495	789	132,893
0–10	22,057	675	913	59	0	23,704
11–20	88,352	7,680	15,469	2,793	474	114,769
21–30	46,618	6,302	10,429	1,455	249	65,052
31–40	13,085	2,624	4,157	988	1,572	22,425
41–50	1,811	107	1,661	94	92	3,764
51+	5,173	1,183	2,746	891	638	10,630
Total Known ΔV	177,095	18,569	35,375	6,279	3,025	240,345
Total	278,117	31,206	49,325	10,775	3,813	373,237

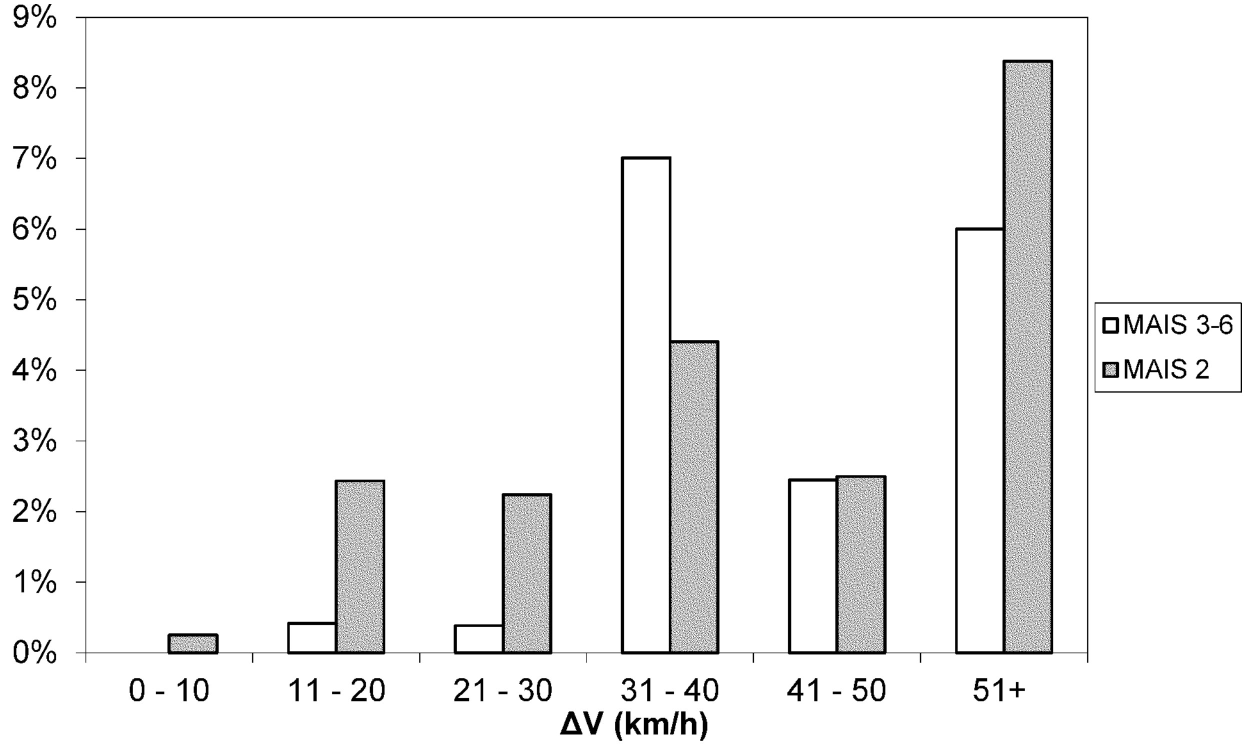

Figure II.5: Risk of MAIS 2 and 3 - 6 injuries by Rear Impact ΔV (2017 - 2021 CISS)

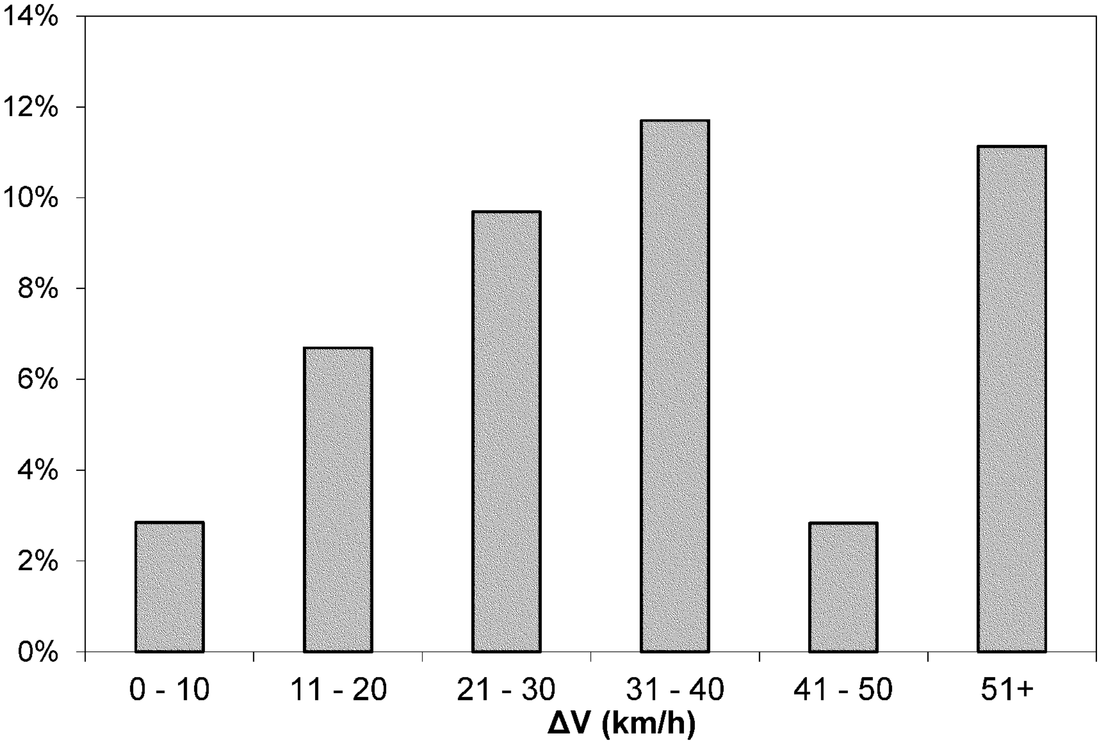

Figure II.6: Whiplash Injury Risk by Rear Impact ΔV (2017 - 2020 CISS)

Figure II.6 provides the whiplash injury rates for towed crashes. CISS does not collect injury data for non-towed crashes. In 2004, using State data, the Final Regulatory Impact Analysis for the upgrade of FMVSS No. 202 found four times as many whiplash injuries in all crashes compared to those in tow-away crashes. NHTSA plans to update this analysis to accurately represent the current whiplash injury risk. Older field data, however, are still useful to provide a sense of the very large proportion of whiplash injuries that occur at low speed.

With historical data, we can attempt to generate estimates that include non-towed whiplash. Between 1982 and 1986, non-towed crash data were collected. Table II.5 shows the distribution of an approximation of whiplash injuries occurring in towed and non-towed impacts for the 1982–86 National Automotive Sampling System (NASS) data. The greatest ratio of non-towed to towed whiplashes was 20 times for the 0–10 km/h (0–6.2 mph) ΔV range. The next highest ratio was for the 11–20 km/h (6.8–12.4 mph) range at 8 times.[27] As expected, this ratio drops significantly at higher speeds because there are fewer non-towed crashes at these speeds. If we use the ratio of NASS data for non-towed to towed crashes as a multiplier for the CISS towed whiplash injury estimates in each speed range to attempt to account for the non-towed whiplash injuries in the newer data set, the result is column four in table II.5. If we distribute proportionally the cases of whiplash injuries where the impact speed was unknown to the known cases, the result is given in the fifth column. In this column we see that more than three-quarters (125,221/161,623) of all whiplash injuries occur at impact ΔV less than 20 km/h (12.4 mph). For only towaway rear impacts (not shown graphically) this ΔV limit captures 45% (8,355/18,570) of whiplash injuries. The whiplash injury distribution is shown graphically in Figure II.7. This estimate is provided to give a general sense of how considering whiplash injury only in tow-away crashes significantly underestimates overall whiplash injury distribution, particularly for lower speed crashes. This estimate comes with a large degree of uncertainty because it is based on historical NASS data.

TABLE II.5—ADJUSTMENTS TO WHIPLASH INJURIES TO ACCOUNT FOR NON-TOWED CRASHES

ΔV (km/h)	Ratio total to towed (82–86 NASS)	Towed whiplash injury (2017–2020 CISS)	Compensated whiplash injury	Unknown ΔV distributed
Unknown	5.1	12,637	64,553	
0–10	19.8	675	13,339	22,210
11–20	8.1	7,680	61,868	103,011
21–30	2.8	6,302	17,550	29,220
31–40	1.1	2,624	2,768	4,609
41–50	1.0	107	110	184
51+	1.0	1,183	1,183	1,972
Total Known ΔV		18,570	96,819	
Total		31,207	161,372	161,372

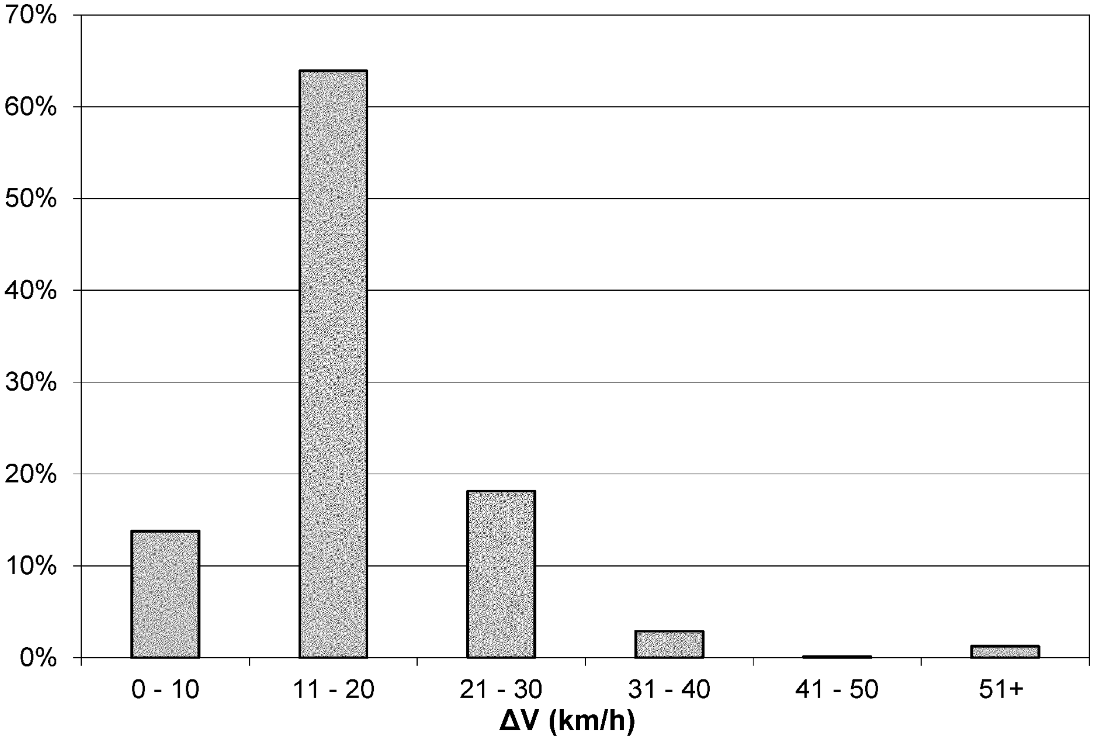

Figure II.7: Distribution of Whiplash Injury by Impact ΔV for Rear Impacts (2017 - 2020 CISS) with Compensation for Whiplash Injury in Non-Towed Vehicles

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[27] We note that these ratios are approximations from a slightly different ΔV segmentation.

C. Field Data Analyses From Relevant Literature

In an earlier 1997 study of the National Automotive Sampling System-Crashworthiness Data System (NASS–CDS) across years 1980–1994, Prasad [28] found that rear impact collisions accounted for 11% of all possible struck vehicle scenarios. The distribution of crashes indicated that 50% of all rear impacts occur at ΔVs of 21 km/h (13 mph) or less, 86% occur at ΔVs less than 32 km/h (20 mph) and 94% occur at ΔVs of 40 km/h (25 mph) or less. Furthermore, when examining the distribution of injuries, it was found that less than 1% of rear end collisions resulted in severe injury of AIS 3 or more.

In another study, Parenteau [29] examined 1999 to 2015 NASS–CDS crash data to investigate the risk for MAIS 3+ outcomes including fatalities in crashes involving vehicles from model year (MY) 2000 and later. The risk for severe injury was lowest in rear crashes. The authors found head trauma to be the most likely severe injury for frontal passengers in rear collisions, followed by thorax and spinal injuries. The severe injuries were mostly the result of contact with the windshield, head restraint, and B-pillar. Many of these severe injuries develop from a seat retention issue (such as not wearing a seat belt) in which the occupant decouples from the seating system. It is unclear to what extent seat strength and retention issues overlap. The most severe injuries were attributed to forward intrusion of rear components.

Most rear collisions lead to a relatively low ΔV of the struck vehicle and this contributes to moderating injury of the vehicle occupants. The characteristics of the struck vehicle affect the injury severity and fatality risk of the occupants. As discussed in the next section, the majority of reported rear collision injuries are cervical injuries with or without clear pathology, while a small percentage of rear collisions are associated with high ΔV and severe injuries.

III. Statutory and Regulatory Background

A. The Safety Act and the Infrastructure, Investment and Jobs Act

Congress enacted the Safety Act for the purpose of ‘‘reduc[ing] traffic accidents and deaths and injuries resulting from traffic accidents.’’ [30] To accomplish this, the Safety Act authorizes the Secretary of Transportation to promulgate FMVSSs as well as to engage in other activities such as research and development. The Secretary has delegated the authority for implementing the Safety Act to NHTSA.[31] The Safety Act requires that FMVSSs ‘‘be practicable, meet the need for motor vehicle safety, and be stated in objective terms.’’ [32] To meet the Safety Act's requirement that standards be ‘‘practicable,’’ NHTSA must consider several factors, including technological and economic feasibility.[33]

In IIJA, Congress required NHTSA to issue this ANPRM to update FMVSS No. 207. The statute further states that if the Secretary determines a final rule complies with the Safety Act, a rule shall be issued with a compliance date not later than 2 motor vehicle model years after the model year the rule goes into effect.[34] Under this requirement, NHTSA is required to issue a final rule only if it meets the requirements of the Safety Act, namely that it is practicable, meets the need for safety, and is objective. In determining whether to proceed with the rulemaking, NHTSA must also consider all of the factors set forth in 49 U.S.C. 30111(b).

B. Regulatory History of FMVSS No. 207 and FMVSS No. 202, and Associated Research/Analyses

1. 1963—SAE Recommended Practice for Seats

The basis of the current FMVSS No. 207 standard is a recommended practice established by SAE International on November 1, 1963: SAE J879—Passenger Car Front Seat and Seat Adjuster. SAE J879 established uniform test procedures and minimum performance requirements for motor vehicle seats and seat adjusters.

J879 defined two test procedures. The first procedure, ‘‘Simulated Occupant Loading,’’ tested rearward seat back strength. It required a seat back to withstand a rearward moment of 480 Nm (4,250 in-lb) that was generated via a static load applied to the uppermost cross member of the seat back frame. However, this moment was calculated ‘‘about the rear attachments of the seat frame to the seat adjusters.’’ The July 1, 1968, revision to J879, J879B—Motor Vehicle Seating Systems, modified the moment to 373 Nm (3,300 in-lb) measured about the H-point, and the direction of the force was specified to be perpendicular to the seat back frame angle. The other procedure, ‘‘Simulated Inertial Loading,’’ established a 20 g minimum strength requirement for horizontal inertial seat loadings, applied in both the forward and rearward direction. This specification was designed to ensure that seat anchorages were strengthened to the point where the seats would remain attached to the vehicle body structure (typically the floor), preventing their inertia from releasing them and creating a ram-like action within the passenger compartment. During these tests, the seat back is braced to the seat base to isolate the seat attachment to the vehicle.

2. 1967—Publication of FMVSS No. 207, Seating Systems

In February 1967, FMVSS No. 207 was enacted, and it went into force beginning with MY 1969 passenger cars.[35] It was later extended to multipurpose vehicles, trucks, and buses in 1972.[36]

FMVSS No. 207 mostly mirrored the 1963 version of SAE J879. However, the minimum rearward moment requirement was set at 373 Nm (3,300

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[28] Prasad, Priya, et al. ‘‘Relationships between passenger car seat back strength and occupant injury severity in rear end collisions: Field and laboratory studies.’’ *SAE transactions* (1997): 3935–3967.

[29] Parenteau, Chantal S., and David C. Viano. ‘‘Serious head, neck and spine injuries in rear impacts: frequency and sources.’’ *IRC–21–10, IRCOBI Conference.* 2021.

[30] 49 U.S.C. 30101.

[31] 49 CFR 1.94.

[32] 49 U.S.C. 30111(a). The Secretary must also (1) consider relevant available motor vehicle safety information; (2) consult with the agency established under the Act of August 20, 1958 (Pub. L. 85–684, 72 Stat. 635), and other appropriate State or interstate authorities (including legislative committees); (3) consider whether a proposed standard is reasonable, practicable, and appropriate for the particular type of motor vehicle or motor vehicle equipment for which it is prescribed; and (4) consider the extent to which the standard will carry out the purpose of the Safety Act to reduce traffic accidents and deaths and injuries resulting from traffic accidents. 49 U.S.C. 30111(b).

[33] *See, e.g., Paccar, Inc.* v. *Nat'l Highway Traffic Safety Admin.,* 573 F.2d 632, 634 n.5 (‘‘ ‘Practicable’ is defined to require consideration of all relevant factors, including technological ability to achieve the goal of a particular standard as well as consideration of economic factors.’’) (citations and quotations omitted). Technological feasibility considerations counsel against standards for which ‘‘many technical problems have been identified and no consensus exists for their resolution . . .’’ while economic feasibility considerations focus on whether the cost on industry to comply with the standard would be prohibitive. *Simms* v. *Nat'l Highway Traffic Safety Admin.,* 45 F.3d 999, 1011 (6th Cir. 1995); *See, e.g., Nat'l Truck Equip. Ass'n* v. *Nat'l Highway Traffic Safety Admin.,* 919 F.2d 1148, 1153–54 (6th Cir. 1990).

[34] IIJA, section 24204 (2021).

[35] 32 FR 2415 (Feb. 3, 1967).

[36] 36 FR 22945 (Dec. 2, 1971).

in-lb) as measured about the H-point.[37] Additionally, provisions were added for seats that folded forward to allow access to rear seats and to assure that seats had a positive restraining device (latch) to prevent them from swinging forward during a frontal crash. This prevented adverse inertial forces by a flailing seat back to the back of an occupant as they pitched forward during a frontal collision. The additional requirement also helped protect unrestrained rear seat occupants during frontal crashes or a hard breaking event who might otherwise get thrown over a pitched-forward seat back and could suffer injuries due to head impacts with the windshield or dash panel.

The new provision required the latch (and, hence, the seat back itself) to withstand a forward load of 20 times the weight of the seat back. The load was applied to the seat back at its center of gravity. There was a concurrent revision to SAE J879 in July 1968. SAE also changed the moment value and its reference point in J879 to be consistent with FMVSS No. 207. However, the SAE requirement applied the force generating the moment in a direction perpendicular to the seat back instead of horizontally (see Figure III.1). The result of this change was that a slightly higher force must be applied in FMVSS No. 207 to achieve the same moment level.[38] Since then, the requirements of FMVSS No. 207 and SAE J879B have not changed.

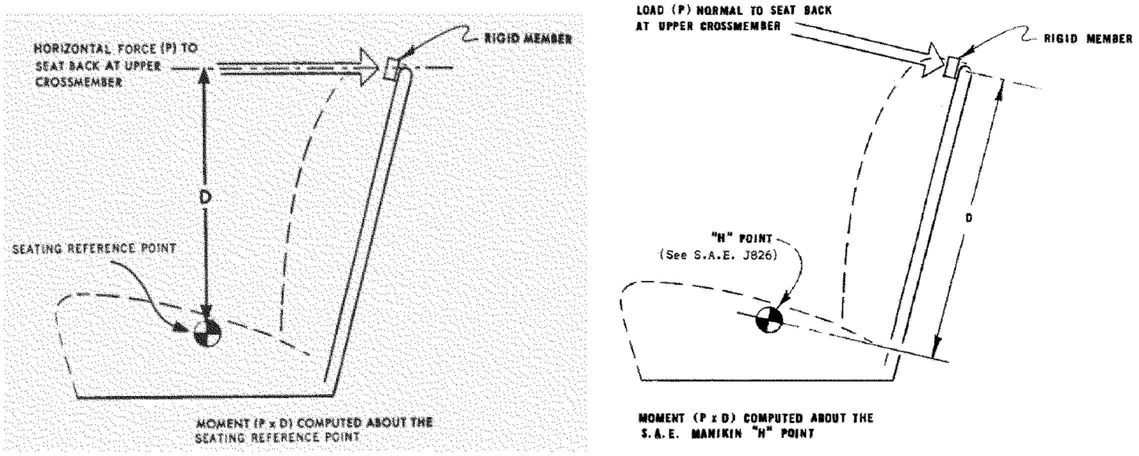

Figure III.1 – FMVSS No. 207 moment schematic (left). SAE J879 moment schematic (right).

3. 1968—Publication of FMVSS No. 202, ''Head Restraints''

In 1968, NHTSA issued FMVSS No. 202, ''Head restraints,'' requiring head restraints on cars manufactured after January 1, 1969.[39] The standard specified that the head restraint must sustain an 890 N (200 lb-f) rearward load applied 65 mm (2.5 in) below the top of the head restraint, while deflecting less than four inches (102 mm) and without a seat back failure. The standard also specified that the top of the head restraint must be at least 700 mm (27.5 in) above the H-point as measured along the torso reference line of the J826 manikin.[40] This effectively placed a 565 Nm (5,000 in-lb) moment minimum strength requirement on the seat back while also placing a lower bound on seat back stiffness because this moment must be achieved within a specified amount of deflection. Thus, between FMVSS Nos. 202 and 207, all requirements for seat back strength were set forth through static loads.

4. 1969—Report on Seat Safety Studies at ITTE

Following the issuance of FMVSS No. 207, Derwyn Severy, a principal investigator at the Institute of Transportation and Traffic Engineering (ITTE) at UCLA, published a paper[41] at the 13th Stapp Car Crash Conference advocating safer seat designs (''Stapp paper''). The ITTE had been conducting field investigations and crash tests throughout the 1960s as they worked to develop design concepts for vehicle seats.

The 1969 Stapp paper provided the basis for several seat design recommendations. Included were recommendations to increase the seat back strength requirement to 11,300 Nm (100,000 in-lb) and limit the seat back rotation to 10 degrees in a quasi-static test. According to Severy, this load level was consistent with collision-induced forces caused by the seat inertial forces augmented by a 50th percentile male occupant in a 30 g rear-end crash.

In 1976, Severy published a follow-on paper on seat design.[42] In it, he offered his observations on safety improvements in production seats brought about by the 1968 standard: ''that laboratory tests established that production seats from cars large and small, foreign and domestic, and from vehicles 30 years old to new, have seat back strengths remarkably alike and that substantially exceed the required FMVSS No. 207 criteria.'' Severy additionally stated that production seats were incapable of effectively resisting motorist inertial forces for any but light impact exposures without experiencing excessive yield and/or component separation.

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[37] The rulemaking that established FMVSS No. 207 did not discuss why it set a rearward moment with a different reference point and value than recommended by the 1963 version of SAE J879. *See* 32 FR 2415.

[38] The magnitude of the force increase is equal to the inverse of the cosine of the angle of the seat back from the vertical. So a seat back with a 25 deg angle would have a 1.1 (1/cos(25)) times greater load applied in FMVSS No. 207 than in SAE J879.

[39] 33 FR 2945 (Feb. 12, 1968).

[40] SAE J826–1995: Devices for Use in Defining and Measuring Vehicle Seating Accommodation; 49 CFR 571.10; 73 FR 58896 (Oct. 8, 2008).

[41] Severy, Derwyn M.; Brink, Harrison M.; Baird, Jack D; Blaisdell, David M.; ''Safer Seat Designs,'' Proceedings of the 13th Stapp Car Crash Conference Society of Automotive Engineers; Warrendale, PA December 2–4, 1969; Boston, MA.

[42] Severy, D.M., Blaisdell, D.M., and Kerkoff, J. F.; ''Automotive Seat Design and Collision Performance,'' 1976 SAE Transactions, Sec. 4, Vol. 85.

5. 1974—Notice of Proposed Rulemaking (NPRM) To Revise FMVSS No. 207

In February 1974, Carl Nash of the Public Interest Research Group petitioned NHTSA to implement a dynamic requirement for seat backs. He asked NHTSA to add a rear impact test into FMVSS No. 208, ''Occupant crash protection,'' with acceptance criteria based on head rotation of a seated crash test dummy. Nash also called on NHTSA to consolidate FMVSS No. 202 with FMVSS No. 207 because of the close relationship between head restraints and seats in mitigating injuries in rear impacts.

In March 1974, NHTSA published an NPRM that included proposed seat back requirements that essentially mirrored Nash's request.[43] However, instead of amending FMVSS No. 208, NHTSA proposed to add the dynamic barrier test to a new, revised version of FMVSS No. 207. The test was to be conducted using the same moving barrier apparatus as that of the FMVSS No. 301 rear impact test for fuel system integrity, which had been proposed a year earlier.[44] Although a seated dummy was specified, NHTSA did not propose any requirements based on dummy head rotation as requested by Nash. Instead, NHTSA proposed a maximum seat back rotation of 45 degrees. The proposal also integrated the requirements of FMVSS No. 202 into a single, consolidated standard.

To support a decision for a final rule, NHTSA contracted with the University of New Mexico to conduct rear impact tests. Sled tests were run on yielding vs. rigid seat backs using post-mortem human subjects (PMHS).[45] At the time, NHTSA was concurrently investigating whether to revise FMVSS No. 202 to better mitigate the effects of whiplash. In consideration of this, rigid and yielding seats were tested with and without a head restraint. Sled tests were run by simulating a crash in which a stationary vehicle is struck from the rear by another vehicle having the same mass and travelling at a speed of 51 km/h (32 mph). The investigators observed that with no head restraint, rigid seats produced higher whiplash effects than yielding seats in low-speed rear impacts. Also, ramping was exacerbated in rigid seats with no head restraint. Thus, the results were deemed to be inconclusive as to whether yielding seats or rigid seats reduced the risk of injury. In addition to the work at the University of New Mexico, other basic research was being conducted on the more general topic of human injury tolerance to rearward forces and the biofidelity of the neck response of test dummies in rear impacts.[46] [47] It is noteworthy that NHTSA commissions another study in 1974 on the safety of occupants of large school buses (school buses with gross vehicle weight rating (GVWR) greater than 4,536 kilogram (kg) (10,000 pounds (lb))) prior to issuance of FMVSS No. 222.[48] Following this study, NHTSA developed the concept of seating compartmentalization for school buses, which led to the following conclusion regarding the seating system: ''The seats and restraining barriers must be strong enough to maintain their integrity in a crash yet flexible enough to be capable of deflecting in a manner which absorbs the energy of the occupant.'' [49] At least in the context of larger school buses, NHTSA found there was a benefit to yielding seats that maintain structural integrity in order to maintain occupant compartmentalization when occupants were not protected by seat belts. Based on this conclusion, NHTSA developed a force-deflection requirement for the forward and rearward directions for large school bus seat backs.[50] The rearward requirement protects occupants in a rear collision, analogous to the rear impact issue discussed in this document.[51]

6. 1978—NHTSA Publishes a Request for Comment on Rulemaking Priorities

On March 16, 1978, NHTSA published a Request for Comments on the agency's plan to prioritize ongoing rulemaking efforts.[52] In establishing priorities for the plan, NHTSA stated that limited resources needed to be focused on rules with the largest safety benefits. It identified the 1974 proposal to require stiffer seats as one of several open rulemakings with low priority and proposed to terminate it. In 1979, when the plan was issued, the 1974 proposal was terminated.[53] No public comments were received in response to the request for comments.

Over the next several years, NHTSA continued to investigate the safety of occupants in rear impacts. Beginning in 1979, NHTSA conducted over 30 full-scale rear-impact crash tests on vehicles with instrumented dummies seated in the front seats. The FMVSS No. 301 barrier was driven into the stationary vehicles at speeds ranging from 48–56 km/h (30 to 35 mph). These rear impact crash tests are catalogued online.[54]

7. 1989—NHTSA Receives Petitions for Rulemaking on Revisions to FMVSS No. 207

In 1989, Kenneth J. Saczalski and Alan Cantor submitted their first petitions for rulemaking on this subject to NHTSA.[55] [56] Saczalski sought an increase in the seat back moment requirement in FMVSS No. 207 from 373 Nm (3,300 in-lb) to 6,330 Nm (56,000 in-lb),a factor of 17 increase. The aim was to reduce the incidence of injuries due to ramping and ejection in rear-end crashes. On July 24, 1989, NHTSA notified Saczalski that his petition was granted.

Cantor's 1989 petition asked NHTSA to amend FMVSS No. 207 to eliminate occupant ramping during a rear impact. Cantor did not provide a standardized test procedure to measure and assess ramping, nor did he describe a practicable countermeasure that could prevent ramping. Nonetheless, on February 28, 1990, NHTSA notified Cantor that his petition was granted.

After granting these petitions, NHTSA published another request for comments (1989 RFC) on the need for amending the seat back performance requirement in FMVSS No. 207 and opened a docket to receive comments on the petitions and pertinent issues.[57] In his comments submitted to this docket, Saczalski provided additional recommendations.[58] He asked NHTSA

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[43] *See,* 39 FR 10268 (Mar. 19, 1974).

[44] *See* 38 FR 22417 (Aug. 20, 1973).

[45] Hu, Anthony S., Stewart P. Bean, and Roger M. Zimmerman. Response of belted dummy and cadaver to rear impact. No. 770929. SAE Technical Paper, 1977.

[46] Ewing, Channing L., et al. ''Effect of duration, rate of onset and peak sled acceleration on the dynamic response of the human head and neck.'' *Proceedings: Stapp Car Crash Conference.* Vol. 20. Society of Automotive Engineers SAE, 1976.

[47] Muzzy, W. H. I., and Leonard Lustick. ''Comparison of kinematic parameters between hybrid II head and neck system with human volunteers for minus-Gx acceleration profiles.'' *Proceedings: Stapp Car Crash Conference.* Vol. 20. Society of Automotive Engineers SAE, 1976.

[48] 39 FR 27584 (July 30, 1974).

[49] 72 FR 65509 (Nov. 21, 2007).

[50] 49 CFR 571.222—Standard No. 222; School bus passenger seating and crash protection.

[51] A rear impact into a large school bus is a much less severe impact environment for the occupants of the bus than that of occupants of a light vehicle experiencing an equivalent rear impact.

[52] 43 FR 11100 (June 7, 1978).

[53] 44 FR 24591 (Apr. 26, 1979), ''Five Year Plan for Motor Vehicle and Fuel Economy Rulemaking''.

[54] *https://www.nhtsa.gov/research-data/research-testing-databases#/vehicle/.*

[55] Docket 89–20-No.1–001 or Docket NHTSA–1996–1817–0002. Both petitions have significant overlap to the 2014 Saczalski and 2015 Cantor petitions discussed in this document.

[56] The previous NHTSA Seat Dockets, 89–20 Notices 1–3, are now available on the Docket Management System (DMS) at NHTSA–1998–1817, –4047 and –4064, respectively.

[57] 54 FR 40897 (Oct. 4, 1989). Originally NHTSA Docket 89–20–No. 1, and later transferred to Docket NHTSA–1996–1817.

[58] Docket NHTSA–1996–1817–0002.

to also include a dynamic rear impact crash test using the FMVSS No. 301 barrier and a 95th percentile male dummy in the seat.

Most comments from the automotive industry on the 1989 Saczalski and Cantor petitions opposed any new seat back stiffness requirements. They argued that real-world crash data did not indicate that a safety-related problem existed. General Motors, for example, cited its own field data to conclude that any benefits associated with seat standard changes for rear impact protection were very limited.[59] Ford cited a study of real-world crashes to conclude that a safety need did not exist.[60] The authors of that analysis had also reviewed test data from prior studies (including those of Severy, et al). They concluded that rigid seat backs would probably exacerbate injuries because yielding seats absorb energy safely as they deform, thus reducing injurious forces borne by the occupant, including whiplash-causing forces. Occupant rebound from a rear impact and a subsequent hard thrust forward was also cited as a negative effect of rigid seats. Furthermore, a follow-up study by two of the same authors concluded that ramping is more likely to occur in a rigid seat regardless of whether a seat belt is used or a head restraint is in place.[61] On the other hand, Mercedes-Benz supported an upgrade to FMVSS No. 207.[62] It noted that seats in Mercedes vehicles were specifically designed to reduce the danger to front and rear occupants during rear impacts as a result of excessive rearward seat back deformation and the resultant interaction between occupants.

At the time, NHTSA commissioned a study on injury incidence to support a rulemaking decision.[63] This analyzed the problem using NASS real-world crash data. The study confirmed that seat back yield in severe rear crashes does occur.[64] Severe crashes were found to be infrequent, however, amounting to approximately 5% of all rear impacts. The study also showed that impacts with components in the rear seat compartment and ejections are a relatively small portion of the injuries. Injuries due to occupant impacts to components in the rear seat compartment accounted for 2.8% (unrestrained occupant) and 0.1% (restrained occupant) of the most severe injury to front seated occupants in rear impacts, and only 3.2% of all harm to unrestrained occupants in rear impacts involved occupant ejection.

The study also concluded that current seat designs provided reasonable safety in rear-end crashes, and that seat belts are effective in reducing injuries. The report suggested that new head restraint designs offered the best possibility to mitigate the largest portion of injuries in rear-end crashes.

Additionally, Transport Canada submitted a report to the docket of 23 case studies of real-world rear impacts, all of which involved vehicles that experienced seat back failures, and 11 of which resulted in occupant ejections.[65] Of the cases involving a rear seat passenger, four of the five rear passengers sustained injuries attributed to seat back failure of the front seat.

NHTSA provided a summation of the comments and reports in a 1992 summary report.[66] This document was placed in the docket for the safety plan discussed below. The report concluded that improving seating system performance may be more complex than simply increasing the strength of the seat back, and that a proper balance in seat back strength and compatible interaction with head restraints and seat belts must be obtained to optimize injury mitigation.

8. 1992–2000 NHTSA Publishes a Request for Comment on Possible Revisions to FMVSS No. 207, Grants Two Petitions and Conducts Research

In November 1992, the agency published another Request for Comment on more recent research findings and a proposed plan to address seat back performance.[67] At that time, the agency had refrained from upgrading FMVSS No. 207 until significant results from research were obtained, though the rulemaking action resulting from the 1989 petition grants was still open. The first document the agency placed in the docket was a report summarizing agency findings up to that point. The 1992 report stated that four categories of performance issues need to be addressed as part of potential future changes to FMVSS No. 207.[68] These four categories are:

(1) Seating system integrity: the ability of the seat and its anchorage to the vehicle to withstand crash forces without failure.

(2) Energy absorbing capability: the extent to which the seat and its attachment components absorb energy and the manner in which the seat and its attachment components release energy during rebound.

(3) Compatibility of a seat and its head restraint: The concern in this category is that any change in seat back energy absorbing capability could exacerbate head or neck injuries if the geometry and energy absorbing capability of the head restraint is not also changed.

(4) Seat belt restraint system: a seating system and its seat belt restraint system must complement each other to prevent injury.

Over the ensuing 10-year period, the agency conducted extensive physical testing of seat backs, performed computer modeling of seated occupants in rear impacts, and conducted dynamic testing of instrumented test dummies in vehicle seats. At the same time, NHTSA also assessed how new requirements for head restraints could mitigate whiplash injury in lower-speed rear-end crashes. The details of those efforts are outlined in several NHTSA reports provided in docket folder NHTSA–1998–4064 (document numbers 24–27, 31).

NHTSA also granted two more petitions related to seat back strength: King (March 1998)[69] and Hogan (December 1998).[70] King petitioned for a dynamic test using the FMVSS No. 301 rear impact test procedure. Hogan stated that conformance to the current regulation was being used in litigation as a defense for the performance of contemporary seat designs, and therefore asked NHTSA to ‘‘suspend’’ FMVSS No. 207 until such time that the standard could be improved.

In comments posted in dockets NHTSA–1996–1817[71] and NHTSA–1998–4064,[72] most in the automobile industry argued that seat back deformation was protective to the occupant by absorbing some crash energy. However, there was recognition that better seat back performance requirements could improve occupant safety in rear impacts greater than 40 km/h (25 mph). Greater control of

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[59] Docket NHTSA–1996–1817–0010.

[60] Docket NHTSA–1996–1817–0004.

[61] James, M.B., Strother, C.E., Warner, C.Y., Decker, R.L., & Perl, T.R. (1991). Occupant protection in rear-end collisions: I. Safety priorities and seat belt effectiveness. SAE transactions, 2019–2027.

[62] Docket NHTSA–1996–1817–0015.

[63] ‘‘Current Issues of Occupant Protection in Car Rear Impacts,’’ February 1990, Data Link, Inc., NHTSA Docket 89–20–No. 1–21 or Docket Management System NHTSA–1996–1817–22.

[64] This study considered severe crashes as those with a vehicle change in velocity greater than 15 mph, CDC extent of damage (exterior vehicle damage) greater than 3, and at least one occupant with a maximum AIS of 3 or greater or with hospitalization or fatality.

[65] NHTSA Docket 89–20–No. 1–018 or Docket Management System NHTSA–1996–1817–019.

[66] NHTSA Docket 89–20–No. 3–001 or Docket Management System NHTSA–1998–4064–001.

[67] 57 FR 54958 (Nov. 23, 1992).

[68] ‘‘Summary of Safety Issues Related to FMVSS No. 207,’’ (1992), NHTSA–1998–4046–001.

[69] NHTSA–1998–4377–0001.

[70] NHTSA–1999–5482–0008.

[71] These were originally posted to NHTSA Docket 89–20-No 1, and subsequently transferred to Docket NHTSA–1996–1817.

[72] These were originally posted to NHTSA Docket 89–20-No 3, and subsequently transferred to Docket NHTSA–1998–4064.

occupant kinematics in severe rear crashes was thought to enhance occupant safety, even for belted occupants, by controlling rearward deflection of the seat back. Further comments presented by the Advocates for Highway and Auto Safety expressed concern about the harm caused by bodily impact with vehicle structures and noted the importance of negating excessive seat back rotation, ramping, and occupant rebound. One individual consultant described the consultant's opinion regarding the deficiency of FMVSS No. 207 and the impact that the standard may have had on automotive seat designs from that time. Another consulting firm expressed concern about the level of deformation that occurs due to the force applied to seat backs of that time in rear impacts and its effect on the effectiveness of the restraint systems in higher severity rear impacts.

The comments and research at the time affirmed that the issues of seat back, head restraint, and belt retention were inextricably linked to overall occupant safety. For example, in studies such as the 1997 Prasad,[73] 1977 University of New Mexico study, and 1976 Severy study, the disbenefits of a rigid seat were particularly evident in seats with baseline head restraints.[74] In the 1997 Prasad study for example, the authors found that stiffer seats led to higher neck and lumbar spine loads in rear impact tests. One complicating factor from this period is that most of the laboratory tests were performed with Hybrid II or Hybrid III 50th percentile male (HIII–50M) dummies, which are seated dummies designed based on human indices measured in frontal crashes. The torso and pelvis of these dummies do not articulate well in rear impacts, and such articulation is needed to faithfully exhibit ramping. While a larger size ATD would more fully exercise a seat back in a rear impact, the additional use of a smaller ATD with female-specific characteristics may have provided a more comprehensive assessment of occupant kinematics and injury risk for different seat designs in these earlier studies. Comments posted in the docket also emphasized the rear impact protection points NHTSA made in the 1992 study, in particular the need for energy absorption of the seat back, while also recognizing that performance requirements may enhance rear impact protection.

9. 2004—NHTSA Issues Final Rule Upgrading FMVSS No. 202, Head Restraints

NHTSA's research on rear impact crashes and head restraints led the agency in January 2001, to address the problem of whiplash injuries by proposing to upgrade the head restraint standard, FMVSS No. 202.[75] At the time, the agency estimated that approximately 800,000 whiplash injuries occurred annually in all crash types, resulting in a total annual cost of $5.2 billion. Whiplashes in rear impacts were estimated to be about 270,000 annually.

After considering public comments on the proposal, NHTSA published the final rule on December 14, 2004.[76] It was estimated to reduce the number of whiplash injuries by about 17,000 per year. The revised standard imposed an increased head restraint height requirement such that all outboard front seat head restraints must be capable of adjusting to at least 800 mm (31.5 in) and not have an adjustment position below 750 mm (29.5 in). It also imposed a minimum backset[77] measurement that required the head restraint to be closer to the back of a seated occupant's head. The updated standard maintained the requirement for the head restraint to withstand a 200 lb-f or 890 N rearward force applied 65 mm (2.5 in) below its top, when adjusted to its highest position, which must be at least 800 mm. Thus, this imposes an effective rearward strength requirement on seat backs of 654 Nm (5,790 in-lb), where 654 = 890*(0.8–0.065). This is a factor of 1.75 greater than the rearward strength requirement of FMVSS No. 207.

10. 2004—NHTSA Terminates Rulemaking on FMVSS No. 207, Seating Systems

By the time NHTSA finalized the head restraint regulation in 2004, it was clear to the agency that additional research and data analyses were needed to allow a fully informed decision on any change to the seat back strength requirement in FMVSS No. 207. A year earlier, researchers at Johns Hopkins University Applied Physics Laboratory completed a study commissioned by NHTSA, which strongly suggested that seat back stiffness plays a role in whiplash injury risk in low-speed rear impacts.[78] The main finding was that the risk of whiplash injury cannot be related to a single design factor, such as head restraint height. The study concluded that altering the seat back design could have an effect on the occurrence of whiplash. Additional analyses were needed to assure that a NHTSA-imposed seat back requirement would not create a greater risk of whiplash. Since it was not clear when such analyses would be complete, on November 16, 2004, NHTSA terminated the FMVSS No. 207 rulemaking proceeding that had been open since 1989.[79] NHTSA was unable to fully establish that a need for a stronger seat back existed, establish a definitive link between injury reductions and potential new regulatory seat back requirements, or show that new requirements under consideration would not exacerbate risk of neck injuries due to whiplash, roof contacts, or rebound. However, NHTSA did not make a finding that an FMVSS No. 207 amendment was not warranted. Instead, NHTSA stated that further study is needed to make a definitive determination of the relative merits of different potential rulemaking approaches and that research on seat back issues would continue.

11. Further Regulatory Changes Since 2004

There have been two prominent regulatory changes regarding occupant safety in rear-end crashes that have been fully implemented since NHTSA terminated the rulemaking on FMVSS No. 207: a revision to FMVSS No. 202, and a revision to FMVSS No. 301, the fuel system integrity standard. FMVSS No. 202 is the standard focused on neck injury protection in rear impacts. Regarding FMVSS No. 301, while the stated purpose of the standard is to reduce incidence of fire and fuel ingestion incidents, it utilizes a test procedure that represents a relatively severe rear impact in the field and has been recommended by petitioners as a viable basis for an upgrade to FMVSS No. 207. Additionally, some researchers have reported that vehicles compliant with the updated FMVSS No. 301 have shown significant reduction in fatality risk in rear impact.[80] Therefore, as part

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[73] See below in Review of Additional Literature, Occupant Dynamics, for an in-depth discussion of the findings.

[74] The term "baseline" indicates head restraints manufactured prior to the 2004 update of the head restraint standard. These provided much less protection than those mandated by today's Federal standard. 69 FR 74848 (Dec. 14, 2004).

[75] 66 FR 968 (Jan. 4, 2001).

[76] 69 FR 74848 (Dec. 14, 2004).

[77] Backset is defined as minimum horizontal distance between the rear of a representation of the head of a seated 50th percentile male occupant and the head restraint, as measured by the head restraint measurement device. 49 CFR 571.202(a).

[78] Kleinberger M, Voo LM, Merkle A, Bevan M, Chang S: The Role of Seatback and Head Restraint Design Parameters on Rear Impact Occupant Dynamics. Proceedings of 18th International Technical Conference on the Enhanced Safety of Vehicles, Paper #18ESV–000229, Nagoya, Japan, May 19–22, 2003.

[79] 69 FR 67068 (Nov. 16, 2004).

[80] Viano, David C., and Chantal S. Parenteau. "Effectiveness of the revision to FMVSS 301: FARS

Continued

of our analysis of the need for new seat back strength requirements, NHTSA considers the effects that these changes have had on seat performance and occupant injury risk in moderate-to-severe rear-end crashes.

(a) FMVSS No. 202a, ''Head Restraints''

FMVSS No. 202a was issued in 2004 and applied an updated set of safety requirements for head restraints beginning with model year 2010.[81] Although the new requirements were not specifically intended to strengthen seat backs, the head restraint upgrade resulted in an increase in the minimum acceptable seat back strength.

FMVSS No. 202a requires a fully extended head restraint to withstand an 890 N (200 lb-f) rearward load. Although this load was not changed in FMVSS No. 202a, the minimum height of the head restraint was raised from 700 mm to 800 mm. Thus, the effective torque requirement on the seat back increased from about 565 Nm (5,000 in-lb) to 654 Nm (5,790 in-lb).[82]

FMVSS No. 202a also introduced a new optional dynamic test for head restraints. In the dynamic test, the entire vehicle is tested on a sled with a seated HIII–50M dummy and subjected to a 17.3 km/h (10.75 mph) rear impulse. The dummy's rearward head rotation with respect to its torso must be limited to 12 degrees for the dummy in all outboard designated seating positions. Though inertial forces of the occupant acting on the seat back in FMVSS No. 202a testing are much lower compared to those associated with an FMVSS No. 301 test pulse, FMVSS No. 202a's dynamic test may have potentially resulted in stronger seat back designs for those seats certified to this option because a stiffer seat back with an adequately positioned head restraint would capture the head motion before the limits are exceeded. Neither NHTSA nor, to our knowledge, the petitioners, however, have studied whether the upgrade to FMVSS No. 202a has resulted in injury reductions other than whiplash.

(b) Upgrade to FMVSS No. 301, Fuel System Integrity

On November 13, 2000, NHTSA proposed a more stringent rear impact offset test using a lighter deformable barrier.[83] A final rule was published on December 1, 2003, and the new requirements for the fuel systems were phased in during MYs 2007–2009.[84] Although the fuel containment requirements remained the same as the previous version of FMVSS No. 301, the crash test was generally more rigorous for most passenger cars. Vehicles that passed the new rear impact requirements were found to provide protection against crashes in which the impact produced a 33 to 50 percent higher ΔV (which corresponds to 110 percent more energy being dissipated in the crash) compared to the previous test.[85]

In a post-regulatory assessment, NHTSA compared the structure of pre- and post-standard vehicles. NHTSA observed substantial structure upgrades in the newer vehicles, which may mitigate intrusion of vehicle structures into the rear seat occupant compartment. For example, in the 2016 study, Viano and Parenteau found MY 2008 and onward FMVSS No. 301 compliant vehicles to have a 27.1–32.8% reduction in fatality risk in rear impacts compared to 1996–2001 MY vehicles. Two considerations limit the conclusions that can be drawn from this data. First, injury risk was estimated irrespective of post-crash fire. Thus, some of the injury risk reduction could be a reduction in the incidence of fire. Second, the authors noted that the changes in rear structures occurred while front seats were transitioning to higher retention designs, which may contribute to the reduction in fatality risk.

(c) NCAP

In 2007 NHTSA published a notice requesting comments on an agency report titled ''The New Car Assessment Program (NCAP) Suggested Approaches for Future Program Enhancements.'' [86] With regard to rear impact protection, NHTSA proposed that it could provide consumers with basic information on rear crashes such as safe driving behavior, proper adjustment of head restraints, real-world safety data by vehicle classes, and links to the Insurance Institute of Highway Safety (IIHS) rear impact test results. The agency further proposed that a dynamic rear impact test, which addresses those injuries not covered by the agency's current standards, could be investigated and incorporated into the ratings program. Several organizations and manufacturers recommended that NHTSA evaluate the effectiveness, cost, and safety benefits of a rear impact test before incorporating such a test into NCAP. Industry comments suggested that NHTSA should also evaluate the effectiveness of the FMVSS No. 202a update and that incorporating rear impact safety into NCAP would be better directed toward areas not fully addressed by the current regulation. Commentors suggested that NHTSA should study whiplash-type injuries and countermeasures and encourage public education on the proper adjustment of the head restraint. NHTSA concluded that a dynamic test would not be premature at that time since such an option existed in FMVSS No. 202a. However, NHTSA noted that the test dummy used by IIHS is not used for testing FMVSS compliance, and some of the injury criteria used for the assessment had not been correlated with real-world injury. Ultimately, the agency did not incorporate rear impact protection information into the NCAP program.

IV. Review of Additional Literature

NHTSA, industrial, academic, and non-profit researchers have conducted significant research into the rear impact protection of seat backs and head restraints, and research is ongoing. Researchers have investigated occupant dynamics in rear impacts, development of safer seats for the occupant in rear impacts, and occupant injury mechanisms in rear impacts.

A. Occupant Dynamics

Occupant dynamics and protection in rear collisions is a complex multivariable problem. The ideal safe seat for one occupant in a certain rear collision scenario may not be the ideal safe seat for another occupant or for a different scenario. For example, research suggests that females have a higher risk of whiplash injury compared to males and respond differently to a rear impact.[87] [88] [89] [90] Additionally, other

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and NASS–CDS analysis of fatalities and severe injuries in rear impacts.'' Accident Analysis & Prevention 89 (2016): 1–8.

[81] 49 CFR 571.202a. *See also* 69 FR 74848 (Dec. 14, 2004). Many requirements became effective on September 1, 2009, while others, in particular those regarding rear head restraints, came into effect the following year. Please review S2 of the standard for further details.

[82] Agency testing of pre-FMVSS No. 202a seats showed seat back strength well in excess of 654 Nm, so there was no need for manufacturers to increase seat back strength to meet the new head restraint requirements of FMVSS No. 202a, see Docket document no. NHTSA–1998–4064–0026.

[83] 65 FR 67693 (Nov. 13, 2000).

[84] 68 FR 67068 (Dec. 1, 2003).

[85] Pai, Jia-Ern. ''Evaluation of FMVSS NO. 301, 'Fuel System Integrity,' as upgraded in 2005 TO 2009.'' National Center for Statistics and Analysis, National Highway Traffic Safety Administration. Washington, DC (2014).

[86] 72 FR 3473 (Jan. 25, 2007).

[87] Berglund A, Alfredsson L, Jensen I, et al. Occupant- and crash-related factors associated with the risk of whiplash injury. Ann Epidemiol 2003;13:66–72.

[88] Carlsson, Anna. Addressing female whiplash injury protection-a step towards 50th percentile female rear impact occupant models. Chalmers Tekniska Hogskola (Sweden), 2012.

occupant characteristics, such as weight, can play a significant role in rear impact injury risk, as shown in the NASS–CDS case number 2011–49–57 noted by Viano and Parenteau.[91] This case outlines a rear collision with an estimated ΔV between 35 and 39 km/h (21.7 and 24.2 mph). The 141 kg (311 lb) driver of the rear impacted 2008 model passenger vehicle suffered critical head and neck injuries after decoupling from the rotated driver seat back and colliding with the rear seat back. The 68 kg (150 lb) right front passenger of the same struck vehicle, however, had no documented injury.[92] The injury severity suffered by the driver in this case is rare in rear impacts. Viano and Parenteau found passengers with injuries of MAIS 4 or greater severity, including fatalities, represented 0.08% of passengers with injury in rear collisions in MY 2008 and newer vehicles. A quantitative description of seat back response is complicated by the potential sensitivity of response to a range of initial conditions and external factors including head posture,[93] awareness,[94] seat belt use and seat geometry including initial seat back recline angle,[95] details of the crash pulse,[96][97] and specific occupant characteristics such as weight distribution. The initial posture and location of the occupant is also thought to influence injury risk. Many occupants in rear collisions are believed to be out-of-position (*e.g.,* seated off-center), and out-of-position occupants are thought to have a higher probability of injury in rear impacts than symmetrically or normal-positioned occupants.[98][99][100]

Some research suggests that limiting seat back rotation can have detrimental effects, particularly regarding neck injuries. In the 1997 Prasad study of real-world rear impacts, the authors concluded that a revision to severely limit seat back rotation would have detrimental effects. The study analyzed the 1980–94 NASS database to compare injury rates in pickup trucks with passenger vehicles in rear impacts. This allowed for comparison between yielding seat performance with the rotationally stiff seats of pickup trucks (stiffness is due to the small gap between seat and cab). A higher rate of occupant injury in rear collisions across all ΔVs was observed in pickup trucks. The authors inferred that rotationally rigid seats could have an increased rate of injury in rear impacts. The 1997 Prasad study further analyzed a series of sled tests to investigate the relationship between seat stiffness and anthropomorphic test device (ATD) kinematics for rear impact ΔV of 16, 24, and 40 km/h (9.9, 14.9, and 24.9 mph). After assessing the range of sampled speeds and ATD measurements, Prasad hypothesized that (all else being equal) stiffening of the baseline 1996 production seats can result in an overall increase in whiplash type injuries at low-to-moderate speeds and a greater potential for serious neck injury at higher speeds, in addition to other conclusions. This study, however, has limitations. Many of the pickups in the crash data analyzed may not have had head restraints because trucks were not required to have head restraints until MY 1993. Moreover, a rotationally rigid seat represents the extreme end of the debate around the seat strength set by FMVSS No. 207. While modern production seats are characterized by a seat strength many times the value set by FMVSS No. 207, these seats also display a degree of balance between high and low-speed rear impact protection and the characteristic of rearward rotation of the seat back.

Other research suggests that optimizing seat back design, including stiffness, can reduce injury risks in rear impact. In a 1996 study, Svensson, et al.[101] analyzed the influence of seat back properties on neck injury using the HIII ATD with a Rear Impact Dummy (RID)-neck in low-speed rear collision sled testing. The study found that it was possible to significantly reduce harmful head-neck motion of the ATD by optimizing the head-to-head restraint gap, seat back frame stiffness, and characteristics of the seat-back cushion.

A separate statistical analysis involving 20 years of the NASS database by Burnett[102] found that front seat occupants are significantly more protected in rear collisions compared to other crash directions, even for the most severe rear impacts where major seat yielding and occupant decoupling from the seat can occur. The study also conducted quasi-static mechanical testing and rear impact sled tests of seven production seats to investigate the correlation between mechanical parameters and ATD kinematics. The study found no significant correlation between the seat strength and any of the recorded ATD metrics, while seat stiffness and an energy absorption parameter were nonlinearly correlated with ATD metrics.

B. Rear Impact Protection Technology

This section discusses some seat designs intended to improve rear impact protection that have been incorporated over the years.

In 1998, a set of design guidelines was published by Volvo Cars and Autoliv, Inc. for seats that emphasized the importance of controlling an occupants' absolute and relative head and torso kinematics throughout the rear impact process, to protect against neck and other injuries.[103] The Volvo Cars' Whiplash Protection System (WHIPS) was introduced in 1998 and is built around these guidelines. In a significant rear collision, the first generation WHIPS seat back rotation point moves rearward and later transitions to rearward rotation. During seat back rotation, a mechanical linkage

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[89] Viano, David C. ''Seat influences on female neck responses in rear crashes: a reason why women have higher whiplash rates.'' *Traffic injury prevention* 4.3 (2003): 228–239.

[90] Linder, Astrid, and Mats Y. Svensson. ''Road safety: the average male as a norm in vehicle occupant crash safety assessment.'' *Interdisciplinary Science Reviews* 44.2 (2019): 140–153.

[91] Viano, David C., and Chantal S. Parenteau. ''Effectiveness of the revision to FMVSS 301: FARS and NASS–CDS analysis of fatalities and severe injuries in rear impacts.'' *Accident Analysis & Prevention* 89 (2016): 1–8.

[92] Comparisons such as these should be made with care because the driver and passenger seat may not be structurally identical, with the driver seat sometimes having more and powered adjustments compared to the passenger seat.

[93] Lenard, James, Karthikeyan Ekambaram, and Andrew Morris. ''Position and rotation of driver's head as risk factor for whiplash in rear impacts.'' *J Ergonomics S* 3.2 (2015).

[94] Siegmund, Gunter P., et al. ''Awareness affects the response of human subjects exposed to a single whiplash-like perturbation.'' *Spine* 28.7 (2003): 671–679.

[95] Kang, Yun-Seok, et al. ''Effects of seatback recline and belt restraint type on PMHS responses and injuries in rear-facing frontal impacts.'' *SAE International journal of transportation safety* 10.2 (2022): 09–10.

[96] Hynes, Loriann M., and James P. Dickey. ''The rate of change of acceleration: Implications to head kinematics during rear-end impacts.'' *Accident Analysis & Prevention* 40.3 (2008): 1063–1068.

[97] Siegmund, Gunter P., et al. ''The effect of collision pulse properties on seven proposed whiplash injury criteria.'' *Accident Analysis & Prevention* 37.2 (2005): 275–285.

[98] Strother, Charles E., Michael B. James, and John Jay Gordon. ''Response of out-of-position dummies in rear impact.'' *SAE transactions* (1994): 1501–1529.

[99] Benson, Brent R., et al. ''Effect of seat stiffness in out-of-position occupant response in rear-end collisions.'' *SAE transactions* (1996): 1958–1971.

[100] Burnett, Roger A., Chantal S. Parenteau, and Samuel D. White. ''The effect of seatback deformation on out-of-position front-seat occupants in severe rear impacts.'' Traffic Injury Prevention (2022): 1–5.

[101] Svensson, Mats Y., et al. ''The influence of seat-back and head-restraint properties on the head-neck motion during rear-impact.'' *Accident Analysis & Prevention* 28.2 (1996): 221–227.

[102] Burnett, Roger, et al. ''The influence of seatback characteristics on cervical injury risk in severe rear impacts.'' *Accident Analysis & Prevention* 36.4 (2004): 591–601.

[103] Lundell, Bjorn, et al. ''The WHIPS seat-a car seat for improved protection against neck injuries in rear-end impacts.'' *Proc. 16th ESV Conference, Paper.* Vol. 98. 1998.

irreversibly absorbs rotational energy, so there is less energy directed into the occupant and rebound is reduced. The seat back will then continue to rotate and deflect rearward as a typical production seat. According to data reported by Volvo, the first generation WHIPS seat reduced soft tissue neck injury risk by 21% to 47% as compared to prior seats.[104]

Another technology for whiplash injury protection is active head restraints that was introduced by Saab in the late 1990s.[105] These systems aim to reduce the head restraint contact time by actively shifting the head restraint forward in a rear impact through a mechanical linkage in the seat structure activated when the seat occupant moves rearward into the seat. Data acquired by the NCAP program for MY2023 show that 21 vehicle models representing 4 percent of vehicle sales are reported as having active head restraints or provide the option. At least one automotive supplier is working on an electromechanical system that moves the head restraint up to 40 mm forward when a rear sensor in the vehicle anticipates a rear impact.[106]

In the early 1990s, General Motors (GM) Research and Development Center undertook an in-depth study of seat characteristics to improve occupant safety in rear impacts. In general, the GM seat design fostered movement of the pelvis rearward and into the lower portion of the seat back frame in a way that would preclude ramping and reduce the moment arm on the seat back. A key design component was to balance the stiffness of the seat resisting the rearward movement of the pelvis against the ability of the seat back frame to resist backward rotation. GM established their own quasi-static test for the purposes of assuring that a given seat met the design parameters. It was a destructive test that made use of a 50th percentile male dummy loaded rearward into the seat back through the lumbar joint. The dummy was free to move up, down, and sideways during rear loading. The test also allowed the seat back to rotate rearward and twist in a manner similar to what was observed in sled testing. Eventually, GM's seat design targets were published by SAE International.[107] The targets were derived from various measurements taken during their quasi-static test. The targets contained many more parameters than FMVSS No. 207's single requirement to withstand a 373 Nm (3,300 in-lb) moment (see table 1 for a list of the parameters). Notably, the GM parameters included a criterion that limited the seat stiffness to no more than 25 kN/m, while attempting to assure that the seat had sufficient energy absorbing properties. GM stressed that simply raising the FMVSS No. 207 moment beyond 373 Nm would not achieve a desirable seat design. According to GM, increasing only the seat back's stiffness would reduce the beneficial effects of yielding.

A seat design feature that was rare 25 years ago, but appears to be much more common in modern seats is a dual recliner system.[108] [109] A dual recliner system places gear mechanisms controlling the static recline angle on both sides of the seat. This improvement significantly strengthened production seats and reduced longitudinal axis twisting.[110] The agency does not have an estimate of the current level of implementation of dual recliners and requests that commenters provide these data.

An IIHS study of contemporary production seats claims that a wide range of seating systems have achieved a balance between low-speed protection while maintaining structural integrity at higher speeds and occupant retention.[111] This study conducted rear impact sled testing on 26 modern production seats at a ΔV of 36.5 km/h (22.7 mph) using a 78 kg (172 lb) Hybrid III 50th percentile male dummy. The maximum dynamic seat back rotation ranged from 15° to 47° from the initial angle and the dummy was retained by all seat backs. During testing, the vertical displacements of the dummies was between 41 mm to 144 mm. The authors concluded that a majority of tested production seats provided adequate occupant retention at a ΔV of 36.5 km/h (22.7 mph), but with a range of performance metrics. Moreover, all 26 seats tested by IIHS had ''Good'' ratings for low-speed rear impact protection as determined by a separate IIHS test using the BioRID dummy at a ΔV of 16 km/h (10 mph).

C. Non-Contact Injuries

This section outlines a segment of the literature concerning non-contact neck and thorax injuries resulting from rear collisions.

1. Neck Injuries

The term whiplash has been used since the 1920s to describe various symptoms or signs of cervical spine injury in motor vehicle accidents. The first case series studies on motor vehicle whiplash injury were published in the early 1950s.[112] Later in the 1960s, studies were conducted on the mechanisms of whiplash injury.[113] These and related efforts developed the notion that the whiplash injury rate could be reduced by preventing hyperextension of the neck. The initial version of FMVSS No. 202 mandated head restraints as a countermeasure to this type of neck injury.[114] After the mandate was introduced, a statistical analysis of crash data sets found modest improvements in the whiplash injury rates.[115] A 1982 NHTSA report of rear impacts in passenger cars, for example, found that integral head restraints reduced whiplash injury risk by 17% while adjustable restraints reduced the risk by 10%.[116] A Swedish study found

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[104] Jakobsson, Lotta, Irene Isaksson-Hellman, and Magdalena Lindman. ''WHIPS (Volvo cars' Whiplash Protection System)—the development and real-world performance.'' *Traffic injury prevention* 9.6 (2008): 600–605.

[105] Wiklund, Kristina; Larsson, Håkan (1 February 1998). ''Saab Active Head Restraint (SAHR)—Seat Design to Reduce the Risk of Neck Injuries in Rear Impacts.'' Journal of Passenger Cars.

[106] ''Can a high-tech headrest reduce whiplash injuries,'' Automotive News, August 14, 2022, *https://www.autonews.com/suppliers/high-tech-headrest-designed-reduce-whiplash-injuries.*

[107] Viano, David C. ''Role of the seat in rear crash safety.'' *Warrendale, PA: Society of Automotive Engineers, 2002. 514* (2002).

[108] About one third of the seats tested by the agency in 1998 were dual recliners. This was a convenience sample not intended to be representative of the fleet. Molino L (1998), Determination of Moment-Deflection Characteristics of Automobile Seat Backs, NHTSA, November 25, 1998. *See Regulations.gov*, Docket document no. NHTSA–1998–4064–0026.

[109] Viano, David C., et al. ''Occupant responses in conventional and ABTS seats in high-speed rear sled tests.'' *Traffic injury prevention* 19.1 (2018): 54–59.

[110] Herbst, B.R., Meyer, SE, Oliver, A.A., and Forrest, S.M. Rear impact test methodologies: quasistatic and dynamic. Proceedings of 21st International Technical Conference on the Enhanced Safety of Vehicles, 2009. Stuttgart, Germany.

[111] Edwards, Marcy A., et al. ''Seat design characteristics affecting occupant safety in low-and high-severity rear-impact collisions.'' *IRCOBI Conference, Florence, Italy, IRC–19–11.* 2019.

[112] Gay, James R., and Kenneth H. Abbott. ''Common whiplash injuries of the neck.'' *Journal of the American Medical Association* 152.18 (1953): 1698–1704.

[113] MacNab, Ian. ''Whiplash injuries of the neck.'' *Proceedings: American Association for Automotive Medicine Annual Conference.* Vol. 9. Association for the Advancement of Automotive Medicine, 1965.

[114] NHTSA, *FMVSS No. 202 Head Restraints for Passenger Vehicles Final Rule, Final Regulatory Impact Analysis,* Nov. 2004, Docket No. NHTSA–2004–19807.

[115] O'Neill, Brian, et al. ''Automobile head restraints—frequency of neck injury claims in relation to the presence of head restraints. *American journal of public health* 62.3 (1972): 399–406. Nygren, Ake, Hans Gustafsson, and Claes Tingvall. *Effects of different types of headrests in rear-end collisions.* No. 856023. SAE Technical Paper, 1985.

[116] Kahane, Charles J. An Evaluation of Head Restraints, NHTSA Publication No. DOT HS 806 108, Washington, DC, 1982, pp. 154–160 and 181–197.

a similar 20% decrease in neck injuries as a result of the head restraint.[117] However, the persistence of frequent whiplash injury motivated later studies of cervical spine dynamics in rear collisions.

In 1995, the Quebec Task Force on Whiplash Associated Disorders categorized whiplash injuries into five grades, 0 to IV, in order of increasing severity. For convenience, we will continue to refer to whiplash associated disorders as whiplash injuries. The Quebec study determined that 90% of insurance claims fell within grades 0 and I where there was no clear pathology based on existing technology, but symptoms may include neck pain, headache, memory loss, jaw pain, hearing disturbance, and dizziness. Grades II and III include musculoskeletal and neurological signs; grade IV contains cervical fractures and dislocations. The most severe soft tissue whiplash type injury occurring in grade IV is typically characterized by disc herniation and is often accompanied by facet-joint hematoma, peripheral spinal nerve and spinal cord contusion or articular process fracture.[118] The findings of a study on very low velocity rear collisions [119] led the authors to conclude that a biomechanical ''limit of harmlessness'' for whiplash exists for rear collision ΔV between 10 to 15 km/h. The author goes on to explain that this is the speed range below which there were no anatomical signs of injury, but did not rule out ''psychological injury.''

Basic research of rear collision neck kinematics indicate that neck and head dynamics occur through a complex process. The neck may experience compression, tension, shear, torsion, retraction, protraction, flexion, and extension to varying degrees and at different points in time. Studies on cervical spine kinematics in rear collisions by Svensson, et al.[120] and McConnell, et al.[121] in 1993, Geigl, et al.[122] in 1994 and Panjabi, et al.[123] in 1998 noted that the neck displayed an unnatural S-shaped curve in the early stages of the kinematics due to retraction, and Panjabi hypothesized that neck injury may occur before head contact with the head restraint. In a study by Feng, et al.,[124] the authors described early rear impact neck dynamics through a series of kinematic spinal processes. The authors noted that rear impact forces are at first distributed across the occupant's torso through the seat back and then are transmitted to the neck and head. These initial forces impose torso straightening and likely movement of the occupant's torso up the seat back. The authors hypothesize that axial compression is generated in the spinal column, which travels up the neck to the head. As the head moves upwards axial tension is then proposed to develop in the neck through disproportionate movement of the head and neck due to a constrained torso. As these first actions evolve the head lag phenomenon (also described in an earlier 1976 study [125]) or retraction develops through a delay between the forward motion of an occupant's torso and head. Retraction leads to shear in the cervical column and curvature of the neck is reduced. These theorized actions occur before the head contacts the head restraint.

2. Thorax Injuries in High-Speed Rear Impacts

A recent NHTSA research study was conducted with 14 PMHS tests in rear facing seats in frontal collisions at a ΔV of 56 km/h for different recline angles and seat types to investigate thorax injuries.[126] The structure supporting the seat back was rigidized to avoid unpredictable permanent deformations of the seat during the event. The goal of the study was to examine non-standard seating configuration for vehicles with automated driving systems (ADS) with reclined rear-facing seats in a frontal collision. It may also, however, provide some insight into rear impact dynamics because the loading is rearward with respect to the seat back orientation. Additionally, the 56 km/h ΔV test is very severe for a rear impact. The CISS data reported in section II.B indicates this speed represents more than 95% of all towaway rear impacts. The authors found that rib fractures occurred in the PMHSs due to a complex combination of chest compression and expansion with upward shear loading. The majority of rib fractures occurred after peak chest compression when the abdominal contents shifted rearward and upward into the thorax due to the ramping motion of the PMHS, which created a combined loading (compression/tension and shear) to the thorax. Similar magnitudes of rib strains were observed regardless of seat types, while strain modes varied according to recline angle and seat type. Fewer injuries were seen with a more upright 25-degree seat back, compared to a more typical initial seat angle of 45-degree seat back.

D. Summary

While progress has been made in understanding rear impact injuries, the literature continues to point toward the need for a greater understanding before conclusions can be drawn about the exact mechanisms of injury and the risk factors involved, particularly in regards to whiplash.[127] Likewise, important safety improvements have been made in production seats over the last 50 years and a greater understanding of the relationship between seat back characteristics and injury has been achieved, but questions remain with respect to precisely quantifying protective characteristics. The continued uncertainty around how best to protect occupants as well as the varied approaches and developments in rear impact technology suggests that, as NHTSA considers amendments to FMVSS Nos. 207 and 202a, there is value in preserving industry flexibility in seat back and head restraint design and strength parameters to allow further

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[117] Nygren, Ake, Hans Gustafsson, and Claes Tingvall. Effects of different types of headrests in rear-end collisions. No. 856023. SAE Technical Paper, 1985.

[118] Davis, Charles G. ''Mechanisms of chronic pain from whiplash injury.'' Journal of forensic and legal medicine 20.2 (2013): 74–85.

[119] Castro, W.H., et al. Do whiplash injuries occur in low-speed rear impacts? European spine journal: official publication of the European Spine Society, the European Spinal Deformity Society, and the European Section of the Cervical Spine Research Society 6.6 (1997): 366–375.

[120] Svensson, Mats Y., et al. *Rear-end collisions-a study of the influence of backrest properties on head-neck motion using a new dummy neck.* No. 930343. SAE Technical Paper, 1993

[121] McConnell, Whitman E., et al. Analysis of human test subject kinematic responses to low velocity rear end impacts. No. 930889. SAE Technical Paper, 1993.

[122] Geigl, B.C., et al. ''The movement of head and cervical spine during rear end impact.'' *Proceedings of the International Research Council on the Biomechanics of Injury conference.* Vol. 22. International Research Council on Biomechanics of Injury, 1994.

[123] Panjabi, Manohar M., et al. ''Mechanism of whiplash injury.'' *Clinical Biomechanics* 13.4–5 (1998): 239–249.

[124] Luan, Feng, et al., ''Qualitative analysis of neck kinematics during low-speed rear-end impact.'' *Clinical Biomechanics* 15.9 (2000): 649–657.

[125] Ewing CL., Thomas D., Lustick L., Muzzy W.H., et al. The Effect of Duration, Rate of Onset and Peak Sled Acceleration on the Dynamic Response of the Human Head and Neck. Proceedings of the 20th Stapp Car Crash Conference, Dearborn, MI, Society of Automotive Engineers, Inc., 1976.

[126] Kang YS, et al. ''Thoracic responses and injuries to post-mortem human subjects (PMHS) in rear-facing seat configurations in high-speed frontal impacts,'' Twenty-Seventh Enhanced Safety of Vehicles Conference (2023).

[127] Holm, Lena W., et al. ''The burden and determinants of neck pain in whiplash-associated disorders after traffic collisions: results of the Bone and Joint Decade 2000–2010 Task Force on Neck Pain and Its Associated Disorders.'' *Journal of manipulative and physiological therapeutics* 32.2 (2009): S61–S69.

research into and development of these systems.

V. Petitions for Rulemaking at Issue in This Document

A. Statutory and Regulatory Background

Under 5 U.S.C. 553(e), 49 U.S.C. 30162(a)(1) and 49 CFR part 552, interested persons can petition NHTSA to initiate a rulemaking proceeding. Upon receipt of a properly filed petition, the agency conducts a technical review of the petition, material submitted with the petition, and any additional information.[128] After conducting the technical review, NHTSA determines whether to grant or deny the petition.[129] The Safety Act states that all FMVSS requirements must be practicable, meet the need for motor vehicle safety, and be stated in objective terms.[130] Accordingly, NHTSA will initiate a rulemaking only if the agency believes that the proposed rule would meet these criteria. If a petition is granted, a rulemaking proceeding is promptly initiated in accordance with statute and NHTSA procedures. A grant of a petition and a commencement of a rulemaking proceeding do not, however, signify that the rule in question will be issued. That decision is made on the basis of all available information developed in the course of the rulemaking proceeding, in accordance with statutory criteria.[131] If a petition under this section is denied, the reasons for the denial are published in the **Federal Register**.[132]

B. Petition of Kenneth J. Saczalski

On October 28, 2014, Kenneth J. Saczalski of ERST petitioned NHTSA to amend FMVSS Nos. 207 (Seating systems), 213 (child restraint systems), and 301 (Fuel system integrity). Saczalski requested that NHTSA increase the static strength requirement for seat backs by a factor of six and implement a new dynamic requirement. The dynamic requirement would assess the seat back of a vehicle by performing a rear impact crash test with a 50th percentile male ATD positioned in the seat. The petition also suggested adding a rear impact requirement to FMVSS No. 213, ‘‘Child restraint systems,’’ and implementing a new requirement for rear seats that would resist the forces of loose cargo that may be stowed behind the rear seats.

1. FMVSS No. 207, Seating Systems

Saczalski seeks an amendment to FMVSS No. 207, S4.2(d) to increase the rearward force that occupant seats must withstand from a 373 Nm (3,300 in-lb) moment measured about the H-point to a 2,260 Nm (20,000 in-lb) moment measured from the pivot intersection of the seat back structure and the seat cushion frame.[133] While this ostensibly represents an increase by a factor of six, because FMVSS No. 202a effectively requires seat backs to withstand a 654 Nm (5,790 in-lb) moment, this would only increase the performance requirement by a factor of 3.5 above current requirements, if measured about the H-point. The actual factors would be closer to a factor of 5.4 above the required FMVSS No. 207 moment and 3.1 above the FMVSS No. 202a requirement, depending on the relative position of the seat pivot with respect to the H-point.[134]

Saczalski also made a more general request that FMVSS No. 207 seat strength testing be conducted ‘‘to ultimate strength levels’’ that establish a seat's capacity to withstand crash forces. According to Saczalski, testing must be repeated to examine strength variations relating to adjustable seat components, such as height adjusters. Saczalski does not, however, provide a specific set of performance requirements or tests that he asserts should be conducted. Saczalski also requested that NHTSA add a requirement that seats not experience a ‘‘sudden load collapse’’ (*i.e.,* a failure of structural components that causes the occupant support loading to suddenly drop off) of 400 pounds force or greater within a short span of rearward deformation. According to Saczalski, this testing should be done using a ‘‘torso body-block’’ device that replicates the upper body weight of a 95th percentile male.

2. Use of FMVSS No. 301, ‘‘Fuel System Integrity,’’ To Test Seats

Saczalski petitioned NHTSA to implement a new seat back requirement using the dynamic rear-end crash test prescribed in the latest revision of the fuel system integrity test described in FMVSS No. 301. In this test, a stationary vehicle is struck in the rear by a 1,368 kg (3,015 lb) deformable barrier travelling at 80 km/h (50 mph). The barrier overlaps the rear end of the vehicle by 70%.

Saczalski asserted that a dynamic, full vehicle test is needed in addition to the static requirements discussed above. The main purpose of such a test would be to fully assess the safety of children in rear seats who may be exposed to collapsing front seat backs. Saczalski cites in his petition a 2008 study by Children's Hospital of Philadelphia (CHoP).[135] The study examined risk levels through an epidemiological study of real-world crashes, and found that in a rear-end crash, children seated directly behind a seat back that yielded exhibited about twice the risk of injury as children seated behind a seat back that did not yield. Saczalski has asked for a dynamic test to be run with Hybrid III 95th percentile male dummies (HIII–95M) in the front seats with 12-month-old dummies seated directly behind in forward-facing child restraints.[136] He recommends a pass/fail limit on front seat back rotation of no more than 25 degrees rearward from its initial seat back orientation. He also recommends that NHTSA impose pass/fail requirements based on dummy measurements within the head, neck, chest, and extremities. This would apply to the HIII–95M and the 12-month-old dummies. Saczalski recommends pass/fail requirements for both dummies equivalent to ‘‘their respective NHTSA injury reference levels for the head, neck, chest, and extremities.’’[137]

Saczalski also suggested that the test be run with 20 kg (44 lb) simulated luggage cases in the trunk area, which he stated could push the rear seat forward. According to Saczalski, such a requirement will guard against injuries due to the intrusion of a rear seat occupied by a child into a yielding front seat back.

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[128] 49 U.S.C. 30162(a)(1); 49 CFR 552.6.

[129] 49 CFR 552.8; *see also* 49 U.S.C. 30162(c).

[130] 49 U.S.C. 30111(a).

[131] 49 CFR 552.9; *see also* 49 U.S.C. 30162(c).

[132] 49 CFR 552.10.

[133] ‘‘Rearward force’’ means the force against the rear side of an occupant seat, regardless of orientation. For a forward-facing seat, this would mean a force applied in the rearward longitudinal direction, whereas with a rear-facing seat, this would mean a force applied in the forward longitudinal direction.

[134] Selecting the seat pivot point as the location for the moment measurement reduces the force needed to produce a given moment. Assuming a vertical distance of 535 mm from the H-point to the location of force application and a vertical distance of 595 mm from the seat pivot to the force location results in a 10% reduction in force for the same moment measure about the pivot compared to the H-point.

[135] Jermakian JS, Arbogast KB, Durban DR, Kallan NJ (2008), Injury risk for children in rear impacts: role of the front seat occupant, 52nd AAAM Annual Conference, Annals of Advances in Automotive Medicine, October 2008.

[136] The 12-month-old dummy, known as the (CRABI) dummy, is already integrated into subpart P of part 572.

[137] Injury reference values recommended by NHTSA for the CRABI and HIII–95M, when used to assess air bags, are contained within: Eppinger R, Sun E, Kuppa S, Saul R (2000), Supplement: development of improved injury criteria for the assessment of advanced automotive restraint systems-II, National Highway Traffic Safety Administration, March 2000.

3. FMVSS No. 213, Child Restraint Seats

Saczalski asked NHTSA to include a rear impact requirement for child restraint systems within FMVSS No. 213, which does not contain such requirements. He suggested using the same test and performance criteria as the European standard for child restraint systems, United Nations Economic Commission for Europe Regulation 44 (ECE R.44),[138] but run at a higher test speed of 40 km/h.[139] The ECE standard contains requirements for various sized child dummies subjected to a 30 km/h rear impact. Like FMVSS No. 213, the European standard also includes requirements for a frontal impact, but those are not discussed in Saczalski's petition.

C. Petition of Alan Cantor

In a letter dated September 28, 2015, Alan Cantor of ARCCA petitioned NHTSA to revise FMVSS No. 207 by implementing new requirements for seat back strength involving a crash test with an ATD. He also requested that NHTSA reinstate a provision to FMVSS No. 209, ''Seat belt assemblies,'' that he states would prevent occupant injuries in rear impacts.

1. Use of FMVSS No. 301, ''Fuel System Integrity,'' To Upgrade FMVSS No. 207

Cantor requested a dynamic test to assess seat back loading by occupants of different sizes. He envisioned the use of the current FMVSS No. 301 procedure with Hybrid III 50th Percentile male dummies (HIII–50M). Additionally, Cantor requested that a test be performed at oblique impact angles to assess the potential of excessive seat back twisting that Cantor stated could facilitate rearward ramping and an out-of-position orientation of the occupant in the seat during subsequent impacts. A full vehicle test was also envisioned, but alternatively Cantor suggested that a sled test could be run using an impulse equivalent to that produced by the dynamic procedure. Cantor did not request a change to the static requirements of FMVSS No. 207, nor did he call for the use of rear seated child dummies in the dynamic, full vehicle test. Under Cantor's rationale, the test with the HIII–50M dummies would serve as the basis for a new set of FMVSS requirements. The requirements would apply to front seats as well as rear ''bucket'' seats, such as those within minivans, that he suggests may also have a propensity to collapse.

2. Rearward Rotation Limit and Structural Symmetry Requirement

Cantor recommended a pass/fail limit for rearward seat back rotation of no more than 15 degrees from its initial seat back orientation (measured in real-time during the test). For the oblique impacts, there would be a requirement that the differential rearward deflection of the seat back is no more than 10 degrees between the left and right sides. According to Cantor, this will assure structural symmetry of the seat to prevent excess twisting of the seat under load, which can lead to ramping or out-of-position orientation of an occupant if subsequent impacts occur.

3. Additional Dynamic Testing and NCAP Implementation

Cantor also requested another dynamic test to assess seat back loading to be performed with a Hybrid III 95th male dummy (HIII–95M) and to incorporate results into the NCAP star rating for the vehicle. This test would be performed in a manner similar to the current FMVSS No. 301 procedure, but at an impact speed of the barrier that is 8 km/h (5 mph) faster than the current FMVSS No. 301 speed. He argues that it would serve to inform consumers on whether a given vehicle seat back has the propensity to collapse. Cantor states it would also provide incentive to manufacturers to develop enhancements to rear impact crash protection.

Cantor recommended the same pass/fail limit for rearward seat back rotation for the NCAP tests as he recommended for the FMVSS No. 301 impacts. Cantor did not specify how the results would be factored into the NCAP rating.

4. FMVSS No. 209, Seat Belt Assemblies

Cantor requested that NHTSA restore S4.1(b), which NHTSA deleted in a final rule published in 1999.[140] This provision required the lap belt portion of the seat belt be designed to remain on the pelvis under all crash conditions. Cantor states that restoring S4.1(b) would assure that vehicles will be equipped with seat belt technologies that prevent ramping in rear impact crashes.

D. NHTSA's Analysis of Saczalski and Cantor Petitions

NHTSA is denying in part the Saczalski and Cantor petitions as they pertain to the following recommendations: Cantor's requested amendments to NCAP and request to restore anti-ramping language to FMVSS No. 209, and Saczalski's requests to add a rear impact test to FMVSS No. 213 and a cargo test requirement to FMVSS No. 207. As part of this rulemaking effort to update FMVSS No. 207 and to facilitate informed comment, NHTSA is granting the petitions in part with regard to updating the strength requirement in FMVSS No. 207, the structural symmetry requirement requested by Cantor, and the possible development of new test procedures for seat back strength under FMVSS No. 207. NHTSA notes that, at this time, insufficient information has been provided to support the petitioners' suggested specific strength levels or test designs, but NHTSA seeks comment on this issue. The remainder of this section provides NHTSA's opinions on the recommendations in the petitions to provide context and information to support informed comment on an update to FMVSS No. 207. Later in this document, we discuss NHTSA's current thinking on an integrated and unified approach to rear impact protection and seeks comment on that approach.

1. Analysis of Data and Research Provided by Cantor and Saczalski Regarding Safety Need

In the past, NHTSA and petitioners on this topic have not been able to demonstrate that a safety need exists regarding the seat back strength requirement in FMVSS No. 207.[141] In their petitions, Saczalski and Cantor both implied that factors related to child safety have given rise to a new safety need for stronger seat backs. NHTSA acknowledges that there is evidence that, in some crash scenarios, seat back deformation or rearward movement due to component failure can lead to injury, but NHTSA believes that the petitioners have not provided sufficient supporting data to demonstrate a worsening safety need related to seat back strength compared to NHTSA's past determination. NHTSA discusses the materials provided by petitioners below and seeks comment on this question.

In support of his petition, Saczalski references the CHoP study. NHTSA agrees with Saczalski that the 2008 CHoP study is useful for understanding the levels of risk to which children in rear seats are exposed, but the CHoP study did not determine that this risk was associated with front seat back strength. The information submitted by petitioners did not provide new or pertinent information to build upon the

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[138] Uniform Provisions Concerning the Approval of Restraining Devices for Child Occupants of Power-Driver Vehicles, (Child Restraint Systems), ECE R.44, E/ECE/324/Rev (*unece.org*).

[139] UNECE Regulation No. 44, Uniform provisions concerning the approval of restraining devices for child occupants of power-driven vehicles (''Child Restraint System'').

[140] 64 FR 27203 (May 19, 1999).

[141] *See* discussion in section III.B.10 of this document and 69 FR 67068 (Nov. 16, 2004).

CHoP study or further demonstrate a safety need.

Saczalski provided NHTSA with his own publications, including one from the 2014 annual meeting of the International Federation of Automotive Engineering Societies (FISITA).[142] This paper described 13 cases of infant fatalities in rear-end crashes in which the infant was seated behind an occupied front seat. However, as with the CHoP study, Saczalski's paper did not provide additional insight on whether the fatalities were associated with front seat back strength. Moreover, because most of the fatalities occurred in vehicles that were built prior to MY 2000, the cases he cites may not reflect the lower level of risk associated with new vehicles. Since then, improvements have been made to FMVSS Nos. 202a, 301, and other standards that may impact the conclusions reached in the CHoP study and Saczalski's paper. In addition, changes in manufacturer's design targets and the more frequent use of dual recliners may have resulted in seat designs that are generally stronger.

Saczalski also provided the results of several sled tests with crash test dummies, which he argues demonstrate that the seat back of a front-seated adult can collapse on a child sitting in the rear in a 48 km/h rear-end impact. While these tests may illustrate the potential consequences of seat back deformation or failure, they simply reinforce a finding of which NHTSA is already aware: that it is possible for some seat backs to yield in a severe rear-end impact in a way that could potentially injure occupants.

Finally, according to Saczalski, fatality counts within the Fatal Accident Reporting System (FARS) from 2001–2011 show that fatalities in infants (0–12 months) have doubled since 1990–2000, from which he infers a worsening safety need.

NHTSA believes that the conclusion Saczalski draws from this data is inaccurate. NHTSA has queried FARS for infant and adolescent fatalities where the child was known to be restrained in a rear seat, non-ejected, in a non-rollover, rear impact. Over the last 15 years captured in the study, the average fatality rate is 7.7 per year, ranging from 1 to 15 per year (See Figure V.1). There is a great deal of scatter and no clear fatality trend over time. If the data are expanded to all children up to an age of 5, the average fatality rate is 31.9 per year, ranging from 22 to 60 (See Figure V.2). Again, there is no clear trend in the data. The data for the 0–5-year-olds have less scatter than that for the 0–12-month-olds. This latest data is not supportive of a claim that there is a fatality risk that continues to increase. NHTSA notes that these data provide an estimate of all-cause mortality and therefore provide no insights into whether front row seat performance contributed to the child's death.

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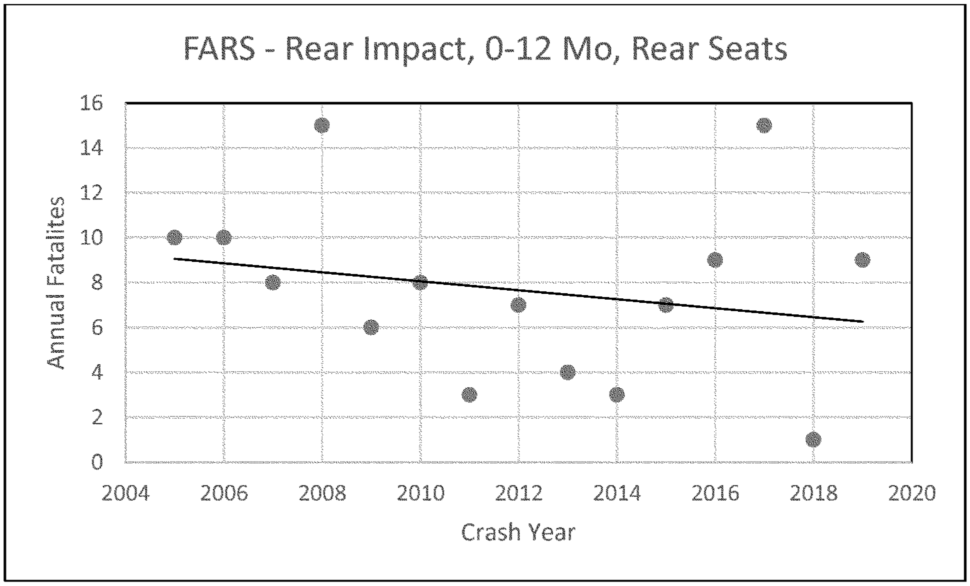

Figure V.1: NHTSAs finding of FARS reported infant annual fatalities in a rear seat, non-ejected, in a non-rollover, rear impact

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[142] Saczalski K, Pozzi M, Burton J, Saczalski T (2014), Experimental and field accident analysis study of factors effecting child occupant injury risk and safety in rear impacts, 2014 Annual FISITA Meeting, Paper No. F2014–AST–013, 2014.

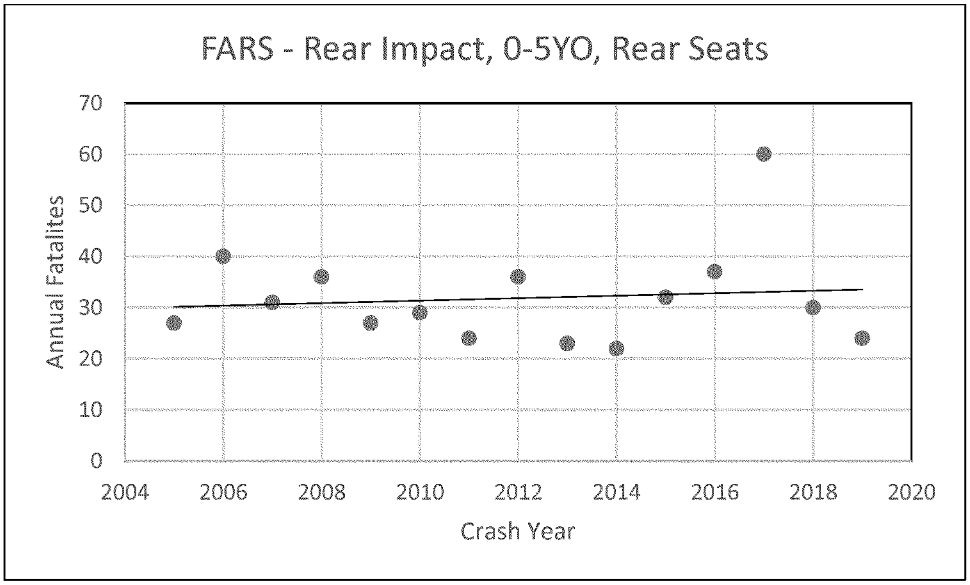

Figure V.2: NHTSAs finding of FARS reported adolescent annual fatalities in a rear seat, non-ejected, in a non-rollover, rear impact

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2. Rear Structure Intrusion

Saczalski states in his petition that there are phenomena other than front seat back failure and ramping that create risk to children in rear seats. He notes that rear-seated children in rear-end collisions are often injured by poorly designed rear structures that push children forward into the front seat back. He supports this claim using a 2008 study of NASS–CDS data, which looked at the risk to children seriously injured in rear impacts and indicated that injury caused by intrusion from the rear seating area is a larger problem than deforming front seat.[143] NHTSA appreciates the analysis done by Saczalski and agrees that there is evidence to support a finding that there is a safety risk to children in the rear seat in a rear impact crash. NHTSA also agrees that this risk involves more factors than just front seat back collapse, such as rear structure intrusion. NHTSA seeks comment on the significance of the intrusion issue in the overall context of rear impacts and whether a practicable solution to this issue exists. NHTSA notes that the 2006 revision to FMVSS No. 301, *Fuel system integrity,* which would not have been in place for the model years of the vehicles Saczalski studied, may have induced changes to rear vehicle structures that mitigated the intrusion problem.

NHTSA wishes to emphasize that Saczalski and Cantor do not appear to have considered whether increasing the requirement for seat strength would have any unintended negative safety impacts. This document discusses at length the literature, such as the 1997 Prasad study, which suggest a possible association between significantly stiffer seats and increased incidence of whiplash and other non-contact injuries. NHTSA seeks comment on these potential negative safety impacts, which the agency believes is critical to understanding the overall safety problem in occupant protection in rear impact and whether changes to FMVSS No. 207 will meet a need for safety.

3. Cost and Practicability

Cantor argues in his petition that upgrading seat back strength would not impose a major cost on manufacturers, claiming that many modern vehicles have stronger seats compared to those in 1989 even in absence of a change to FMVSS No. 207. To support this claim, he cites his own testing, in which he claims to have studied newer vehicles using the FMVSS No. 207 procedure and found that they ‘‘tested out’’ somewhere between 2.5 to 10 times the current compliance level (373 Nm). Based on his own testing, he concludes that it would not be cost prohibitive for original equipment manufacturers that use less strong seats to increase seat back strength, and he argues that an upgrade to the standard is needed to assure all seat backs have a minimum strength.

NHTSA does not believe that Cantor’s examples of actual seat back strength in the modern vehicles provide new or better data over what was known to NHTSA in 2004, when NHTSA terminated a rulemaking to increase seat back strength. The variance seen in Cantor’s test results is consistent with that seen in the Severy data from the 1960s. It was also seen in data in a 1998 report prepared by NHTSA.[144]

NHTSA agrees that increasing seat back strength is technically feasible. Any rulemaking action to change the seat back strength requirement, however, must be practicable, meet the need for motor vehicle safety, and be stated in objective terms. As part of this analysis, a rulemaking action would assess whether this would be a cost-effective way to increase overall motor vehicle safety.

E. Assessment of the Specific Recommendations by Cantor and Saczalski

In this section, NHTSA presents its assessment of specific matters petitioned for by Cantor and Saczalski. The first section discusses the matters on which NHTSA is granting the petitions and initiating rulemaking and provides NHTSA’s opinions on those specific petitioned-for issues to facilitate informed comment. The second section covers the issues on which NHTSA is

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[143] Viano D, Parenteau C (2008), Field Accident Data Analysis of 2nd Row Children and Individual Case Reviews, SAE Technical Paper 2008–01–1851.

[144] Molino L (1998), Determination of Moment-Deflection Characteristics of Automobile Seat Backs, NHTSA, November 25, 1998. *See Regulations.gov,* Docket document no. NHTSA–1998–4064–0026.

denying in part and provides the reasons for denial as required in 49 CFR part 552.

1. Matters on Which NHTSA Is Granting the Petitions

(a) Amend FMVSS No. 207 To Increase Seat Back Moment Requirement and Alter Load Application Method

Saczalski asked NHTSA to raise the torque requirement about the seat back pivot to 2,260 Nm (20,000 in-lb). This would raise the current FMVSS No. 207 requirement of 373 Nm (3,300 in-lb) by a factor of about 5.4 and by a factor of about 3.1 above the FMVSS No. 202a requirement of 654 Nm (5,788 in-lb). In addition, Saczalski recommended that the load be applied through a “body block” representing a 95th percentile male, rather than to the upper member of the seat frame. NHTSA is granting the petition on the torque requirement and static test design issues in part, is initiating rulemaking to consider whether to upgrade FMVSS No. 207 on these topics and seeks comment on the analysis below.

Saczalski did not explain why a torque limit of 2,260 Nm was preferable to other limits that NHTSA has considered previously (See table V.1) and would not result in the potential safety harms discussed above. Furthermore, Saczalski does not provide a compelling reason why a body block test would be the most effective way to test rearward moment strength statically. NHTSA notes that Saczalski is also requesting a dynamic requirement, and he did not explain why amending the FMVSS to use a body block for the static test would be necessary if NHTSA were to accept his recommendation to incorporate a dynamic test with a more biofidelic dummy.

TABLE V.1—PAST RECOMMENDATIONS FOR REVISING THE QUASI-STATIC SEAT BACK TORQUE REQUIREMENT IN FMVSS NO. 207

Test reference	Current standard	Recommendations				
	FMVSS No. 207 (since 1968)	Severy (1969)	NHTSA (1974 NPRM)	Saczalski (1989 petition)	Viano[1] (2003)	Saczalski (2014 petition)
H-point moment, min	373 Nm (3,300 in-lb).	11,300 Nm (100,000 in-lb).	373 Nm (3,300 in-lb).	6327 Nm (56,000 in-lb).	1700 Nm (15,000 in-lb).	2260 Nm (20,000 in-lb).
Seat back requirement	“withstand” torque			“withstand” torque	specifics given below.	“withstand” torque.
Seat back rotation, max		10 deg	40 deg.			
Load drop limit, max					2000 N over 10° rot.	1780 N “sudden”.
Load application	upper member of seat back frame.	upper member of seat back frame.	upper member of seat back frame.	upper member of seat back frame.	thru HIII–50M lower torso.	thru HIII–95M body block.
Seat stiffness, max					25 kN/m.	
Frame compliance, max					2.0 deg/kN.	
Load limit, min					7.7 kN.	
Seat twist, max					15 deg.	
Dummy H-point upward displ., max (design target only).					50 mm.	

[1] Viano’s quasi-static test equipment and procedure represents more of an alternate test method than a simple revision to FMVSS No. 207. Details are described in Viano (2003), “Resolving the debate between rigid (stiff) and yielding seats: seat performance criteria for rear crash safety,” cited earlier.

Saczalski also suggested that NHTSA impose a requirement so that, when tested to failure, there is no sudden drop in load of 1,780 N (400 lb-f) or greater within a short span. NHTSA is also granting the petition on this issue in part. NHTSA is aware of others who have recommended similar changes in the past to assure a gradual deformation of seat back components. NHTSA notes that Saczalski did not suggest an objective and practicable test procedure. Depending on how a test is carried out, a sudden load drop in a quasi-static test may not necessarily indicate an unsafe design. Even a drop to zero is not necessarily problematic if a slight perturbation in backward movement brings the load back up. NHTSA seeks comment on this requirement. What safety benefits could be obtained from such a requirement? Is there a practicable and objective test procedure that can be developed?

(b) Structural Symmetry

To assure structural symmetry of the seat, Cantor petitioned for a pass/fail limit for rearward seat back rotation of no more than 15 degrees from its initial seat back orientation (measured in real-time during the test) and 10 degrees of differential rearward deflection between the left and right sides for oblique impacts. NHTSA is granting in part on this issue and seeks comment. In particular, does the increased prevalence of dual recliners in the fleet remove any safety benefits that may be gained from a structural symmetry requirement? If not, what test procedures and anti-twisting standards should NHTSA consider and why? NHTSA notes that Cantor does not provide data or evidence supporting his proposed pass/fail limit or deflection amounts proposed.

(c) Dynamic Rear Impact Test Design

Both Saczalski and Cantor petitioned NHTSA to add a new dynamic crash test to FMVSS No. 207, which would test seat back performance using a 1,368 kg (3,015 lb) deformable barrier that strikes the rear of the vehicle at 80 km/h.[145] NHTSA is granting the petitions in part on this issue and seeks comment on the analysis below. NHTSA has previously considered, in the 1974 NPRM, adding a new dynamic requirement of the type recommended by Saczalski and Cantor. Table V.2 shows the various dynamic rear impact tests that have been proposed and considered in the past.

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[145] This barrier test would be similar to the barrier test that NHTSA included in its latest revision of the FMVSS No. 301; *see* 68 FR 67068 (Dec. 1, 2003).

TABLE V.2—PAST RECOMMENDATIONS FOR A DYNAMIC SEAT BACK STRENGTH REQUIREMENT

	Nash 1974	NPRM 1974	Saczalski 1989[1]	Cantor 1999[2]	Viano 2002	Saczalski 2015[4]	Cantor 2015
Test type	FMVSS No. 301 (1974).	FMVSS No. 301 (1974).	FMVSS No. 301 (1974).	FMVSS No. 301 (1974).	Sled test	FMVSS No. 301 (2003).	FMVSS No. 301 (2003).
Impactor speed[3]	48 km/h	48 km/h	48 km/h	48 km/h	30–36 km/h[3]	80 km/h	80 km/h.
Barrier specs	1814 kg rigid	1814 kg rigid	1814 kg rigid	1814 kg rigid		1368 kg deformable.	1368 kg deformable.
Impact angle	+/− 30 deg	0 deg	0 deg	0 deg	0 deg	0 deg	+/− 30 deg.
Impact overlap	100%	100%	100%	100%	100%	70%	70%.
Dummy size	HII–50M	HII–50M	HIII–95M	50M2	HIII–50M	HIII–95M	HIII–50M.
Rear seat dummy						CRABI–12M in FFCS.	
Seat back rotation, max.	No fail	40 deg	40 deg	15 deg	35 deg	25 deg	15 deg.
Seat back twist, max.					8 deg		10 deg.
Head, HIC				unspecified value		CRABI 390 | HIII 700.	
Head/neck extension.	45 deg				45 deg	n/a	10 deg.
Neck moment	45 deg			unspecified value	20 Nm	CRABI 17 Nm | HIII 179 Nm.	
Neck x-displacement.					60 mm	n/a	
Neck y-displacement.					30 mm	n/a	
Chest deflection						CRABI 30 mm | HIII 70 mm.	
Femur load						CRABI n/a | HIII 12.7 kN.	

[1] Contained within Saczalski's comments to NHTSA's 1989 Request for Comments. *See Regulations.gov*, Docket Document No. NHTSA–1996–1817–0024.

[2] Contained within Cantor's presentation to NHTSA on November 18, 1999. Cantor recommended the use of a dummy designed with an articulated pelvis. *See Regulations.gov*, Docket Document No. NHTSA–1998–4064–0030 for a copy of the presentation.

[3] Except for the Viano (2003) recommendation, the impactor speed for each recommendation represents the speed of the moving barrier when it strikes the stationary test vehicle. The Delta-V experienced by the test vehicle is about half of the impactor speed, depending on the mass of the vehicle. For the Viano recommendation, the 30–36 km/h impulse for the sled test corresponds to the Delta-V range observed in FMVSS No. 301 rigid barrier tests run at 54.2 km/h (33.2 mph).

[4] Saczalski's 2015 petition recommended use of "NHTSA injury reference values for the head, neck, chest, and extremities" for the HIII–95 seated in the front and the CRABI seated in the rear. For convenience, we have entered IARVs for the CRABI "C" and the HIII–95M "H" in the table above that correspond to those that NHTSA recommended in Eppinger, 2000 (cited earlier)

(1) The Saczalski Petition

In his petition, Saczalski states that a dynamic test is needed, but he does not explain the reason that he recommends using a deformable barrier travelling at 80 km/h, a HIII–95M in the front seat, and a rear seated CRABI in a forward-facing child restraint.

NHTSA believes that his recommendations are intended to represent the crash Saczalski studied in his 2014 FISITA paper, a real-world crash that involved an infant fatality in the rear seat.[146] For the paper, Saczalski reconstructed the crash by staging a crash test on the same vehicle model (a 2004 Chrysler minivan) with a CRABI dummy in the child restraint and an HIII–95M in the front seat. A crash pulse generating a ΔV of 40 km/h was applied. The test resulted in seat back yielding and head-to-head contact between the two dummies. This produced a head injury criteria (HIC) of 3192 in the CRABI dummy, which is well above the reference value of HIC = 390.

Saczalski then re-ran the test but replaced the minivan's standard front seat with a stronger seat removed from a 2004 Chrysler convertible. This was a belt integrated seat design, where the torso belt anchorage was attached to the seat back. For such a seat design, the seat back attachment to the seat base must be much stronger than a typical design because it must be capable of sustaining the seat belt loading from frontal crashes. According to Saczalski, the replacement seat did not yield significantly in the crash, resulting in no head-to-head contact and a very low (HIC=36) HIC value of the CRABI dummy. In addition, Saczalski presented a process by which he was able to develop a predictive equation for determining HIC in the CRABI dummy as a function of the front seat occupant mass and the impulse of the crash (ΔV), which involved running slight variations of the above-described scenario multiple times using the same model of 2004 Chrysler minivan. Based on Saczalski's findings, to avoid occupant to occupant interaction in the particular crash he studied, the seat back of the front seat would need to be strong enough to not excessively yield in a crash that involves a ΔV of 40 km/h when the seat is occupied by a HIII–95M dummy.

Saczalski's analysis in his FISITA paper is informative, but insufficient to support a final rule implementing the test parameters utilized and suggested in his petition. First, it is based on tests of only a single vehicle model (a 2004 Chrysler minivan), two seat designs, and a single child restraint system (CRS) model. Additional data from a wider variety of vehicles, seats, and CRS models would be needed to determine whether Saczalski's findings in his FISITA paper are consistent across the U.S. fleet of passenger cars. Of particular concern is the fact that the belt integrated seat design used as an acceptably performing seat is relatively rare in the fleet (primarily used in convertibles) and designed for seat belt loading in the frontal direction.[147]

Second, the tests use a front seat test dummy, the HIII–95M, which is not a regulated test tool and may not have the full scope of necessary traits for rear impact testing at high speed. In particular, the HIC response generated by the dummy may be of limited value for analyzing the situation in question because the rear part of the dummy's

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[146] The crash Saczalski describes in a forward-facing child restraint, and a rearward ΔV of 40 km/h. (*Note:* ΔV is the change in velocity of a vehicle due to a crash or impulse. In this instance, the 80 km/h barrier impact with a stationary vehicle resulted in a ΔV of 40 km/h.)

[147] 2016–2016 estimates put convertible sales at approximately 1.9% in the U.S. Source: *https://www.iseecars.com/most-convertibles-by-state-2017-study.*

head, which contacts the child dummy, is not designed to provide an internal or external biofidelic impact.

Third, the predictive HIC equation on which Saczalski based his recommended test setup does not use adequate statistical methods. It is generated using only five data points, potentially making it insufficiently robust. Moreover, it bases the prediction through two of the more extreme data points, while ignoring the other three. As a result, the predictive function fits the two selected points perfectly, but very poorly fits the others. Finally, because standard regression techniques were not applied, there were no statistical computations of standard errors or other measures of fit, such as R-squared. Given these shortcomings, NHTSA does not believe it could base its selection of test parameters in a new dynamic seat back strength test on Saczalski's data. NHTSA seeks comment on this analysis and whether there is additional supporting data for Saczalski's proposed test design.

(2) The Cantor Petition

Cantor similarly does not provide support for the test parameters he chose in his recommendation for a dynamic rear-impact seat back strength test. He argues that because the impulse created by the 80 km/h barrier is appropriate for the FMVSS No. 301 fuel system integrity standard, it would also be appropriate for setting a minimum seat back requirement. This is a generalization that requires further justification. Because the minimum requirements for seat back strength and fuel system integrity do not address the same safety concerns, NHTSA believes this is insufficient basis, on its own, to implement this test parameters.

Finally, NHTSA would need to show that any dummy used in a new dynamic test is chosen appropriately. The petitioners suggested the use of a Hybrid III dummy (HIII–95M by Saczalski; HIII–50M by Cantor). As stated, in regard to Saczalski's 2014 FISITA paper, the Hybrid III dummies have significant biofidelity limitations when used for rear impact analysis. NHTSA seeks comment on whether there is evidence showing these limitations are acceptable and would lead to appropriate seat designs if these dummies are chosen for a new dynamic test in FMVSS No. 207.

2. Matters on Which NHTSA Is Denying the Petitions

(a) Incorporate a Cargo Stipulation Into FMVSS No. 207

Saczalski requested that NHTSA amend FMVSS No. 207 to include a cargo stipulation in a dynamic vehicle test. Saczalski argued that deformation of the rear of the vehicle caused by crash forces could cause loose cargo stored in the rear (or trunk) to be pushed forward into the back of the second row of seats, causing those seats and their occupants to in turn be pushed forward into the back of the front row seats.

NHTSA previously denied a similar request from Cantor in 2004, and Saczalski did not provide additional field data or analysis to support adding specifications for cargo placement.[148] Without further analysis, NHTSA is not considering incorporating a cargo stipulation in FMVSS No. 207 at this time. This decision will allow NHTSA to focus its resources more fully on the aspects of the petitions related to rearward seat back strength.

(b) Amend FMVSS No. 209 To Require That Seat Belts Remain on Pelvis Under All Conditions

Cantor requested NHTSA restore language, previously deleted in 1999, in FMVSS No. 209 requiring that the pelvic restraint portion of both Type-1 and Type-2 seat belts remain on the pelvis under all conditions.[149] NHTSA is denying this request.

Cantor states that restoration of this paragraph will prevent ramping by assuring that manufacturers install a device that keeps the lap belt portion of the seat belt on the pelvis under all crash conditions. According to Cantor, technology that would prevent ramping is already available on the market, including the following: a sliding/cinching latch plate to prevent excess shoulder belt webbing from transitioning to the lap belt portion and causing the lap belt to go slack; an integrated seat in which both lap and shoulder belt anchors are mounted to the seat; and seat belt pretensioners sensitive to rear impacts and designed to work with an integrated seat with a belt configuration as described above.

The agency removed this stipulation from the standard in 1999 because it was deemed redundant and unnecessary.[150] FMVSS No. 208, other provisions in FMVSS No. 209, and FMVSS No. 210 contained more specific requirements that collectively have the effect of requiring pelvic restraint and thereby reducing the likelihood of occupants submarining[151] during a crash. It was also deemed unenforceable because the regulation did not provide an objective means to determine that a lap belt complied with the requirement and was in fact ''designed'' to remain on the pelvis. In addition, NHTSA noted that the meaning of the words, ''remain on the pelvis,'' was unclear. Because these conditions and reasons have not changed since that action was taken, NHTSA will not reinstate the requested language.

(c) Add a Rear Impact Test to FMVSS No. 213, Child Restraint Systems

Saczalski requested that NHTSA revise FMVSS No. 213 by including a rear impact requirement for child restraint systems like the one described in ECE Reg. No. 44. Saczalski's only change from Reg. No. 44 is performing the rear impact test at a 40 km/h velocity instead of 30 km/h. Saczalski stated that such a revision is necessary to prevent rear facing child restraint systems (CRSs) from folding rearward when they become trapped between a rear seat and a yielding front seat back during a rear impact crash.[152]

NHTSA is denying this request for change. NHTSA considered adopting ECE Reg. No. 44's rear impact test into FMVSS No. 213 in the past.[153] In a 2002 ANPRM, NHTSA discussed agency tests evaluating ECE Reg. No. 44's rear impact test conducted at 30 km/h (18.6 miles per hour), with peak deceleration between 14 g and 21 g over a 70-millisecond time period. The tests were dynamic sled testing performed by NHTSA in research on FMVSS No. 202 and FMVSS No. 207, where NHTSA added a rear-facing child restraint with a 12-month-old test dummy to a 1999 Dodge Intrepid vehicle seat. One test, simulating a dynamic FMVSS No. 202

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[148] Cantor sought inclusion of an unrestrained cargo test for the safety of occupants in the rear seat. 71 FR 70477 (Dec. 5, 2006). 71 FR 70478. NHTSA denied that petition because the incidence of injuries caused by loose luggage was very low and did not warrant an amendment to a Federal safety standard, and Cantor did not provide any field data demonstrating a correlation between cargo intrusion and occupant safety.

[149] The paragraph in question, S4.1(b), read as follows: ''4.1(b) Pelvic restraint. A seat belt assembly shall provide pelvic restraint whether or not upper torso restraint is provided, and the pelvic restraint shall be designed to remain on the pelvis under all conditions, including collision or roll-over of the motor vehicle. Pelvic restraint of a Type 2 seat belt assembly that can be used without upper torso restraint shall comply with requirement for Type 1 seat belt assembly in S4.1 to S4.4.''

[150] 64 FR 27203 (May 19, 1999).

[151] ''Submarining'' refers to the tendency for a restrained occupant to slide forward feet first under the lap belt during a vehicle crash, which could result in serious abdominal, pelvic, and spinal injuries.

[152] This condition was highlighted in Saczalski's 2014 FISITA paper.

[153] NHTSA analyzed this issue in a rulemaking amending FMVSS No. 213 pursuant to the Transportation Recall Enhancement, Accountability and Document Act (TREAD Act), November 1, 2000, Public Law 106–414, 114 Stat. 1800. The agency requested comments on the merits of incorporating the rear impact test of ECE Reg. No. 44 into FMVSS No. 213 (ANPRM; 67 FR 21836, 21851 (May 1, 2002)).

condition, was conducted at approximately 17.5 km/h (11 mph). The other two tests were conducted at approximately 30.5 km/h (19 mph). In all of the tests the 12-month-old dummy in the rear-facing child restraint was able to easily meet the injury criteria of FMVSS No. 208, *i.e.* was below the threshold for injury. After examining these data, comments to the ANPRM, and data showing that fatalities for children in rear impact crashes constitute a much smaller percentage of the total than other crash modes, NHTSA decided to focus its resources on developing a side impact test and not a rear impact test.[154]

NHTSA disagrees with Saczalski that there is a need to adopt a 40 km/h rearward impact test based on ECE Reg. No. 44. NHTSA does not believe adopting such a rear impact test is warranted for a number of reasons. First, rear impact fatalities among children restrained in CRSs are generally in very severe crashes that result in significant passenger compartment intrusion into the rear seating area. However, the ECE Reg. No. 44 sled test requested by the petitioner does not simulate such intrusion into the seating area. Second, the ECE test protocol does not evaluate the circumstance about which Saczalski is concerned. The rear impact test in ECE Reg. No. 44 does not have a simulated front seat and therefore does not replicate the crash scenario the petitioner seeks to evaluate. The standard seat assembly in FMVSS No. 213 also does not include a simulated front seat, and it is yet to be determined if a representative front seat could be designed and whether it could be made to collapse in a compliance test in a repeatable and reproducible manner.

Finally, the petitioner provides no information about a practicable countermeasure that CRSs can provide that would prevent injuries and fatalities if there is a front seat collapse and/or intrusion into the rear seating area. NHTSA undertakes rulemakings on FMVSS No. 213 weighing various principles and considerations, in addition to the considerations and requirements for FMVSS specified by the Safety Act, statutory mandates, Executive Order (E.O.) 12866,[155] and other requirements for agency rulemaking. In making regulatory decisions on possible enhancements to FMVSS No. 213, NHTSA considers the consumer acceptance of cost increases to an already highly effective item of safety equipment and whether an amendment could potentially have an adverse effect on the sales of this product. The net effect on safety could be negative if CRSs are not used as much because of cost increases. NHTSA also weighs the effects of an amendment on the ease of correctly using child restraints. We consider whether an amendment may cause child restraints to become overly complex or frustrating for caregivers, resulting in increased misuse or nonuse of the restraints. The petitioner did not provide information that would enable NHTSA to assess these practicability issues.

Based on the forgoing, NHTSA is denying Saczalski's request to amend FMVSS No. 213.

(d) NCAP Implementation

Cantor requested that NHTSA implement a rear-impact crash test into the 5-star rating as part of his dual FMVSS/NCAP approach. NHTSA's regulations at 49 CFR 552.3 state that a petition for rulemaking may be filed respecting the issuance, amendment or revocation of a motor vehicle safety standard. NCAP is not a motor vehicle safety standard. Therefore, a petition for rulemaking is not the appropriate mechanism for requests to amend the NCAP program. NHTSA therefore denies Cantor's petition for rulemaking. After NHTSA's planned research is completed, however, we will be in a better position to consider how best to implement any necessary changes both in our standards and/or NCAP.

F. Conclusion of NHTSA Assessment of Cantor and Saczalski Petitions

In accordance with 49 CFR part 552 and after careful consideration, Cantor's request to restore pelvic restraint language to FMVSS No. 209, and Saczalski's request to add a rear impact test to FMVSS No. 213 and to add a cargo test and requirement to FMVSS No. 207 are denied based on the information presented above. This ANPRM provides the required notification of the denial. As part of our effort to facilitate further research and data development to support a potential rulemaking to updated FMVSS No. 207, NHTSA grants in part both petitions regarding updating the moment strength requirement in FMVSS No. 207 and the development of updated static and dynamic test procedures for seat back strength, and Cantor's petitioned-for request on structural symmetry. NHTSA seeks comment on the issues discussed above.

G. Center for Auto Safety (CAS) Petition

On March 9, 2016, CAS petitioned NHTSA to amend FMVSS No. 208 and FMVSS No. 213 to require additional warnings instructing parents to place children in rear seating positions behind unoccupied front seats, if possible, or behind the lightest front seat occupant.

CAS requested that FMVSS No. 208, S4.5.1(f), be amended so that the vehicle owner's manuals be required to include the following language (or similar):

''If possible, Children Should Be Placed in Rear Seating Positions Behind Unoccupied Front Seats. In Rear-End Crashes, the Backs of Occupied Front Seats Are Prone to Collapse Under the Weight of Their Occupants. If This Occurs, the Seat Backs and Their Occupants Can Strike Children in Rear Seats and Cause Severe or Fatal Injuries.''

CAS also requested that the label found at FMVSS No. 213, Figure 10, be amended to include the statement ''Place behind an unoccupied front seat where possible.''

H. Analysis of CAS Petition

CAS requested that NHTSA add warning statements in the owner's manual and on CRS labels to warn parents to ''Place behind an unoccupied front seat where possible.'' Currently, the CRS label warns of the potential injury that could result from placing a CRS in front of an air bag but does not make any statement relating to where else in the vehicle the CRS should not be placed. Moreover, the CRS label instructs that ''The back seat is the safest place for children 12 and under.''[156]

CAS does not provide analysis demonstrating a net benefit to placing the child in a specific rear seat. Long established data show that the rear seat is the safest place for children under the age of 13.[157] Published NHTSA data shows that rear seats are 25–75 percent more effective in reducing fatalities (compared to front seats) for children 0–12 years old.[158] However, the overall risk to CRS-seated children in each rear position depends on many factors other than front seat occupancy. These factors may include which side of the vehicle

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[154] NHTSA withdrew the rulemaking in a final rule, 68 FR 37620, 37624 (June 24, 2003). *See also* Report to Congress, ''Child Restraint Systems, Transportation Recall Enhancement, Accountability and Document Act,'' February 2004. *chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://www.nhtsa.gov/sites/nhtsa.gov/files/documents/tread.pdf.*

[155] E.O. 12866, ''Regulatory Planning and Review,'' September 30, 1993, as amended by E.O. 14094.

[156] FMVSS No. 213, Figure 10.

[157] Braver, ER et al. Seating positions and children's risk of dying in motor vehicle crashes. Inj Prev. 1998;4:181–187. Durbin, DR et al. Effects of seating position and appropriate restraint use on the risk of injury to children in motor vehicle crashes. Pediatrics. 2005;115:e305–e309.

[158] Kuppa, S et al. Rear Seat Occupant Protection in Frontal Crashes. 2005 Enhanced Safety of Vehicles Conference, Paper No. 05–0212.

is struck in a side impact (and where the CRS is placed in relation to that impact) and the risks involved in more common frontal impacts. CAS fails to provide sufficient data or other information to conclude that the warning recommended in its petition would have any net benefit.

By contrast, there may be unintended safety harms that such a label could generate. The suggested label could dilute the message about the importance of placing children in the rear seat. It could be read by some consumers as inconsistent with the label required by Figure 10 of FMVSS No. 213 that the rear seat is the safest place for children aged 12 and under. Such inconsistency may confuse them and reduce the efficacy of the current CRS label. The label could lead some caregivers to install the child restraint system in a front seating position rather than a rear seating position to avoid rear proximity to an occupied front seat. This outcome could have severe consequences if the rear-facing CRS were positioned in front of a deploying air bag. Another unsafe outcome of such confusion could be some caregivers deciding not to use a CRS at all with their child when the CRS cannot be placed behind an unoccupied front seat. CAS did not provide any assessment of the risk of unintended consequences related to the petition for a label. The guidance recommended by CAS may result in the continual removal and reinstallation of a CRS by parents, depending on front seat occupancy, as they decide which seating position is safer. Such actions could lead to fatigue, with some caregivers eventually ignoring the instruction. Not only would that undermine the label's purpose, but NHTSA is also concerned that caregivers may start to ignore other instructions and warnings on the label, such as the warning on the label required by Figure 10 not to place the CRS on the front seat with an air bag. Such a warning is crucial to the safety of the child and must be always followed.

Finally, NHTSA rejects CAS's request to add language to FMVSS No. 208, S4.5.1(f) and therefore required in owner's manuals, stating ''If possible, Children Should Be Placed in Rear Seating Positions Behind Unoccupied Front Seats. In Rear-End Crashes, the Backs of Occupied Front Seats Are Prone to Collapse Under the Weight of Their Occupants. If This Occurs, the Seat Backs and Their Occupants Can Strike Children in Rear Seats and Cause Severe or Fatal Injuries.'' We are denying this request for the same reasons discussed above, namely that CAS has not provided supporting information demonstrating the benefit of the change and has not provided analysis of unintended consequences that the amendment may cause. We also emphasize that this language proposed for the owner's manual, by focusing even more on the risk of seat back collapse than the language proposed for the label, has added potential to cause confusion beyond the language petitioned for the label. Therefore, NHTSA will not incorporate the requested amendment.

For these reasons, NHTSA does not believe adopting CAS's recommendation to change the CRS label or amend FMVSS No. 208, S4.5.1(f) would be appropriate. The agency continues to promote the message that the rear seat is the safest place for children. In accordance with 49 CFR part 552 and after careful consideration, the CAS petition for a labeling requirement to be added to FMVSS No. 213 and to amend FMVSS No. 208 is denied based on the information presented above. This ANPRM provides the required notification of the denial.

VI. Unified Approach to Rear Impact Protection

A. Introduction

As NHTSA undertakes this process, our main considerations, as always, are safety and the obligations the agency has under the Vehicle Safety Act. IIJA requires that we publish this ANPRM to update FMVSS No. 207. Throughout this rulemaking effort, we need to take into account the Safety Act's imperative that FMVSS be practicable, meet the need for motor vehicle safety, and be stated in objective terms. The long-term and ongoing challenge to meeting these goals has been to develop an update to FMVSS No. 207 and rear impact protection in general that effectively balances the tradeoffs to improve overall safety with a reasoned consideration of all factors involved. As far back as 1974, NHTSA understood that there would be advantages in taking a more unified approach to rear impact protection. The 1974 NPRM preamble stated that consolidation of Standards 202 and 207 logically reflects the relationship of the seat and its head restraint and would improve the possibilities of eventually testing the whole seating system with a dynamic test procedure.

In 1992, the agency again signaled that it continued to believe that a unified approach was likely the best approach to rear impact protection. In that report, the agency stated that there are four categories of performance issues that need to be addressed as part of future changes to FMVSS No. 207. These four categories are: (1) Seating system integrity; (2) Seat energy absorbing capability; (3) Compatibility of a seat and its head restraint; and (4) Seat and seat belt working together. In the 2004 final rule to update FMVSS No. 202, NHTSA again reiterated the ultimate goal of adopting a method of comprehensively evaluating the seating system.

The four rear impact protection categories outlined in 1992 indicate the need to maintain a balance between energy absorbing and stiffness characteristics and the fact that the severity and type of occupant injuries varies with impact velocity in rear collisions. Low-to-moderate velocity crashes represent the majority of rear collisions, and these crashes are responsible for the majority of reported injuries, mainly whiplash. At higher impact velocities the injury risks for the occupant of a seat include bodily impact with vehicular structures, severe thorax, pelvis, and neck injuries, and other risks.[159] Additionally, at higher impact velocities deformation of the seat sufficient to allow interaction between front and rear occupant rows and associated injuries can occur. The debate around FMVSS Nos. 202a and 207 concerns how effective these standards are in mitigating these risks and the inevitable tradeoffs.

NHTSA seeks comment broadly on an update to the FMVSS regarding occupant protection in rear impacts. Even if it has been clear for many years that the ideal approach to rear impact safety would incorporate consideration of both moderate and severe rear impacts, is there a sound scientific basis for a reasonable update to the standards for rear impact protection and are the necessary technical tools available for a sound rulemaking proposal? Can we have a high degree of confidence that any such proposal will be generally beneficial? In the following section, we further analyze, discuss, and seek comment on potential paths forward for an update to rear impact protection required by the FMVSSs, with emphasis on a unified approach.

B. FMVSS No. 207

Generally, the discussion around FMVSS No. 207 has been a narrow focus on seat back strength. However, occupant protection in rear impact involves many other issues. Some, such as Prasad in 1997 and Burnett in 2004,

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[159] We note that 2017–2020 CISS data indicates that at all rear impact crash speeds whiplash remains more frequent than any MAIS 2+ injury.

suggested that seat back strength has limited correlation with occupant dynamics prior to seat back failure. Such conclusions, however, were drawn from older designs whose seat strength is much lower than some have proposed for a FMVSS No. 207 upgrade.[160] Nonetheless, in its present form, the standard provides limited guarantees on how an occupant will respond to a rear collision prior to the seat back failing. In fact, the FMVSS No. 202a requirements likely have a greater influence on occupant protection because the majority of rear collisions yield minor or no injuries and occur at relatively low ΔVs. For example, table II.3 shows NHTSA's estimate that in rear collisions, 96% of injuries were MAIS 1–2 and, if ΔV was known, 76% of MAIS 1–2 injuries occurred at ΔV of 30 km/h or less. Therefore, the present scope of FMVSS No. 207 is limited in the sense that it focuses only on the first category of the four seat performance categories for rear impact protection, *i.e.,* seating system integrity.

Furthermore, a very high seat back strength requirement in FMVSS No. 207 would likely result in a seat back with very high stiffness due to the necessary structural reinforcements. Such seats may impose high occupant loading due to rapid acceleration in higher speed rear impacts.[161] However, whether such loading is necessarily injurious, the speeds at which such loading may be injurious, and whether the trade-offs between stiffness and injury are inherent or can be compensated for in other design elements, are all matters to be considered. On the other hand, a seat back with very low strength may quickly reach a rotation limit, or fail, at lower rear impact speeds.

In striking this balance, manufacturers have, in general, settled on seat back strength that has increased on average over the decades to many times the value set by FMVSS No. 207.[162] Viano, et al., for example, noted that MY 1990s dual recliner seats had an average peak moment strength of 1,970 Nm while MY 2000s era dual recliner seats had an average peak moment strength of 2,360 Nm.[163] As noted in the 2019 Edwards study,[164] it appears as if some manufacturers have strived to achieve balance in modern seating systems between low-speed whiplash protection and structural integrity at higher speeds.

Currently, FMVSS No. 207 addresses a segment of the overall rear impact protection issue. In addition, the regulated seat strength set by FMVSS No. 207 is considerably lower than the average seat strength of modern production seats. The following section outlines different approaches for updating the standard to enhance or broaden the scope of rear impact protection, thereby further addressing the rear impact protection points set by NHTSA.

C. Analysis of Approaches To Updating Standards for Occupant Protection in Rear Impact

1. Seat Back Strength and Other Mechanical Properties

A foundational consideration for updating standards related to rear impact protection is the strength of cantilevered seat backs in the rearward direction, regardless of how the seat back strength is tested or measured. The current strength level set by FMVSS No. 207 is far below the average design strength of production seats. As a result, manufacturers have great flexibility in seat back design. This flexibility allows manufacturers to readily adopt new technology such as active head restraints, and to allow their seat designs to quickly evolve as the understanding of rear impact protection changes. Any increase in the seat back strength requirement will reduce manufacturer flexibility. Furthermore, any new strength requirement should reduce injuries and adequately balance tradeoffs. As with any other regulatory change, due consideration must be given to overall cost effectiveness of proposed changes to the regulatory regime.

As a starting point, the required level of seat back strength should limit the interaction between the occupants of different rows of seats in a rear impact. It is not clear, however, what level of crash severity is sufficient to protect against and for what size of occupant. No seat strength requirement can protect all occupants in all possible rear impact severities, but the selected strength should attempt to be protective of as many occupants as possible within the constraints of practicality and cost. Therefore, we seek comment on the correct minimum seat back strength requirement. We further seek comment on ways this parameter can be tested and measured. We also seek comment on the benefits or harm generated by the manufacturer flexibility allowed by a low minimum seat back strength requirement, and how NHTSA should understand those benefits or harms as well as the cost to manufacturers to comply with alternative elevated lower bound seat back strength options.

Another issue is energy absorption. The energy absorption or force-deflection characteristics of seat backs are currently not regulated by FMVSS No. 207. Controlled deformation of the seat back allows the occupant of a seat to ride-down a crash in a manner that may minimize injury. However, if the seat back absorbs the crash energy elastically rather than irreversibly,[165] there may potentially be injurious rebound of the occupant. Thus, remaining residual energy after occupant ride-down may be an important consideration. We note that FMVSS No. 222 incorporates a rearward energy absorption and force deflection requirement for school bus seat backs. We seek comment on whether a similar requirement should be incorporated into FMVSS No. 207 and what the performance level should be.

Older seat designs have typically used a single recliner mechanism to control seat back rotation. Because of the nature of such a design, rearward seat back load is not uniformly restricted, leading to one side of the seat back rotating more than the other; this lack of structural symmetry may lead to a subsequent twisting of the seat back. It has been theorized that such twisting reduces the ability of the seat back to prevent occupant ramping. Both of the current petitions discussed earlier in this ANPRM desired some limit to be placed on seat twist. We seek comment on whether a similar requirement is needed, what the performance level should be and how it should be measured.

We also seek comment on whether an updated FMVSS should regulate other seat characteristics that may be related

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[160] *See* table VI.1, above.

[161] The reader is referred to the increased risks as noted in the 1997 Prasad study and concerns drawn out from the 1989 Request for Comments. We note, however, that these conclusions are based on seats that are now decades old. A more recent examination of this can be found in 2023 Kang, for a very severe rear impact condition and a rigid seat structure.

[162] Saunders, J., Molino, L.N., Kuppa, S., and McKoy, F.L. Performance of seating systems in a FMVSS No. 301 rear impact crash test. Proceedings of 18th International Technical Conference on the Enhanced Safety of Vehicles, 2003. Nagoya, Japan.

[163] Viano, David C., et al. ‘‘Occupant responses in conventional and ABTS seats in high-speed rear sled tests.’’ *Traffic injury prevention* 19.1 (2018): 54–59.

[164] Edwards, Marcy A., et al. ‘‘Seat design characteristics affecting occupant safety in low-and high-severity rear-impact collisions.’’ *IRCOBI Conference, Florence, Italy, IRC–19–11.* 2019.

[165] When the seat back deforms elastically it absorbs energy like a spring and will return to its original position and shape after the applied force is removed. When the applied force is sufficient to cause yielding in the seat back there is irreversible, also termed inelastic or plastic, deformation in the seat back which permanently absorbs some energy; in which case the seat back will not return to its original position and shape after the applied force is removed.

to occupant ramping, such as pocketing and the coefficient of friction of the upholstery. We also seek comment on any other seat characteristics that should be regulated for rear impact protection.

2. Test Parameters

This section discusses and requests comment on means of testing or measuring seat parameters. We first discuss the benefits and limitations of a quasi-static approach. Afterward, we discuss and seek comment on a dynamic testing regime that utilizes two testing speeds to cover the variety of rear impact occupant protection scenarios.

3. Quasi-Static Testing

One approach to update FMVSS No. 207 is to increase the required seat back moment while retaining the current test procedure of loading the upper frame member or some other part of the seat back. This is appealing in its simplicity but has some potential shortcomings. First, the required moment is specified to be applied through a horizontal force and a distance from the seating reference point. This works well as an initial condition and within the required moment value, which typically results in a relatively small amount of seat back rotation. Depending on the increase in moment value, however, significant seat back deformation could occur during testing. In this circumstance, maintaining a horizontal load throughout the test becomes a serious challenge.

In addition, it is not clear that loading the seat back at the upper crossmember is the best way to quasi-statically load the seat back. Over the years, several different methods of loading the seat back have been developed that may better achieve the goals of the test.[166] For example, NHTSA has tested seat backs to failure by modifying the FMVSS No. 207 procedure such that the loading arm rotates with the seat back and the initial direction of loading perpendicular to the seat back as specified by SAE J879.[167] Some methods involve the use of body-blocks or counter balanced ATDs, pushed or pulled into the seat back, which loads the seat back in a manner more closely related to how a human may load the seat back. Such methods can also measure force-deflection in addition to strength.

However, existing quasi-static test procedures are also limited because they can tell us how the seat reacts when it is loaded, but they cannot tell us whether the seat's characteristics are potentially injurious to or protective of the occupant in certain rear impacts. Thus, the value of the quasi-static method may be limited if the relationship between mechanical seat properties and occupant response in a rear impact is not well understood. This may lead to a lack of optimization and the potential introduction of harmful seat behavior.

We seek comment on the use of quasi-static testing in an updated rear impact occupant protection regime. Could changes be made to quasi-static procedures or loading devices that would help discern the effect of the seat design on the seat's occupant? Is this important to fully understand how changes to seat strength or other seat design parameters will affect the occupant prior to determining what level of increase in minimum seat back strength is sufficient? Is this information necessary to develop objective measures, tests, and strength requirements for seat backs?

The above discussion is primarily related to determining seat back performance at higher severity levels. Any unified approach, however, must also consider the frequent lower speed rear impacts correlated to whiplash injury. Currently, FMVSS No. 202a requires the head restraint to have a minimum height and maximum backset or optionally limit the head to torso rotation of a Hybrid III dummy in a sled test. What changes can be made to the test method and standard for head restraints from a quasi-static requirement perspective that may improve the protection against whiplash in moderate severity rear impacts and/or create more synergistic total rear impact protection?

4. Dynamic Testing

Considering the limitations of quasi-static testing in an environment with significant uncertainty regarding injury dynamics, a dynamic assessment of seat behavior at multiple impact severities may be a more effective method for achieving a unified and synergistic approach to rear impact protection. As noted above, this approach has been a feature of past efforts to update standard FMVSS No. 207 and is also consistent with the four rear impact protection points. In this section, we discuss and seek comment on various dynamic testing approaches to achieve the goal of improved rear impact protection. Topics of discussion include test speeds, seat performance measures, ATD selection, and ATD performance measures.

To fully assess the four rear impact protection points, NHTSA is considering a dynamic approach that contains both a low and high-speed test. Each of these regimes place distinct requirements on the seating system, and a dual speed regime can help ensure balance in rear impact protection. NHTSA believes a two-tiered approach will preserve seat design flexibility while improving protection for the occupant across a range of rear impact severities.

NHTSA is considering which ATDs are best suited to use in rear-impact dynamic testing, at both low and high-speed. A low-speed test would assess the seating system's ability to protect against injuries to the cervical spine. As mentioned previously, FMVSS No. 202a currently includes a low-speed sled test option using the HIII–50M test dummy. NHTSA is considering a similar test utilizing the BioRID 50th percentile male dummy and believes this dummy provides significant improvements over other ATD options. A high-speed test would assess the rear impact regime where significant rearward rotation of the seat back may occur, and occupant retention becomes a concern as well as contact with rear seat occupants. An ATD used for this type of test should have characteristics that replicate the interaction of the occupant with the seat back. NHTSA is also considering BioRID for use in the higher speed test but acknowledges that the two test severities require different ATD capabilities. NHTSA is aware of a female rear impact dummy finite element model, EvaRID FE, which is a scaled down version of the BioRID, with mass and geometrical dimension representing a 50th percentile female. The agency is also aware of the development of a prototype 50th percentile female rear impact dummy known as the BioRID–P50F,[168] and is also interested in, and seeks comment on, the potential for its use and to what extent its state of readiness is consistent with a potential rulemaking proposal. The agency seeks comment on which ATDs would be most appropriate to use in both low and high-speed rear impact testing of seats, and whether using two different sized ATDs (for example, BioRID and BioRID–P50F) in one or both of these test configurations would

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[166] Burnett, R; Viano, D; Parenteau, C; (2022) "Quasi-Static Methods to Evaluate Seat Strength in Rear Impacts." Traffic Injury Prevention.

[167] Molino, L (1998): Determination of Moment-Deflection Characteristics of Automobile Seat Backs. NHTSA Technical Report, DOT Docket Management System NHTSA–1998–4064.

[168] The physical BioRID–P50F dummy is currently in prototype stage and not available for evaluation by the agency.

offer a more comprehensive assessment of seat performance.

(a) Low-Speed Test

An upgraded low-speed test would assess the energy absorption characteristics and compatibility of the seat and head restraint with respect to occupant protection in low severity rear impacts. The primary concern in low-speed rear impacts are cervical spine injuries associated with whiplash. Therefore, a low-speed test should promote best practices that mitigate whiplash beyond what is currently achieved by FMVSS No. 202a by ensuring compliance with a standard that establishes a minimum level of injury prevention. During the rulemaking establishing FMVSS No. 202a, the agency acknowledged commenters' criticism of the biofidelity sufficiency of the HIII–50M used in 202a, particularly its neck, in the rearward direction.[169] Thus, it is appropriate for the agency to explore the use of alternative ATDs such as BioRID, which may more accurately replicates spinal, torso and head motion. As discussed below, this comes with challenges in determining an acceptable and repeatable biomechanical measurement. Below, we discuss and seek comment on certain considerations relevant to a low-speed test: test pulse and injury criteria and test repeatability.

First, we consider the appropriate test pulse. The low-speed regime is typically associated with rear impact ΔV between 16 and 24 km/h. The dynamic sled test option in FMVSS No. 202 has a ΔV target of 17.3 ± 0.6 km/h. The Euro NCAP whiplash assessment uses low, medium and high severity sled acceleration corridors with target ΔVs of 16.10, 15.65 and 24.45 km/h. The IIHS dynamic whiplash rating uses a simulated rear impact conducted on a sled using a ΔV of 10 mph. In addition to the issues outlined below, NHTSA seeks comment on the test pulse for a low-speed rear impact test, such as ΔV and acceleration profile.

Next, we consider injury criteria and test repeatability. Current low-speed testing practices present challenges with well-defined injury criteria and repeatability of the tests. The understanding of whiplash injury mechanisms continues to evolve, and contemporary ATD injury criteria are therefore derived from nonlinear statistical correlations with biomechanical data. Because of this evolving understanding, existing dynamic whiplash assessments use a range of ATD measures. For example, the 2009 EuroNCAP dynamic whiplash ratings system[170] calculates a rear impact seat performance rating using a combination of seven measures from rear impact sled testing using the BioRID ATD. These measures are:

- NIC (neck injury criteria),
- Nkm (shear force and bending moment),
- Head rebound velocity,
- Fx upper neck shear,
- Fz upper neck axial force,
- T1 acceleration up to head contact, and
- Head restraint contact time

Any assessment based on a threshold value of these parameters should accurately assess the injury risk. To be objective, the ATD metrics of a low-speed test should also be based on a fundamental understanding of the biomechanical injury mechanisms. For example, NIC is based on the principle of neck retraction prior to the head contacting the head restraint, described earlier in the Neck injuries subsection, leading to injurious pressure waves in the spinal canal.[171] An injury threshold of 15 m^2/s^2 for the NIC was suggested[172] after analyzing human volunteer results[173] to find a lower bound of injury tolerance. However, the predictive basis of ATD metrics for low-speed injury are usually based on a statistical nonlinear analysis of biomechanical data and shows varying degrees of success in predicting real world outcomes. In the 2019 Edwards study,[174] the authors compared low-speed BioRID measurements with insurance claim data. The standard whiplash metrics, such as those listed above, did not have a significant correlation with the insurance claim data for all the seats analyzed. The longitudinal pelvis displacement of the BioRID dummy into the seats, an atypical metric in whiplash assessments, had the most significant correlation with insurance data. NHTSA has also studied intervertebral rotations in low-speed rear impacts using PMHS and ATD occupants.[175] [176] [177] NHTSA found the intervertebral rotations of the PMHS subjects to be comparable with BioRID rotations[178] and the PMHS intervertebral rotations were found to correlate with PMHS subluxation injuries (an incomplete or partial dislocation of a joint or organ).[179] The use of ATD injury metrics in assessing low-speed rear impact injury risk is still developing, and further investigation is needed to develop metrics or ratings systems with a direct relationship to real world whiplash injury. NHTSA's forthcoming research discussed later will explore various ATD whiplash criteria.

Multiple studies have shown lack of reproducibility in low-speed impacts. In 2007, a study compared the measurements of a BioRID–IIg dummy in rear impact sled tests run across 18 identical production seats.[180] The authors were concerned that because the loads in a low-speed rear impact test are very low, there could be high variability in results due to small changes in the test setup. The study ran tests at 3

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[169] 69 FR 74873 (Dec. 14, 2004); The agency concluded at that time that the HIII–50M was sufficient to discern between acceptably safe head restraint systems and those that allow unacceptable levels of head-to-torso rotation. Nonetheless, the agency stated it was likely "to revisit the decisions made in [the] final rule about dynamic performance values and the test device as more advanced dummies are developed and the injury criteria achieve broader consensus."

[170] van Ratingen, Michiel, et al. "The Euro NCAP whiplash test." 21st international technical conference on the enhanced safety of vehicles. 2009.

[171] Aldman, B.: An analytical approach to the impact biomechanics of head and neck injury." Proceedings of the 39th American Association for Automotive Medicine Conference; October 6–8, 1986, Montreal, QC. 1986.

[172] Boström, Ola, et al. "A new neck injury criterion candidate-based on injury findings in the cervical spinal ganglia after experimental neck extension trauma." *Proceedings of The 1996 International Ircobi Conference On The Biomechanics Of Impact, September 11–13, Dublin, Ireland.* 1996.

[173] Eichberger, Arno, et al. "Comparison of different car seats regarding head-neck kinematics of volunteers during rear end impact." Proc. IRCOBI Conf. 1996.

[174] Edwards, Marcy A., et al. "Seat design characteristics affecting occupant safety in low-and high-severity rear-impact collisions." *IRCOBI Conference, Florence, Italy, IRC–19–11.* 2019.

[175] Moorhouse K, Kang Y, Donnelly B, Herriott R, Bolte JH. (2012, Nov). Evaluation of The Internal and External Biofidelity of Current Rear Impact ATDs to Response Targets Developed from Moderate-speed Rear Impacts of PMHS. *STAPP Car Crash Journal,* 56, 12S–21.

[176] Kang Y, Moorhouse K, Donnelly B, Herriott R, Bolte JH. (2012, Nov). Biomechanical Responses of PMHS in Moderate-speed Rear Impacts and Development of Response Targets for Evaluating the Internal and External Biofidelity of ATDs. *STAPP Car Crash Journal,* 56, 12S–20.

[177] Kang Y, Moorhouse K, Herriott R, Bolte JH. (2013, May). Comparison of Cervical Vertebrae Rotations for PMHS and BioRID II in Rear Impacts. *Traffic Injury Prevention,* 14 (Supplement 1), S136–S147.

[178] Kang Y, Moorhouse K, Icke, K., Stricklin, J., Herriott R, Bolte J.H. Rear Impact Head and Cervical Spine Kinematics of BioRID II and PMHS in Production Seats (2015, Sept). *International Research Council on Biomechanics of Injury (IRCOBI),* IRC–15–38, 246–260.

[179] Kang Y, Moorhouse K, Icke K, Herriott R, Bolte JH. (2014, Sept). Head and Cervical Spine Responses of Post Mortem Human Subjects in Moderate Speed Rear Impacts. *International Research Council on Biomechanics of Injury (IRCOBI),* Berlin, Germany. IRC–14–33, 268–285.

[180] Bortenschlager, Klaus, et al. "Review of existing injury criteria and their tolerance limits for whiplash injuries with respect to testing experience and rating systems." *Proceedings of the 20th International Technical Conference on Enhanced safety of vehicles, Lyon, France.* 2007.

different severities with 6 equivalent repetitions at each severity. The authors found that the ATD metrics displayed high variability across the equivalent tests. The dummy rebound velocity showed the least variability with 2.76%, 1.83% and 1.23% coefficient of variation in the low, medium, and high severity tests. The NIC had greater variability with a 9.18%, 10.5%, and 13.83% coefficient of variation. The neck shear Fx, however, had very high variability with a 21.04%, 27.86%, and 32.57% coefficient of variation across like tests. After computing the ranking score for each of the 6-test series, the authors found the scores to vary by 26% from lowest to highest. Because of variability in the measurements and ranking scores the authors called into question the discriminatory power of the scoring system and noted the lack of robustness in the scoring system. This study underlines the challenge in developing a low-speed rear impact testing approach with high reproducibility. Note that the values of a characteristic for a rating system or standard might be set in such a way as to account for the variability associated with the test.

The precise understanding of how whiplash injuries occur is evolving, but not complete. We seek comment on this approach. Are the ATD measurements described above sufficiently objective and correlated with whiplash injury? If so, can a low-speed test be conducted in a repeatable and reproducible manner that would ensure objective results and positive safety outcomes that are equitably distributed across all occupant types? Do practicable countermeasures for whiplash injuries exist to meet such a regulatory requirement? Would the requirement work synergistically with a high-speed dynamic requirement?

(b) High-Speed Test

A high-speed test would assess rear impact protection at a severity where significant rearward deflection of the seat back may occur, and occupant retention becomes a concern. This test would assess all four of the rear impact protection points. The high inertial forces placed on a seat back would test seating system integrity and energy absorption capabilities of the seat back through rearward rotation and deflection, as well as the ability of the seat belt restraint system to maintain retention and support an occupant in rebound. Finally, compatibility of the seat and head restraint would be assessed through appropriate ATD injury limits. The assessment would likely include neck (whiplash or higher-level injury), thorax, spine, and pelvis results, but could include other body regions as well.

Occupant injuries in a high-speed rear impact are primarily severe head, neck, and thorax injuries and have clear pathology. Research conducted by NHTSA has shown that severe thorax injuries, *i.e.,* rib fracture, may also occur in a retained seat occupant through inertia and interaction with the seat back in very high-speed rear collisions and rigid seat supporting structures.[181]

Seat retention provides continual support to the occupant and is important to avoid severe contact injuries and injurious occupant kinematics. A lack of occupant retention may also lead to severe injuries to passengers other than the forward row occupants through occupant-to-occupant interaction. A high-speed test would assess seating protection against injury through data from an ATD and related seating retention metrics. The occupant retention metrics of concern may include the maximum dynamic seat back rotation angle and ATD displacement measures. NHTSA seeks comment on the appropriate occupant retention metrics and ATD injury criteria at high-speed. We request comment on how the availability of specific ATDs might limit or inform the selected measurements.

The forces applied to seat backs in rear impacts range over a continuum of severities. The applied inertial forces are proportional to the seat base acceleration induced by the crash pulse, the occupant's mass, and acceleration. The distribution of occupant mass along the seat back influences the torque generated at the seat back recliner mechanism, and the torque is proportional to the occupant's mass. A high-speed test would need to set a test severity within the range of potential real-world severities for which practicable countermeasures may be available. Extreme forces on the seat back due a rear impact are a relatively rare occurrence in the real-world, with the highest forces requiring both a relatively high ΔV and occupant mass. As noted in our analysis of 2017—2020 CISS data reported in Figure II.4, 94% of rear towaway collisions occur at ΔV of 40 km/h (24.9 mph) or less. Table II.2 indicated that the most probable ΔV range for MAIS 3+ injuries in rear impacts was the 31–40 km/h (19.3–24.9 mph) range. For some seat designs, a dynamic test in the ΔV range of 35 to 40 km/h (21.7 to 24.9 mph) that is conducted with a 50th percentile male ATD would likely lead to significant rotation of the seat back and occupant movement along the seat back, as described in the 2019 Edwards study.[182] The authors also noted that within the context of a 50th percentile male ATD and 37.5 km/h (23.3 mph) ΔV rear impact sled test, a degree of balance was achieved between low and high-speed rear impact protection in a range of production seats, as measured by the low-speed ratings system, seat back rotation, and occupant displacement in the high-speed test. Such a dynamic test conducted with a 95th percentile male ATD or at higher ΔV, however, would lead to greater forces on the seat back with a greater potential for plastic deformation of the seat structure, a more extreme test of retention, and potential interaction with rear seats. The high-speed test ΔV would ideally be high enough to be sufficiently representative of real-world crashes to generate practicable and, ideally, cost effective countermeasures for protection against higher level injuries. NHTSA seeks comment on the appropriate test severities for a possible high-speed test and the appropriate ATD to utilize.

Positioning of the ATD in the seat may be an important factor in a high-speed test. Studies such as the 1994 Strother and James cited above, have shown occupant posture to influence injury outcome in rear impacts. In addition, the sensitivity of an ATD itself to positioning may be a factor to explore. For example, how sensitive are results to atypical positions like leaning on the arm rest, creating an off-center midsagittal plane for the ATD? NHTSA seeks public comment on the appropriate positioning of the ATD in a high-speed rear impact test and whether and/or what type of out-of-position testing should be performed.

A well-designed high-speed rear impact test would account for all four of NHTSA's rear impact protection points in the context of high inertial forces leading to significant rearward deflection of the seat back. The performance measures of concern may include retention measures such as maximum dynamic seat back rotation angle, but also ATD injury metrics relating to thorax and neck injury. In addition to these concerns, NHTSA seeks comment regarding what objective rear impact protection metrics are of most concern in a high-speed rear impact test. Does existing ATD

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[181] Kang, Yun-Seok, et al. ''Biomechanical responses and injury assessment of post mortem human subjects in various rear-facing seating configurations.'' *Stapp car crash journal* 64 (2020): 155–212.

[182] Edwards, Marcy A., et al. ''Seat design characteristics affecting occupant safety in low-and high-severity rear-impact collisions.'' *IRCOBI Conference, Florence, Italy, IRC–19–11.* 2019.

technology adequately replicate occupant kinematics at high-speeds? What ATD injury metrics would be most objective and relevant?

(c) Rear Impact Delivery Methods

Another factor to consider for a dynamic testing approach is how the crash pulse should be delivered to the seat base. There are two basic approaches to consider: a sled (with the seat mounted to either the vehicle floor plan or a rigid platform) or moving barrier to vehicle approach. This section explores the advantages and disadvantages of each approach.

In experimental study of rear impacts, the most common method for crash pulse delivery is a sled-based method. In this approach, a moveable sled is accelerated with a high degree of accuracy on a linear track. Mounted on the sled may be a rigid platform to which the vehicle seat is attached. With appropriate mounting hardware, many types of seats can be accommodated without significant modification to the setup. However, the mounting of the seat to a rigid platform may not transmit loading to the seat identically to how it would be transmitted if the seat were mounted to the vehicle floor pan. Thus, a more realistic approach would be to mount a floor pan to the sled and mount the seat to the floor pan. Such an approach can be expanded to mount all or portions of the vehicle body and interior to the sled, potentially allowing for multiple ATDs in multiple rows of seats. The agency uses a vehicle body mounted sled test approach currently for the optional dynamic testing in FMVSS No. 202a.

Sled-based methods are relatively low cost and deliver a highly repeatable pulse that can be readily applied to all seats. This removes a degree of uncertainty about test repeatability. However, a sled pulse only approximates a real-world crash pulse. A sled offers one-dimensional translational motion, while actual rear impact crash test may contain three-dimensional translational motion and rotation of the vehicle, albeit likely relatively small accelerations in the vertical and lateral direction. While a sled-based approach is advantageous from a cost and repeatability standpoint, it may discount case-specific design considerations. In addition, for higher speed impacts, if seats were designed around a universal rear impact sled pulse, some seats may in turn be over-designed and others under-designed relative to their actual need for rear impact protection. This is because the design of rear impact protection in seats could consider vehicle factors, *e.g.,* vehicle weight and/or stiffness of the vehicle.

A vehicle approach would deliver a rear impact to a motor vehicle using a moving barrier, similar to tests conducted under FMVSS No. 301. In fact, while conducting FMVSS No. 301 tests outlined in the 2003 Saunders study, the agency has added instrumentation to seat backs and placed HIII–50M ATDs in the front seats to assess the performance of seat backs. As is the case with the vehicle body being mounted to a sled, this approach would test rear impact protection in the context of the entire vehicle. However, it differs in that the acceleration pulse delivered to the seat will be a function of the vehicle's structural deformation. In a real collision, the seat base acceleration depends on vehicular factors, *e.g.,* vehicle mass and structural characteristics, and therefore the moving barrier to vehicle approach would be closer to reality compared to a typical sled-based approach. A moving barrier to vehicle approach is more of a consideration for higher speed impacts, where the vehicle characteristics would have a greater influence on the crash pulse. A sled-based approach could tune the sled pulse to the actual vehicle crash pulse, if it were known, or use some adjustment to the pulse that considers vehicle-based factors. Nonetheless, a barrier impact approach would place a greater load on seats of lighter and stiffer vehicles because ΔV has positive correlation with these features if all else is equal.

The barrier impact approach places the seat in the full vehicle environment. However, a sled-based approach allows the possibility of the seat mounted on a platform in isolation. Whether a full vehicle or isolated seat is tested is less likely to influence testing outcomes in low-speed testing. However, high-speed testing will cause much more seat back deformation. In certain vehicle environments, such as convertibles, two-door cars, standard cab pickup trucks, and vehicles with rigid second row seating, there may be structures near the seat back which could restrict its rearward movement. Such restrictions could be advantageous with respect to meeting seat back rotation limits. How such restrictions would influence risk of injury, however, is not obvious.

In summary, a sled-based method using a rigid platform and a generic sled pulse is the most cost effective and simplest method for inertial loading of a seat. Sled testing using the vehicle floor and even more of the actual vehicle would likely increase cost and perhaps complexity. The use of generic sled pulses, whether for lower or higher speed impact simulation may also potentially allow for greater repeatability, while sacrificing closeness to reality. Sled testing using a vehicle specific crash pulse would add some complexity and the need for knowledge of the crash pulse. A moving barrier to vehicle test would be the option but would deliver the best approximation to the real-world impact while simplifying crash pulse generation. It would have instrumentation measurement complexity similar to sled testing. Additionally, a moving barrier to vehicle test may also introduce more avenues for test-to-test variability, part of which can be attributed to vehicle build variability. NHTSA seeks comment on the different approaches for delivering a rear impact crash pulse.

(d) Characteristics and Performance Measures Needed for a Rear Dummy

As discussed above, fostering the synergistic performance of seats suggests dynamic testing should sample at least two different ΔV regimes: including a low-speed and high-speed test. A different ATD could be used for each test to adequately assess the range of occupant kinematics that occur as ΔV is varied. The primary ATD performance measures of concern for a low-speed test relate to whiplash injuries and as noted earlier, important characteristics include the ability to replicate torso straightening and neck kinematics. These factors are also important for biofidelity in a high-speed test along with thoracic compression, spine flexibility, and pelvic rotation.[183]

The HIII–50M has long been widely used for rear impact protection research, even though this dummy was developed and validated for frontal crash testing. Nonetheless, the HIII–50M has provided an effective means of ballasting the seat and measurements of dummy kinematics and loading. Over time, significant progress has been made on the development of the BioRID ATD, which is designed specifically for rear impacts. BioRID performance has thus far been focused on low-speed testing to assess neck injury risk but has more recently been evaluated in higher speed rear impact conditions. Additionally, dynamic sled tests are used by ratings groups, academic researchers and industrial researchers to assess the performance of seating systems in a rear impact, and results are compared with adult volunteers in low-speed tests and

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[183] Hagedorn, A., Stammen, J., Ramachandra, R., Rhule, H. et al., ''Biofidelity Evaluation of THOR–50M in Rear-Facing Seating Configurations Using an Updated Biofidelity Ranking System,'' *SAE Int. J. Trans. Safety* 10(2):291–375, 2022.

PMHS at higher speeds to validate modern ATD measurements.[184] [185] These efforts have built a better technological basis for a dynamic test compared to the past.

The BioRID 50th percentile male dummy was developed by a Swedish team in the 1990s.[186] The development was in response to low-speed rear impact testing using human volunteers indicating that torso straightening, and angling of the lower spine were essential for accurate cervical spine dynamics,[187] [188] and the determination that existing ATDs of that era did not properly simulate the cervical vertebrae motions. Therefore, development focused on an ATD with more realistic spinal motion, particularly in the neck, and one that would simulate torso straightening.[189] The BioRID dummy has an articulated mechanical spine and is primarily intended to replicate spinal motion in low-speed rear impacts. BioRID vertebrae are connected by linear pin joints and a tension cable. This mechanical system shows comparatively high torsional, shear, compression, and tension inter-vertebral forces in rear impacts.[190] NHTSA has evaluated the BioRID and believes it is the best available 50th percentile male ATD for the low-speed rear impact test discussed in this ANPRM, but seeks comment on this topic. NHTSA also seeks comment on the potential use of appropriate female crash test dummies designed specifically for rear impact to offer a more comprehensive assessment of seat performance.

For the higher speed rear impact test, NHTSA is examining the use of BioRID as well as the HIII–50M and Test device for Human Occupant Restraint 50th percentile male (THOR–50M) ATD.[191] The BioRID has the advantages articulated above, but there may be limits to the speed of the crash environment that it can be used in and BioRID replicates only two-dimensional motion of the spine with injury assessment being limited to the cervical spine.

The HIII–50M and THOR–50M have limitations due to being designed for frontal impacts. Nevertheless, these dummies are typically used in studies of high-speed rear impact dynamics and have been used as seat occupants in rear impact tests. In the case of high-speed tests these ATDs enable the measurement of seat back rotation and retention by acting as ballasts that impose a biofidelic inertial load on the seat back. The 2019 Edwards study, for example, used the HIII–50M dummy for the high-speed test. The HIII–50M is limited because it has a rigid thoracic spine so its interaction with a seat back is significantly different than a real occupant whose bendable spine conforms with the seat cushion profile and structural cross members. The THOR–50M ATD, a refinement of the TAD–50M thorax, integrated a new multi-directional neck and instrumented pelvis, abdomen, and lower extremity concepts. Both the HIII–50M and THOR–50M allow for the measurement of chest injury risk. While a high-speed test that uses one of the male ATDs discussed above is necessary to assess seating system integrity, a comprehensive test of seat retention may also require a test using a female ATD. NHTSA seeks comment on the ATDs to use for high-speed rear impact tests.

NHTSA is exploring a low and high severity test as components of a unified approach to updating FMVSS No. 207 and the ATD requirements of these tests overlap with capabilities of the HIII–50M, THOR–50M, and BioRID dummies. NHTSA seeks comment on the benefits and costs, in particular the practicability and objectivity concerns, of using different ATDs for different rear impact test severities versus the use of a single ATD for both low and high-speed testing.

D. Crash Avoidance Technology

Over the last several years, automatic emergency braking (AEB) and forward collision warning (FCW) have become more prevalent in the light vehicle fleet. An AEB system uses various sensor technologies and sub-systems that work together to detect when the vehicle is in a crash imminent situation, to automatically apply the vehicle brakes if the driver has not done so, or to apply more braking force to supplement the driver's braking. A FCW system uses sensors that detect objects in front of vehicles and provides an alert to the driver. FCW systems may detect impending collisions with any number of roadway obstacles, including vehicles. NHTSA has recently published a final rule requiring that all new light vehicles be equipped with AEB and FCW systems.[192] NHTSA anticipates that over time, AEB and FCW prevalence in the fleet will increase and the technology will improve. Therefore, any future rulemaking action related to the upgrade of rear impact protection through modification of seat related standards will need to fully consider the effects of crash avoidance technology such as AEB and FCW. AEB and FCW are expected to reduce the incidence of high-speed rear impact collisions, either through avoiding a collision entirely or mitigating impact speeds into lower-speed collisions. If AEB and FCW have this impact, their availability may in turn affect crash frequencies and injury types relevant to this ANPRM, such as the incidence of seat back failure in vehicles struck from the rear. AEB and FCW may also reduce the incidence of low-speed rear impacts that cause injuries such as whiplash in occupants of the struck vehicle. However, it is possible that AEB and FCW, by mitigating some high-speed impacts into lower-speed collisions, may increase the number of lower-speed rear impacts. It is not clear what the net impact would be. NHTSA seeks comment on how best to consider the effects of this technology on the issues discussed in the ANPRM. In particular, how might a change in frequency of rear impacts of different velocities impact the benefit-cost considerations for regulatory changes discussed in this ANPRM, such as the seat back strength requirement?

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[184] Willis, Claire, Jolyon Carroll, and Adrian Roberts. ''An evaluation of a current rear impact dummy against human response corridors in both pure and oblique rear impact.'' *Proceedings of the 19th International Technical Conference of the Enhanced Safety of Vehicles, Paper.* No. 05–0061. 2005.

[185] Croft, Arthur C., and Mathieu MGM Philippens. ''The RID2 biofidelic rear impact dummy: A pilot study using human subjects in low-speed rear impact full scale crash tests.'' *Accident Analysis & Prevention* 39.2 (2007): 340–346.

[186] Davidsson, Johan, et al. ''BioRID I: a new biofidelic rear impact dummy. '' Proceedings of the International Research Council on the Biomechanics of Injury conference. Vol. 26. International Research Council on Biomechanics of Injury, 1998.

[187] McConnell, Whitman E., et al. Analysis of human test subject kinematic responses to low velocity rear end impacts. No. 930889. SAE Technical Paper, 1993.

[188] Ono, Koshiro, and Munekazu Kanno. ''Influences of the physical parameters on the risk to neck injuries in low impact speed rear-end collisions.'' *Accident Analysis & Prevention* 28.4 (1996): 493–499.

[189] Lövsund, Per, and Mats Y. Svensson. ''Suitability of the available mechanical neck models in low velocity rear end impacts.'' *CNR–PFT2 ELASIS International Conference on Active and Passive Automobile Safety in Capri, Italy.* 1996.

[190] Viano, David C., et al. ''Neck biomechanical responses with active head restraints: Rear barrier tests with BioRID and sled tests with Hybrid III.'' *SAE Transactions* (2002): 219–237.

[191] Hagedorn A, Stammen J, Ramachandra R, Rhule H, Thomas C, Suntay B, Kang YS, Kwon HJ, Moorhouse K, Bolte IV JH. Biofidelity Evaluation of THOR–50M in Rear-Facing Seating Configurations Using an Updated Biofidelity Ranking System. SAE Int. J. Trans. Safety 10(2):2022, *https://doi.org/10.4271/09-10-02-0013*.

[192] 89 FR 39686 (July 8, 2024). This final rule builds on a voluntary commitment, announced by NHTSA in March 2016, by 20 vehicle manufacturers to make AEB a standard feature on nearly all new light vehicles.

VII. NHTSA's Forthcoming Research

NHTSA is pursuing research to build a greater understanding of the issues presented in this document. Based upon the current understanding of these issues, the goals are to better define the scope of the current rear impact safety problem, validate seated ATD measurements in rear impacts, quantify rear impact injury risks, attempt to develop injury risk curves, and analyze rear impact dynamics and testing procedures. Because the understanding of the rear impact problem continues to evolve, the priorities and objectives are subject to change and likely to evolve as research progresses. Currently, the aim is to identify sled test ΔVs, test types (*e.g.,* static versus dynamic), test tools (*e.g.,* loading fixture, ATDs) and performance limits (*e.g.,* strength requirements, displacement limits, injury assessment reference values). It is anticipated that the research outcomes will contribute to the determination of whether to propose an update to FMVSS No. 202a and FMVSS No. 207 and, if the determination is made to do so, provide the basis for such a proposal. The following discussion outlines NHTSA's path forward for research activities related to this ANPRM.

A. Field Data Analysis and Market Research

A study of rear impact field data will investigate the scope of the rear impact safety problem. NHTSA intends to examine the incidence of injuries to the seated front occupant, the types of injuries, the degree to which modern occupied seat backs fail or become deformed (by row), and which parts of the seat incur yielding (*i.e.,* just the seat back, the anchors and seat track, the vehicle floor, etc.). For higher speed rear impacts, this is needed to identify the level of crash severity that may represent a reasonable dynamic testing level. Overall trends will be examined by analyzing aggregate field data and occupant injury and multiple seat row interaction. An attempt will be made to attribute vehicle occupant injury to seat performance. It is expected that manual reviews of case file material will be necessary to discern seat performance and failure mechanisms. NHTSA also intends to examine how seat designs may have improved across the fleet or how second row seats differ in performance from front row seats.

B. Test Procedure Assessment

NHTSA plans to conduct a sled-based study of rear impact seat back and occupant dynamics to develop a greater knowledge base in the performance of modern seats in both low and high-speed regimes and to investigate the feasibility of a dynamic approach for updating FMVSS No. 207 and rear impact protection in general.

1. High-Speed Test

The agency expects to perform high-speed sled tests across a range of ΔVs including the high-speed rear impact fuel integrity test performed in FMVSS No. 301 and at speeds identified in the field data analysis mention above that result in relatively high risks to vehicle occupants. Through this testing, NHTSA will attempt to determine what physical characteristics govern occupant protection and what severities lead to substantial deformation of seat backs in high-speed rear impacts. This testing will take a variety of configurations and serve a variety of functions. One important question to be answered is what deceleration pulse and/or ΔV will achieve the agency's regulatory goals, particularly with respect to a front seat occupant intruding into the rear seat occupant space. Another important research question is whether the deceleration pulse and/or ΔV should be vehicle specific or generic. It is expected that sled testing will be performed with partial vehicles as well as platform mounted seats to decern the effect of these two configurations of seat performance as well as to assess the challenges related to testing a seat within a vehicle. This testing will also help identify the important seat performance characteristics and the best way to measure them. We expect to use multiple ATDs and PMHS occupants in the seats for a variety of tasks discussed below.

2. Exploratory Testing

NHTSA recently conducted exploratory high-speed rear impact sled testing on a series of production seats to gain insight into instrumentation and measurement needs for such tests. The test closely resembled the 2019 high-speed rear impact tests from the IIHS study,[193] except that NHTSA used the THOR–50M as a normally positioned occupant. NHTSA's crash pulse achieved a maximum sled acceleration of 15.1 g after approximately 80 ms resulting in a ΔV of 36 km/h (22.4 mph). The test series consisted of 6 total sled tests involving the front driver seat of three different major auto manufacturers in 2013 and 2018 MY used passenger vehicles. The three models were tested with and without seat belt pretensioners. The seats were instrumented with accelerometers, load cells, strain gages and camera target standoffs and fixed to the sled buck with an initial seat back recline angle of 25°. The time-dependent seat back rotation angle was determined by postprocessing film data and 6DX (Diversified Technical Systems) sensor package measurements and are shown in Figure VII.1 in the case of no pretensioners.

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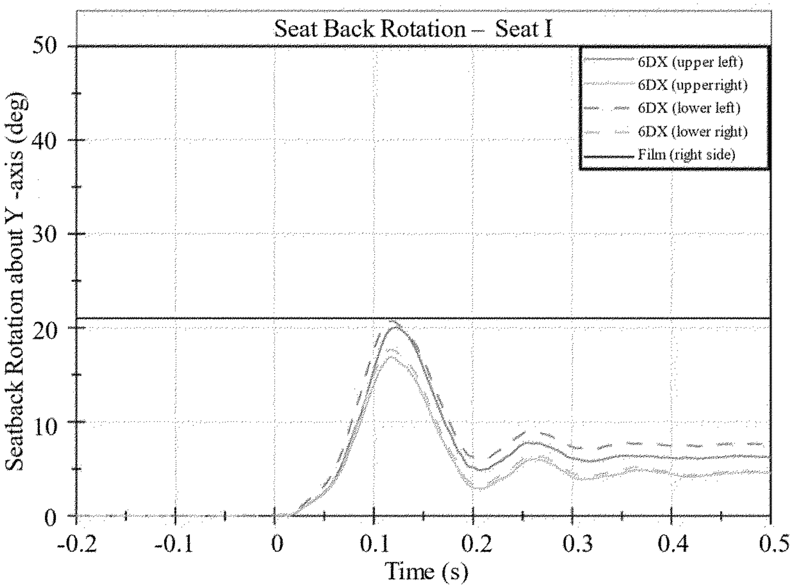
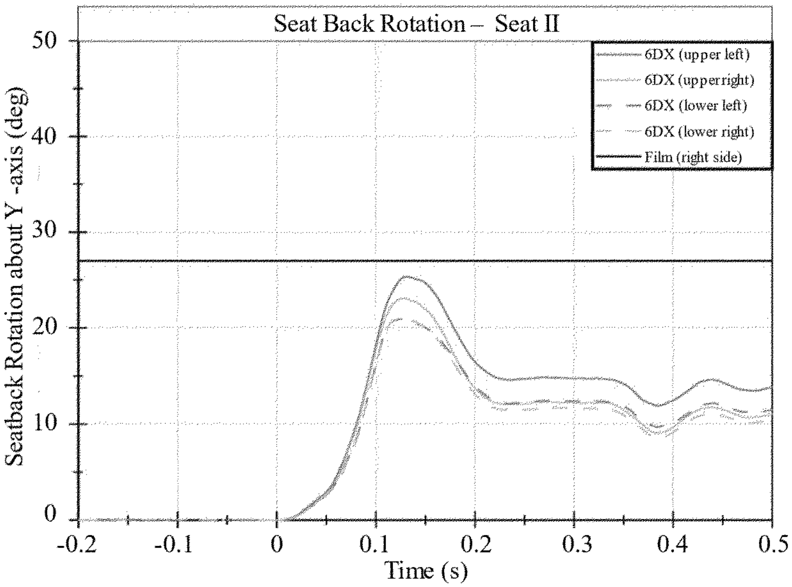
[193] Edwards, Marcy A., et al. ''Seat design characteristics affecting occupant safety in low-and high-severity rear impact collisions.'' *IRCOBI Conference, Florence, Italy, IRC–19–11.* 2019.


Seat Back Rotation – Seat I
6DX (upper left)
6DX (upperright)
6DX (lower left)
6DX (lower right)
Film (right side)
Seatback Rotation about Y -axis (deg)
0
10
20
30
40
50
-0.2
-0.1
0
0.1
0.2
0.3
0.4
0.5
Time (s)


Seat Back Rotation – Seat II
6DX (upper left)
6DX (upperright)
6DX (lower left)
6DX (lower right)
Film (right side)
Seatback Rotation about Y -axis (deg)
0
10
20
30
40
50
-0.2
-0.1
0
0.1
0.2
0.3
0.4
0.5
Time (s)

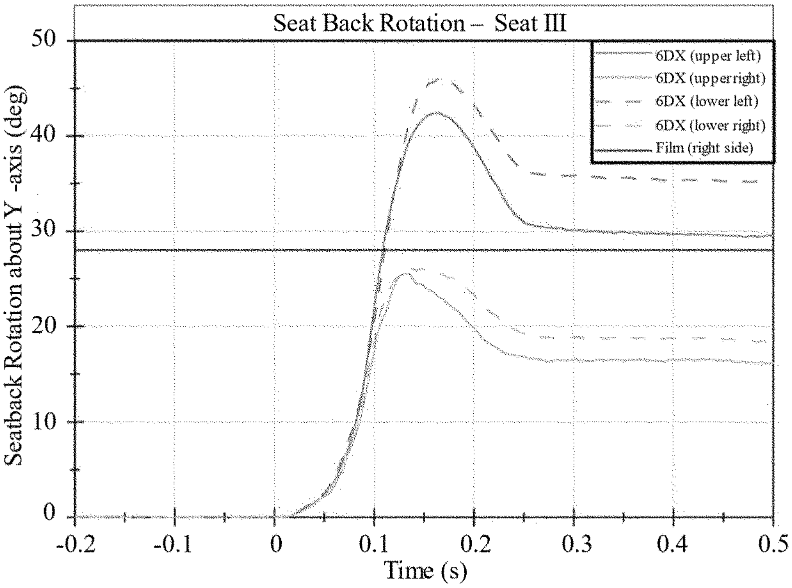


Figure VII.1: Seat back rotation angles measured by NHTSA in the current high-speed rear impact test series, ΔV = 36 km/h, seat I is MY 2018, seat II is MY 2018-2019 and seat III is MY 2013.

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The seat backs reached their maximum rearward rotation at approximately twice the point of peak sled acceleration and then, upon reversing, decayed to a final recline angle that is greater than the initial recline angle. Seat I had the least rearward rotation and its final recline angle was the least among the three models. Seat III had the most rearward rotation and its final recline angle was the greatest among the three models. The difference between the initial and final recline angles are a product of irreversible deformation in the seat frame and an indication of energy absorbed by the seat. In seat I and to a lesser extent seat II, as the rotation angle decayed to the final angle there was oscillation of the seat back about the final angle; this is a characteristic of spring-mass-damper systems. Seat III had significant twisting about the longitudinal axis as seen in the large differences between the left and right seat back rotations. A post-test visual tear down analysis found that in all seats the side bolsters bent inward toward the occupant and deformation was also seen in the lower seat frames and pans. This initial series of tests demonstrates that rearward excursion and rotation are high-speed seat performance metrics that can be reliably obtained in different seat models.

3. Low-Speed Test

To broadly assess the rear impact protection measures of a seat, the performance should be compared in a low- and high-speed test to analyze whether improvements in seat performance at high-speed impacts sacrifice whiplash injury mitigation at low-speeds. Thus, it is expected that seats will be tested in both a low- and a high-speed test, to see how the performance compares in both rear impact conditions. This study may determine if the design requirements for low- and high-speed performance align or contradict one another.

As stated above, one important factor in test procedure development will be exploring the appropriate low- and high-speed deceleration for rear impact tests. A reasonable starting point for the lower speed test is the head restraint optional dynamic test in FMVSS No. 202a. We are aware of other sled pulses used for whiplash assessment by IIHS and EuroNCAP, however, and will explore these as well. We will also explore the need or acceptability of platform mounted seats versus in-vehicle testing. Finally, a key factor for low-speed testing will be the ATD. NHTSA expects to focus on the use of the BioRID for these tests.[194] We also expect to assess various whiplash injury criteria.

C. Parametric Modeling

A computational model of seat occupant dynamics in a rear impact that is validated against experimental data could provide insight into a range of safety issues. It is expected that both ATDs and human body models will be used as seat occupants and the impact of various occupant characteristics on injury risk can be determined, such as the occupant size and gender. NHTSA may also study the extent to which seat design specifications have a positive influence on injury risk. A computational model can be run over a range of deceleration pulses and seat characteristics to determine at which point significant seat deformation and the onset of serious injuries to seat occupant occurs.

D. ATD and Injury Risk Function Development

Rear impact testing with PMHS seat occupants provides biomechanical data for ATD evaluation as noted in the NHTSA citations above. By comparing equivalent pairs of ATD and PMHS tests, more realistic injury risk functions can be developed for the ATD seat occupant in a rear impact. NHTSA has, for example, performed extensive work on low-speed whiplash injury risk functions for the BioRID. NHTSA expects the BioRID to be the focus of low-speed testing in this research; however, various whiplash injury criteria will be explored.

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[194] See discussion at section IV.4., above, for additional information related to use of the BioRID.

For high severity research, further PMHS testing will provide the injury information to correlate with ATD measurements in an injury risk function. This information will also be correlated to seat performance parameters to assist in identification of factors that influence injury risk. Additionally, both BioRID and THOR–50M will be evaluated for high-speed testing. The BioRID has a fully articulated spine but was designed specifically for lower speed rear impacts. Thus, durability and biofidelity in higher speed rear impacts will need to be evaluated. The THOR–50M was not designed for rear impacts, but has thoracic measurements not available in BioRID. However, its acceptability for overall rear impact injury risk will need further consideration. Once injury risk functions are developed, the ATD(s) will be used in a broader evaluation of seats on the market against identified performance metrics.

E. Cost Analysis

The purpose of a cost analysis is to determine the financial implications of improving rear impact protection. A broad understanding will be gained by performing a cost analysis in each aspect of NHTSA's research initiative. A tear down analysis of tested seats provides an indication of failure mechanisms and protective design measures. The cost differential between good and poor performing seats could be estimated by quantifying the difference in design measures determined through tear down. The computational study could assess the overall impact and cost of design changes within a seat; for example, if design changes are made to a poorly performing seat for a high-speed test with a specific occupant, would these changes in fact have a detrimental impact in other scenarios? After the cost differential between good and poor performing seats is well defined, then market research and assessment of the fleet will determine the overall costs of improving rear impact protection.

F. Summary

NHTSA is pursuing research to gain a greater understanding of the modern rear impact protection issue that the agency regulates under FMVSS Nos. 207 and 202a. An examination of recent rear impact field data is helpful to define the overall safety issue and determine whether any countermeasure to a problem is cost effective. This document discusses a two-tiered dynamic testing approach. NHTSA is pursuing sled testing of rear impacts to explore this dynamic approach and has conducted an initial exploratory series of high-speed rear impact tests described above. NHTSA has ongoing research in rear impact sled testing using PMHS occupants that in turn supports an ATD based assessment of rear impact injuries and dynamics. A computational parametric study has also been proposed to broadly investigate rear impact dynamics and various protection measures. If a rulemaking is pursued, NHTSA will also perform research tasks to develop the necessary cost and benefit estimates for upgraded rear impact protection estimates. NHTSA would like this research to make decisive contributions and therefore seeks comment on the research proposed here. Would a greater impact be achieved if the agency's resources were directed in another area of rear impact protection or more focused in a critical area?

VIII. Public Participation

A. How can I inform NHTSA's thinking on this rulemaking?

Your comments will help us improve this rulemaking. NHTSA invites you to provide different views on options NHTSA discusses above, new approaches the agency has not considered, new data, descriptions of how this ANPRM may affect you, or other relevant information.

NHTSA welcomes public review of all aspects of this ANPRM, but requests comments on specific issues throughout this document. NHTSA will consider the comments and information received in developing a potential proposal for how to proceed with updating requirements for motor vehicles. Your comments will be most effective if you follow the suggestions below:

- Explain your views and reasoning as clearly as possible.
- Provide solid technical and cost data to support your views.
- If you estimate potential costs, explain how you arrived at the estimate.
- Tell NHTSA which parts of the ANPRM you support, as well as those with which you disagree.
- Provide specific examples to illustrate your concerns.
- Offer specific alternatives.
- Refer your comments to specific sections of the ANPRM, such as the units or page numbers of the preamble.

B. How do I prepare and submit comments?

Your comments must be in writing. To ensure that your comments are filed correctly in the Docket, please include the docket number of this document located at the beginning of this notice in your comments.

Your primary comments should not be more than 15 pages long.[195] You may attach additional documents to your primary comments, such as supporting data or research. There is no limit on the length of the attachments.

Please submit one copy of your comments (two if submitting by mail or hand delivery), including the attachments, to the docket via one of the methods identified under the **ADDRESSES** section at the beginning of this document. If you are submitting comments electronically as a PDF (Adobe) file, we ask that the documents submitted be scanned using an Optical Character Recognition (OCR) process, thus allowing NHTSA to search and copy certain portions of your submission.

Please note that pursuant to the Data Quality Act, for substantive data to be relied upon and used by the agency, it must meet the information quality standards set forth in the OMB and DOT Data Quality Act guidelines. Accordingly, NHTSA encourages you to consult the guidelines in preparing your comments. DOT's guidelines may be accessed at *www.transportation.gov/regulations/dot-information-dissemination-quality-guidelines.*

C. How can I be sure that my comments were received?

If you submit comments by hard copy and wish Docket Management to notify you upon its receipt of your comments, enclose a self-addressed, stamped postcard in the envelope containing your comments. Upon receiving your comments, Docket Management will return the postcard by mail. If you submit comments electronically, your comments should appear automatically in the docket number at the beginning of this notice on *https://www.regulations.gov.* If they do not appear within two weeks of posting, we suggest that you call the Docket Management Facility at 202–366–9826.

D. How do I submit confidential business information?

NHTSA is currently treating electronic submission as an acceptable method for submitting confidential business information to the agency under part 512. If you claim that any of the information or documents provided in your response constitutes confidential business information within the meaning of 5 U.S.C. 552(b)(4), or are protected from disclosure pursuant to 18 U.S.C. 1905, you may either submit your request via email or request a secure file transfer

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[195] 49 CFR 553.21.

link from the Office of the Chief Counsel contact listed below. You must submit supporting information together with the materials that are the subject of the confidentiality request, in accordance with part 512, to the Office of the Chief Counsel. Do not send a hardcopy of a request for confidential treatment to NHTSA's headquarters.

Your request must include a request letter that contains supporting information, pursuant to § 512.8. Your request must also include a certificate, pursuant to § 512.4(b) and part 512, appendix A.

You are required to submit one unredacted ''confidential version'' of the information for which you are seeking confidential treatment. Pursuant to § 512.6, the words ''ENTIRE PAGE CONFIDENTIAL BUSINESS INFORMATION'' or ''CONFIDENTIAL BUSINESS INFORMATION CONTAINED WITHIN BRACKETS'' (as applicable) must appear at the top of each page containing information claimed to be confidential. In the latter situation, where not all information on the page is claimed to be confidential, identify each item of information for which confidentiality is requested within brackets: ''[ ].''

You are also required to submit one redacted ''public version'' of the information for which you are seeking confidential treatment. Pursuant to § 512.5(a)(2), the redacted ''public version'' should include redactions of any information for which you are seeking confidential treatment (*i.e.,* the only information that should be unredacted is information for which you are not seeking confidential treatment). For questions about a request for confidential treatment, please contact Dan Rabinovitz in the Office of the Chief Counsel at *Daniel.Rabinovitz@dot.gov*.

E. Will the agency consider late comments?

NHTSA will consider all comments received to the docket before the close of business on the comment closing date indicated above under the **DATES** section. NHTSA will consider any late-filed comments to the extent possible.

F. How can I read the comments submitted by other people?

You may read the comments received by Docket Management in hard copy at the address given above under the **ADDRESSES** section. The hours of the Docket Management office are indicated above in the same location. You may also read the comments on the internet by doing the following:

(1) Go to *https://www.regulations.gov*.

(2) *Regulations.gov* provides two basic methods of searching to retrieve dockets and docket materials that are available in the system:

a. The search box on the home page which conducts a simple full-text search of the website, into which you can type the docket number of this notice and

b. ''Advanced Search,'' which is linked on the *regulations.gov* home page, and which displays various indexed fields such as the docket name, docket identification number, phase of the action, initiating office, date of issuance, document title, document identification number, type of document, **Federal Register** reference, CFR citation, etc. Each data field in the advanced search function may be searched independently or in combination with other fields, as desired. Each search yields a simultaneous display of all available information found in *regulations.gov* that is relevant to the requested subject or topic.

(3) Once you locate the docket at *https://www.regulations.gov,* you can download the comments you wish to read. We note that because comments are often imaged documents rather than word processing documents (*e.g.,* PDF rather than Microsoft Word), some comments may not be word searchable.

Please note that, even after the comment closing date, NHTSA will continue to file relevant information in the Docket as it becomes available. Further, some people may submit late comments. Accordingly, NHTSA recommends that you periodically check the Docket for new material.

IX. Regulatory Analyses and Notices

A. Executive Order (E.O.) 12866, E.O. 13563, and E.O. 14094 and DOT Regulatory Policies and Procedures

The agency has considered the impact of this rulemaking action under Executive Order (E.O.) 12866, E.O. 13563, E.O. 14094, and the Department of Transportation's regulatory procedures DOT Order 2100.6A. This ANPRM was determined to be significant under E.O. 12866 and was reviewed by the Office of Management and Budget.

This ANPRM presents possible avenues for updating regulations regarding occupant protection in rear impact and seeks public comment to develop information that may inform a future proposal. NHTSA is using this ANPRM to solicit public feedback before potentially proceeding with a proposed rule.

We have asked commenters to answer a variety of questions to elicit practical information about alternative approaches and relevant technical data, which will enable analysis of the costs and benefits of a possible future proposal.

B. Paperwork Reduction Act

Under the Paperwork Reduction Act of 1995 (PRA), a person is not required to respond to a collection of information by a Federal agency unless the collection displays a valid OMB control number. This ANPRM would not establish any new information collection requirements.

C. Privacy Act

DOT solicits comments from the public to better inform its rulemaking process. DOT posts these comments, without edit, including any personal information the commenter provides, to *www.regulations.gov,* as described in the system of records notice (DOT/ALL–14 FDMS), which can be reviewed at *www.dot.gov/privacy*. Please note that anyone is able to search the electronic form of all comments received into any of our dockets by the name of the individual submitting the comment (or signing the comment, if submitted on behalf of an association, business, labor union, etc.). For information on DOT's compliance with the Privacy Act, please visit *https://www.transportation.gov/privacy*.

D. Plain Language

Executive Order 12866 requires each agency to write all rules in plain language. Application of the principles of plain language includes consideration of the following questions:

- Have we organized the material to suit the public's needs?
- Are the requirements in the document clearly stated?
- Does the document contain technical language or jargon that isn't clear?
- Would a different format (grouping and order of sections, use of headings, paragraphing) make the document easier to understand?
- Would more (but shorter) sections be better?
- Could we improve clarity by adding tables, lists, or diagrams?
- What else could we do to make the document easier to understand?

If you have any responses to these questions, please include them in your comments.

E. Regulation Identifier Number (RIN)

The Department of Transportation assigns a regulation identifier number (RIN) to each regulatory action listed in the Unified Agenda of Federal

Regulations. The Regulatory Information Service Center publishes the Unified Agenda in April and October of each year. You may use the RIN contained in the heading at the beginning of this document to find this action in the Unified Agenda.

X. Conclusion

In accordance with 49 CFR part 552, NHTSA grants in part and denies in part the petitions by Mr. Saczalski and Mr. Cantor and denies the CAS petition.

Issued in Washington DC, under authority delegated in 49 CFR 1.95, 501.5, and 501.8.

Jack Danielson,

Executive Director.

[FR Doc. 2024–15390 Filed 7–15–24; 8:45 am]

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